NASA SP-7037 (286)
January 1993

P-234

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

NASA STI PROGRAM
SCIENTIFIC & TECHNICAL INFORMATION

NASA SP-7037 (286)
January 1993

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

National Aeronautics and Space Administration
Scientific and Technical Information Program
Washington, DC 1993

INTRODUCTION

This issue of *Aeronautical Engineering—A Continuing Bibliography* (NASA SP-7037) lists 845 reports, journal articles, and other documents originally announced in December 1992 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

Accession numbers cited in this issue are:

STAR (N-10000 Series)	N92-32243 — N92-34247
IAA (A-10000 Series)	A92-53430 — A92-57500

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the publication consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals.

Seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number—are included.

A cumulative index for 1992 will be published in early 1993.

Information on availability of documents listed, addresses of organizations, and CASI price schedules are located at the back of this issue.

CONTENTS

Category 01 Aeronautics (General) 1015

Category 02 Aerodynamics 1017
Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

Category 03 Air Transportation and Safety 1043
Includes passenger and cargo air transport operations; and aircraft accidents.

Category 04 Aircraft Communications and Navigation 1045
Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

Category 05 Aircraft Design, Testing and Performance 1051
Includes aircraft simulation technology.

Category 06 Aircraft Instrumentation 1063
Includes cockpit and cabin display devices; and flight instruments.

Category 07 Aircraft Propulsion and Power 1065
Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboard auxiliary power plants for aircraft.

Category 08 Aircraft Stability and Control 1073
Includes aircraft handling qualities; piloting; flight controls; and autopilots.

Category 09 Research and Support Facilities (Air) 1089
Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.

Category 10 Astronautics 1102
Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications, spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

Category 11 Chemistry and Materials 1105
Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.

Category 12 Engineering 1111
Includes engineering (general); communications and radar; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

Category 13 Geosciences 1129
Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

Category 14 Life Sciences N.A.
Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.

Category 15 Mathematical and Computer Sciences 1130
Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

Category 16 Physics 1135
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

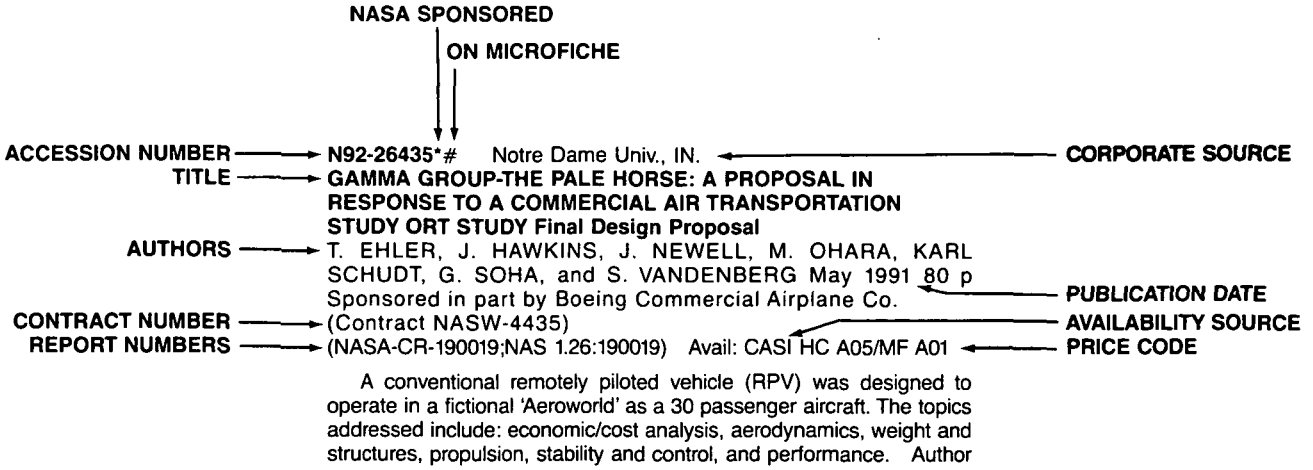
Category 17 Social Sciences 1141
Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

Category 18 Space Sciences N.A.
Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

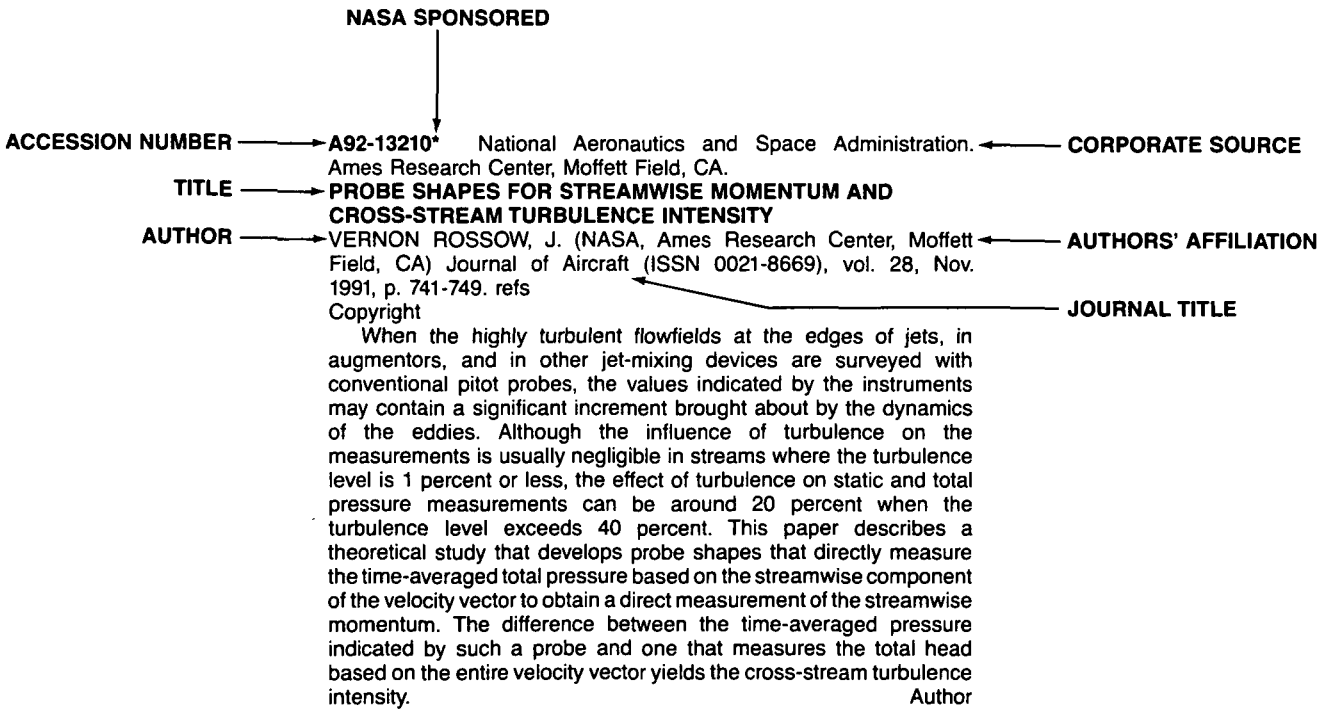
Category 19 General 1142

Subject Index A-1
Personal Author Index B-1
Corporate Source Index C-1
Foreign Technology Index D-1
Contract Number Index E-1
Report Number Index F-1
Accession Number Index G-1
Appendix APP-1

TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 286)

January 1993

01

AERONAUTICS (GENERAL)

A92-53434
JAPAN PUSHES HIGH SPEED RESEARCH
MICHAEL A. DORNHEIM Aviation Week & Space Technology (ISSN 0005-2175), vol. 137, no. 7, Aug. 17, 1992, p. 48-57.
Copyright

An overview is presented of Japan's effort to simultaneously improve its technology base, learn how to jointly develop complex systems, and also calm foreign criticism of a one-way flow of technology into the country. Attention is given to program activity toward future SST/HST developments for both vehicles and propulsion systems. Consideration is given to high-performance materials research and Japan's evaluation of the high speed civil transport market. R.E.P.

A92-55099
MODIFIED DOPPLER DETECTS WIND SHEAR MORE RELIABLY
BRUCE D. NORDWALL Aviation Week & Space Technology (ISSN 0005-2175), vol. 137, no. 10, Sept. 7, 1992, p. 143, 145, 147, 149, 151.
Copyright

NASA/FAA flight tests have determined that advanced, predictive sensor systems can provide airline crews up to 30-sec warning of wind shears during the critical takeoff and landing flight phases. The modified Doppler weather radar is detecting wind shear consistently and at longer ranges than lidar or the IR sensors. Attention is given to the Terminal Doppler Weather Radar, the 'F-factor' (a number that indicates the danger of a specific wind shear), and a new lightweight multimode radar designed for the medium-performance fighter market. R.E.P.

A92-55102
REGIONAL AIRLINE AND EQUIPMENT REVIEW - EVOLUTION, TRENDS, AND FUTURE PROSPECTS
F. B. WALLACE (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) Aerospace Engineering (ISSN 0736-2536), vol. 12, no. 9, Sept. 1992, p. 16-21.
Copyright

A history and description of the regional airline industry is presented. Key equipment and operational trends are discussed, and the development and evolution of regional aircraft and engines, and the industries that supply them are reviewed. Consideration is given to regional aircraft market requirements and how the operator's needs are evolving to the growing demand for more seats and greater speed. R.E.P.

A92-55103
AIR TRANSPORTS IN THE 21ST CENTURY
JOHN D. WOLF and DALE S. WARREN (Douglas Aircraft Co., Long Beach, CA) Aerospace Engineering (ISSN 0736-2536), vol. 12, no. 9, Sept. 1992, p. 29-34. refs
Copyright

This paper looks ahead a quarter century and projects that can be expected in commercial aircraft configurations and performance limits. Attention is given to air transportation demand, a review of the 1992-2017 transport scene, and air transport development and production envisioned for the 21st century. Consideration is given to technology improvement predictions and a comparison of the advanced 1990's and 'synergistic technology' next generation transports. R.E.P.

A92-56001
AIRCRAFT SYMPOSIUM, 29TH, GIFU, JAPAN, OCT. 7-9, 1991, PROCEEDINGS
Symposium sponsored by Japan Society for Aeronautical and Space Sciences and Japan Aeronautical Engineers Association. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, 597 p. In Japanese. For individual items see A92-56002 to A92-56055, A92-56057 to A92-56121.

Various papers on aerospace technology are presented. Among the topics addressed are: analysis and test of low aspect wing gust load elevation, automation of emergency landings for helicopters, A320 flight control from the pilot's point of view, new techniques in missile guidance and control, application of fuzzy control to aircraft guidance, maneuvering tests of an ACV model, configuration of flexible skirts for an ACV and its CAD, potential flow theory of 2D bifurcated curtain jets, midcourse guidance study on a future autonomous tactical missile, sensitivity analysis for structural optimization of helicopter rotor blades, composite hingeless hub for rotary wing aircraft. Also considered are: pilot simulation for BK117 FBW demonstrator, development of the B777, operational status of automated aircraft washing system, aircraft satellite communication system, satellite data link for oceanic ATC, space environment resistance of CFRP for use in space infrastructure, development of aircraft bonded structure and the NDI method, polymer matrix composite for fireproof panels, state of the art materials for future gas turbine engines, properties of superplastic 7475 Al alloy 'T5'. C.D.

A92-56080
WORKING TOGETHER IN THE DEVELOPMENT OF THE B777
H. HAYASHI (All Nippon Airways, Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 358-361. In Japanese.

The Boeing-777 integration system and the structure of the design build team both in the United States and in Japan for comanufacturing in 1996 are presented. Attention is given to the B777 steering committee. Y.P.Q.

A92-56083
AUTOMATIC FUNCTION TESTING IN THE AIRCRAFT PRODUCTION
HIROMICHI TAKEDA (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 370-373. In Japanese.

Introduction is presented of the helicopter's Automatic Function Tester that we developed recently as an example of automated function testing for aircraft. An overview of proceeding or future task of automating at function testing in the process of aircraft production is given. Author

A92-56085
CURRENT REPAIR TECHNOLOGIES FOR JET ENGINE COMPONENTS
SHOJU MASAKI (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 378-381. In Japanese.

The main jet engine maintenance and repairing methods are presented. The welding technology and thermal spring method are addressed, and cleaning methods for jet engine components, such as plastic blast, water jet, and ion cleaning, are discussed. Y.P.Q.

A92-56087
THE OPERATIONAL STATUS OF AUTOMATED AIRCRAFT WASHING SYSTEM
TOMOKATSU SOGA (Japan Airlines Co., Ltd., Tokyo) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 394-397. In Japanese.

The performance and configurations of an automated aircraft washing facility are presented. The brushing area, the operation time, and rinsing are controlled in this computerized washing system. Y.P.Q.

A92-56100
DEVELOPMENT OF AIRCRAFT BONDED STRUCTURE AND THE NDI METHOD
AKIRA YAMANASHI (Japan Airlines Co., Ltd., Tokyo) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 454-457. In Japanese.

Boeing aircraft bonded structures, such as aluminum honeycomb and glass fiber reinforced plastic honeycomb, are presented. The honeycomb bond inspection system is described, and the nondestructive inspection method is addressed. Y.P.Q.

A92-56221
FIELD TEST OF AN ADVANCED MAINTENANCE-SYSTEM
JOHN B. SCHROEDER, GARY M. SMITH (USAF, Wright Laboratory, Wright-Patterson AFB, OH), PAUL BURSCH, and JOHN W. MEISNER (Honeywell Systems and Research Center, Minneapolis, MN) IN: Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1992, p. 216-222. refs
Copyright

The Flight Control Maintenance Diagnostic System (FCMDS), a knowledge-based laboratory development that can serve as a prototype in addressing the common and persistent problems in the maintenance of military aircraft, has completed a preliminary field test. FCMDS was developed to test the theories that a range of maintenance technicians can effectively troubleshoot and repair complicated aircraft systems using a knowledge-based expert system and portable computer-aided tools. This system tested the ability of technicians to interact with the aircraft and use a portable maintenance aid to increase diagnostic accuracy and decrease the time necessary to make the repair. Results of the field test show enhanced levels of performance can be achieved at all technician levels by using a computer-aided maintenance system. The average fault isolation time was reduced 26 percent and diagnostic accuracy was improved by 92 percent over standard flight line practices. I.E.

A92-56277
REPAIR PROCEDURES FOR ADVANCED COMPOSITES FOR HELICOPTERS
HERMANN ESCHBAUMER (MBB GmbH, Munich, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 23 p. Previously announced in STAR as N92-29874.

Standard repair procedures and the various solutions determined for structural repairs are discussed. Repairs on load introduction areas and extensive damages were rated to require specific repairs and therefore assistance of stress design. Specific repairs are not discussed. Standard repairs applicable for primary and secondary structures are referred to. The difference between 'in hourse repairs', 'depot and on aircraft repairs', and 'field repairs' are clarified. Suitable nondestructive test techniques for nonstationary inspection are considered and aspects to transfer the required standard repair procedures to maintenance personnel are discussed. Author

A92-56299
THE EUROFAR PROGRAM - AN EUROPEAN OVERVIEW ON ADVANCED VTOL CIVIL TRANSPORTATION SYSTEM
J. RENAUD (Aerospatiale, Paris, France), H. HUBER (MBB GmbH, Ottobrunn, Germany), and G. VENN (Westland Helicopters, Ltd., Yeovil, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 10 p. refs

A summary is presented of several European overviews of three years of activity on the development of an advanced VTOL civil transportation system based on tilt-rotor (the Eurofar program). The vehicle requirements, the design process, the aircraft performance, and the technological innovations introduced during the development process are described. Special attention is given to the conditions for the acceptance of the tilt-rotor aircraft as a civil transportation vehicle, including the cost efficiency, the safety requirements, and the civil marketing issues involved in the transportation system introduction. I.S.

A92-56304
MODERN HELICOPTER TECHNOLOGIES AT MBB AND THE APPLICATION IN FUTURE PROGRAMMES
WERNER REINL (MBB GmbH, Munich, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 20 p. refs

The history of helicopter technologies in Germany is briefly reviewed, and current helicopter activities at MBB are discussed. Attention is given to the principal technology programs covering rotor technology, vibration suppression, advanced composite airframes, avionic/cockpits, and flight controls. Consideration is also given to the current status and future prospects of civilian and military helicopter projects, such as BO108, PAH2, NH90, and ALH. V.L.

A92-56306
ORGANIZATION AND TECHNICAL STATUS OF THE NH90 EUROPEAN HELICOPTER PROGRAMME
J. P. BARTHELEMY, R. D. VON RETH (NH Industries, Aix-en-Provence, France), and G. BEZIAC (Aerospatiale, Marignane, France) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 14 p. refs

Design considerations and mission profiles are described that guide the development of the NH90 European helicopter, and attention is given to the structure and results of the development. French, Italian, German, and Dutch contributions to the program are outlined, and the NH90 missions include those for tactical transport, frigate, and search and rescue types. General aircraft specifications are reported emphasizing dimensions and performance data. Two engines are expected to be used for the mission types that provide 1500 kW MCP in standard conditions, and advanced technologies are incorporated in the composite blades, modem hub, and the flight controls with higher harmonic control. Also presented are the general systems architecture, core-system avionics, the fly-by-wire control system, and tactical control subsystems. The NH90 family of helicopters is shown to provide good performance characteristics and high survivability for the proposed mission profiles. C.C.S.

A92-56327
TECHNOLOGY EXPLOITATION FOR IN-SERVICE SUPPORT OF FUTURE ROTORCRAFT
B. P. MERCER (RAF, Swanton Morley, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 9 p. Research supported by Ministry of Defence Procurement Executive, Stewart Hughes, Ltd., Westland Group, PLC, et al.

Advanced technology projects and technical demonstration programs (TDP) which are being examined by the Royal Air Force and the Defence Research Agency to increase the levels of supportability of their rotorcraft are reviewed. It is noted that advanced technology itself will not increase supportability, but through greater cooperation between industrial and military engineers designs will be influenced by the customer at the earliest stages of projects where the greatest cost savings can be made. The change in policy which has placed supportability alongside performance, time, and cost will be a permanent feature of future contracts. The ultimate aim of TDPs is to build a common understanding of in-service support problems and rectify them long before any prototype is developed. O.G.

A92-56736#
INTEGRATED TEST AND EVALUATION FOR HYPERVELOCITY SYSTEMS
KEITH L. KUSHMAN and MARK S. BRISKI (USAF, Arnold Engineering Development Center, Arnold AFB, TN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 10 p. refs
(AIAA PAPER 92-3901)

Test requirements for hypersonic systems are examined, and the concept of integrated test and evaluation is discussed. The concept is aimed at achieving early synergistic integration of modeling and ground and flight testing and is particularly applicable to hypervelocity systems. The benefit of integrated test and evaluation are reduced cost, time, and risk for system acquisition programs. Testing facilities implementing this approach are described. V.L.

N92-33176# Federal Aviation Administration, Washington, DC.
FEDERAL AVIATION REGULATIONS. PART 91: GENERAL OPERATING AND FLIGHT RULES
Feb. 1992 218 p
(PB92-197334) Avail: CASI HC A10/MF A03; SOD HC

Given here are general flight rules, visual flight rules, and instrument flight rules. Regulations are given covering special flight operations, aircraft maintenance, preventive maintenance, alterations, large and turbine-powered multiengine aircraft, additional equipment and operating requirements for large and transport category aircraft, foreign aircraft operations and operations of U.S. registered civil aircraft outside the United States, and operating noise limits and waivers. Author

N92-33499# RAND Corp., Santa Monica, CA.
DEVELOPING ROBUST SUPPORT STRUCTURES FOR HIGH-TECHNOLOGY SUBSYSTEMS: THE AH-64 APACHE HELICOPTER
MARC L. ROBBINS, MORTON B. BERMAN, DOUGLAS W. MCLVER, WILLIAM E. MOOZ, and JOHN F. SCHANK 1991 92 p
(Contract MDA903-91-C-0006)
(AD-A252773; RAND/R-3768-A) Avail: CASI HC A05/MF A01

The U.S. Army is relying more and more on high-technology weapons systems, which present a challenge for the logistics structure that must support them. Unlike the simpler weapons systems of the past, today's technologically sophisticated systems have components that are extremely expensive; in addition, maintaining today's systems is far more difficult, because diagnosing and repairing complex subsystem faults require sophisticated and expensive test and diagnostic equipment. And on top of all this, the uncertainties of war make forecasting demands for these expensive items highly problematic. These factors combine in ways that negate the value of preplanned inventory as a way to solve the demands for spares in changing environments. We believe that a more realistic solution to this challenge involves developing and evaluating alternative logistics structures whose more fundable resources-like transportation and repair-are used to respond to changing wartime demands. Using data on the high-technology subsystems of the AH-64 Apache attack helicopter, we hypothesize alternative logistics structures and assess their responsiveness in terms of cost effective improvements to weapon system availability under contingency scenarios. GRA

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A92-53547
AERODYNAMIC HEATING CHARACTERISTICS OF SPACE PLANES TESTED BY NAL HYPERSONIC WIND TUNNEL
YASUTOSHI INOUE, TADAO KOYAMA, AKIRA YOSHIZAWA, and KOUICHI HOZUMI (National Aerospace Laboratory, Chofu, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, AGNE Publishing, Inc., 1990, p. 707-712. refs
Copyright

Heat transfer rate distributions of space plane models have been experimentally investigated in Mach 7.1 hypersonic air flow with parametrically modified geometries. The characteristics of the distribution pattern and the peak heating values at the nose and at the leading edge are examined. The results show the predominant wing sweep angle effect on the leading edge peak heating and the outstanding differences in the distributions of the leeward surfaces based on flow separation and reattachment. C.D.

A92-53549
HYPERSONIC FLOWS WITH AIR CHEMISTRY OVER A REENTRY VEHICLE AT HIGH ALTITUDES
YOSHITAKA SAKAMURA (Kyushu University, Fukuoka, Japan), HITOSHI KAWABATA (Ishikawajima-Harima Heavy Industries, Co., Ltd., Engine Design Dept., Tanashi, Japan), and MICHIO NISHIDA (Kyushu University, Fukuoka, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, AGNE Publishing, Inc., 1990, p. 729-734. refs
Copyright

The governing equations for viscous shock layer flow with thermal and chemical nonequilibrium are numerically solved for the flight regimes of NASDA's reusable low-cost space transportation system HOPE. The equations are formulated for a multicomponent gas flow the thermal and chemical nonequilibrium. The results show that the temperature profile on the stagnation streamline is strongly affected by dissociation of air. The vibrational temperature tends to equilibrate with the translational-rotational temperature at lower altitudes. C.D.

A92-53552
RAREFIED GAS NUMERICAL WIND TUNNEL
KATSUHIKA KOURA (National Aerospace Laboratory, Chofu, Japan), EMI KANEMATSU, and YUKIKO KIMURA (Fujitsu, Ltd., Tokyo, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 747-752. refs
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The 'rarefied gas numerical wind tunnel' (RGNWT) is constructed on the National Aerospace Laboratory Numerical Simulator System for the simulation of rarefied gas flows around 2D or 3D flight bodies. The RGNWT consists of the simulation program universally described using the null-collision direct-simulation Monte Carlo method, which is very effective for 3D simulations, and the pre- and post-process programs for the collision-cell generation, the graphic display, etc. The computation domain is taken as a rectangular solid and divided into small rectangular-solid collision cells for the simulation of molecular collisions. The aerodynamic characteristics and flowfield properties

of a whole flight body are calculated and illustrated. Some results obtained using the RGNWT without real gas effects are presented for a 2D flat plate and circular cylinder and a 3D delta wing.
Author

A92-53553
THE BEHAVIOUR OF THE PRESSURE TEMPERATURE AND DENSITY IN AN INVISCID UNSTEADY TRANSONIC AXISYMMETRIC FLOW WITH SHOCK WAVES
CARLOS F. ESTRADA ALVES (Centro Tecnico Aeroespacial, Instituto de Atividades Espaciais, Sao Jose dos Campos, Brazil) and DEMETRIO BASTOS-NETTO (INPE, Sao Jose dos Campos, Brazil) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 753-758. refs

The thermodynamical properties in an inviscid, unsteady, transonic axisymmetric shocked flow of a perfect gas through an axisymmetric nozzle are described here using the method of asymptotic expansions for the velocity potential, pressure, temperature, and density. The governing equations are obtained assuming that a weak shock wave exists at a given location downstream of the throat and that disturbances exist at a given location downstream of the shock.
C.D.

A92-53555
EXPERIMENTAL AND NUMERICAL INVESTIGATION OF A SUPERSONIC FREE JET IMPINGING ON A PERPENDICULAR SURFACE
KOJI TESHIMA (Kyoto University of Education, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 765-770. refs

An experimental apparatus was developed for observation of the transport phenomena in liquid together with the interface phenomena during unidirectional solidification processes of transparent material. An incoherent moire interferometric technique, which eliminated wavefront deformation by the interference of two interferograms at different times, made it possible to visualize the temperature profile in liquid. A time-dependent temperature profile in liquid was taken, and the growth rate of the solid-liquid interface was measured. It was found that when supercooled liquid was solidified quickly, the temperature reversed layer appeared due to the released latent heat, which was conducted not only to the solid but also to the liquid. The effect of thermal convection in an unstable system was also observed.
Author

A92-53556
NUMERICAL STUDY ON THE SECONDARY JET INTO A SUPERSONIC FLOW
MASAHIRO TAKAHASHI and OICHI HAYASHI (Nagoya University, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 771-776. refs

A 2D sonic hydrogen jet transversely injected into a supersonic hot air flow is simulated numerically to understand the phenomena and mechanism of the mixing and combustion processes. The flowfield is governed by the 2D Raynolds-averaged full Navier-Stokes equations with an algebraic eddy viscosity model developed by Baldwin and Lomax. Chemical kinetics are described by 9 species and 19 elementary reactions of the full hydrogen-oxygen system assuming nitrogen is inert. The numerical results are compared with the 2D experiment to study a validity of the turbulence model and the chemical kinetics model. The influence of the oxygen concentration in the main flow is studied.
Author

A92-53557
EXPERIMENTAL INVESTIGATION ON TURBULENT PHENOMENA IN THREE-DIMENSIONAL SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTION INDUCED BY BLUNT FIN
SHIGERU ASO, SHIGEHIDE NAKAO (Kyushu University, Fukuoka, Japan), SEISHI KURANAGA (Mitsubishi Heavy Industries Co., Ltd., Nagoya, Japan), and MASANORI HAYASHI (Nishinippon Institute of Technology, Fukuoka, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 777-782. refs

Turbulent properties in the shock wave/turbulent boundary layer interaction induced by blunt fins with semicylindrical leading edge have been investigated. Flowfields are visualized by the Schlieren method and oil flow technique. Pressure fluctuations are measured in the whole interaction region in order to understand the phenomena and provide sufficient information for turbulent modeling. Distributions of standard deviations and higher moments of pressure fluctuations are also measured. Those properties show significant changes in the interaction region and quite interesting characteristics are observed. In the interaction region, intermittent phenomena due to the shock wave motion are observed. The results suggest that more sophisticated turbulent modeling is necessary to simulate the flowfield.
Author

A92-53558
NUMERICAL SIMULATIONS OF SHOCK REFLECTIONS BY A TVD SCHEME
SHIGERU ASO (Kyushu University, Fukuoka, Japan) and MASANORI TAKANO (Toyota Motor Co., Ltd., Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 783-788. refs

Shock reflection processes at a ramp are simulated here by solving thin-layer approximated Navier-Stokes equations using a TVD scheme in convective terms. Viscous effects in unsteady aerodynamic heating and weak Mach reflections are calculatively studied, and unsteady aerodynamic heating due to impingments of Mach stem and slip layers in shock-wave reflection at higher Mach numbers are numerically investigated. The results show good agreement with experiments. Mach reflections in lower Mach number ranges are calculated numerically, and significant changes of shock reflection patterns with Reynolds number are observed. The results show that viscous effects are quite important in weak shock reflections.
C.D.

A92-53559
NAVIER-STOKES SIMULATION FOR THE WINGED SPACE VEHICLE 'HOPE' AT SUBSONIC, TRANSONIC, AND SUPERSONIC REGIMES
MASAKAZU TACHIBANA, SUSUMU TAKANASHI (National Aerospace Laboratory, Tokyo, Japan), and TOSHIO AKIMOTO (NASDA, Tsukuba, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 789-797. refs

Numerical simulations of subsonic, transonic, and supersonic flows for a winged vehicle HOPE were carried out using the Navier-Stokes equations. Calculated force coefficients were in good agreement with experimental data except for axial force. Oil-flow patterns also agree well with each other except for the location of strong shock wave near the trailing edge of the wing.
C.D.

A92-53560
CALCULATIONS FOR AERODYNAMIC CHARACTERISTICS OF HOPE TYPE VEHICLE IN SUBSONIC AND HYPERSONIC FLOW
MITSUNORI YANAGIZAWA (Tokyo, University, Japan) and TOSHIO AKIMOTO (NASDA, Sakura, Japan) IN: International

Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 799-806. refs
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The aerodynamic characteristics of a HOPE type configuration are investigated using the panel method in the subsonic region and Newtonian impact theory in the hypersonic region. An analysis of the results obtained indicates that the panel method, considered for its effect on the leading-edge vortex, should be used for wings with a large sweptback angle. The calculation of attached flow is partially correct, but correct results are not obtained for the aerodynamic coefficient. The Newtonian theory is shown to give roughly correct aerodynamic characteristics. V.L.

A92-53561
A DOUBLE CHAOTIC ATTRACTOR IN TRANSONIC FLOW
TREVOR H. MOULDEN (Tennessee, University, Tullahoma) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 807-812. refs
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The low-dimensional model of the shock wave formation problem in transonic flow is examined. It is found, in particular, that the three-mode model has a rich structure which includes a double chaotic strange attractor. The properties of the attractor are discussed. The emphasis of the discussion is on the properties of the dynamical system established here, rather than the relationship of the system to the physical problem it models. V.L.

A92-53579
RADIATIVE HEAT TRANSFER FROM NONEQUILIBRIUM SHOCK LAYER TO A HYPERSONIC REENTRY BODY
XIN-YU CHANG, AKIHIRO SASOH, and TOSHI FUJIWARA (Nagoya, University, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 921-926. refs
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The hypersonic reentry of a space shuttle or similar vehicle into the atmosphere is analyzed with respect to the radiative heat transfer of the high-temperature shock layer to the vehicle surface. An axisymmetric blunt body is considered to be travelling at Mach 25 at 70 km through seven chemical species, and the flowfield is studied with Navier-Stokes equations from the two-temperature model by Park (1985). The results are substituted into NASA's NEQAIR code to calculate the radiation field with high spectral resolution. The radiative heating at the stagnation point is 3.5 W/sq cm as opposed to a smaller value given by a one-temperature model which does not allow for nonequilibrium thermal phenomena. Radiative heating is shown to be a key component of the heat transfer which is strongly correlated with temperature and number density. C.C.S.

A92-53580
THERMALLY AND CHEMICALLY NONEQUILIBRIUM HYPERSONIC FLOW IN THREE-DIMENSIONAL GEOMETRY
TOSHI MURAYAMA and TOSHI FUJIWARA (Nagoya University, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 927-932. refs
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The reentry of an axisymmetric space vehicle is analyzed with a one-temperature model and a two-temperature model incorporating the effects of both chemical and thermal nonequilibrium. The model includes the translational temperatures of heavy particles and the vibrational temperatures of molecules, and two sets of reactions/species are investigated. The first set comprises six reactions and seven species vs fifteen reactions and eleven species in the second model, and reentry runs are conducted for Mach 15, 20, and 25. Attention is given to the difference between the one- and two-temperature models, chemical reactions at different flight speeds, and the use of the different numbers of reaction/species. The model with more species can be used to treat the flows at Mach numbers 20 and 25, and the two-temperature model is found to be effective with this larger list of reactions/species. C.C.S.

A92-53641
AERODYNAMIC STUDIES ON SPACE PLANE CONFIGURATION AT HYPERSONIC SPEED
KOICHI HOZUMI, SHIGEYA WATANABE, and SHIGEAKI NOMURA (National Aerospace Laboratory, Chofu, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 2. Tokyo, AGNE Publishing, Inc., 1990, p. 1365-1376. refs
Copyright

The present analytical and experimental investigation of means for improving the aerodynamic configuration of an SSTO spaceplane proceeded by estimating the aerodynamic characteristics of configurations created by through changes of parametric variables. Ascent simulations were also conducted to estimate fuel requirements; the configuration thus defined was then subjected to force and moment measurement tests at the NAL hypersonic wind tunnel. The SSTO configuration thus defined is found to be superior to the initial baseline, with substantially greater L/D and trim characteristics. O.C.

A92-53867
INTERACTION BETWEEN A BODY FLYING AT A SUPERSONIC VELOCITY AND A POINT EXPLOSION [VZAIMODEISTVIE LETIASHCHEGO SO SVERKHZVUKOVOI SKOROST'IU TELA S TOCHECHNYM VZRYVOM]
V. P. GOLOVIZNIN and I. V. KRASOVSKAIA (Rossiiskaia Akademiia Nauk, Fiziko-Tekhnicheskii Institut, St. Petersburg, Russia) Zhurnal Tekhnicheskoi Fiziki (ISSN 0044-4642), vol. 61, no. 12, Dec. 1991, p. 12-16. In Russian. refs
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The problem of the interaction of a blunt body traveling at a supersonic velocity and a spherical detonation wave is investigated using numerical modeling. Attention is given to the evolution of flow near the body, and data are obtained on changes in the structure of the shock layer as a function of the gasdynamic parameters of the detonation wave. It is shown, in particular, that the front of the head shock extends forward as the body penetrates the point explosion zone, and the shock wave degenerates into a Mach wave. V.L.

A92-53882
PULSATION CHARACTERISTICS OF ONE-PHASE AND TWO-PHASE STEAM FLOWS IN LAVAL NOZZLES UNDER OFF-DESIGN CONDITIONS [PUL'SATSIONNYE KHARAKTERISTIKI ODNOFAZNOGO I DVUKHFAZNOGO POTOKOV PARA V SOPLAKH LAVALIA NA NERASCHETNYKH REZHIMAKH]
M. E. DEICH, M. IU. OSHCHEPKOV, A. A. TISHCHENKO, and SH. KH. AL'-DZHANABI Rossiiskaia Akademiia Nauk, Izvestiia, Energetika (ISSN 0002-3310), no. 2, Mar.-Apr. 1992, p. 104-128. In Russian. refs
Copyright

A study is made of transonic flow of superheated saturated and wet steam in four plane Laval nozzles with different profiles of the subsonic and supersonic sections. The results confirm the effect of wall turbulence decay in the critical section of the nozzle. It is shown that the use of an extended subsonic section makes it possible to achieve flow laminarization up to an initial humidity of 12 percent. It is also shown that the longitudinal gradient in the supersonic nozzle section has a substantial effect on pressure pulsations excited by the interaction between stationary condensation and adiabatic discontinuities with the boundary layer. V.L.

A92-53997
EXPERIMENTAL STUDY ON THREE-DIMENSIONAL SHOCK WAVE-TURBULENT BOUNDARY LAYER INTERACTION INDUCED BY PROTUBERANCE

SHIGERU ASO, SYOZO MAEKAWA, SHIGEHIDE NAKAO, KAZUO ARASHI, KENJI TOMIOKA, and HIROYUKI YAMAO Kyushu University, Technology Reports (ISSN 0023-2718), vol. 65, no. 3, June 1992, p. 253-260. In Japanese. refs

Three-dimensional shock wave/turbulent boundary layer interaction region induced by protuberance is experimentally investigated. The structure of the flowfield is studied with the oil-flow technique and surface-pressure measurements. A flat plate model is installed in a supersonic wind tunnel and a fully developed turbulent boundary layer is obtained on the plate. A conventional shape of protuberance is selected and set on the plate. Three models with similar form and different sizes are used in order to investigate the effect of the height of the model on the interaction region for the same incoming boundary layer. The oil flow pictures show the quite complicated separated flows in the interaction region. The extent of separated region is investigated carefully. The results show that the height of protuberance is the primary scale factor of the flowfields, although detailed pressure distributions change significantly due to the height of the protuberance. Author

A92-53998
AERODYNAMIC AIRFOILS DESIGN BY QUASI-SOLUTIONS METHOD OF INVERSE BOUNDARY-VALUE PROBLEMS
A. M. ELIZAROV, N. B. IL'INSKII, and A. V. POTASHEV (Kazan State University, Russia) Advances in Mechanics - Uspekhi Mekhaniki (ISSN 0137-3722), vol. 14, no. 2, 1991, p. 49-91. refs Copyright

This report presents and reviews new results on the solution of inverse boundary value problems (IBVP) of aerodynamic/hydrodynamics. The principal point of those problems is the determination of the shape of an airfoil, either isolated or as an element of a cascade, when a pressure or velocity distribution providing reasonable velocity aerodynamic/hydrodynamic characteristics of the airfoil surface is given. A major part of the studies involving the IBVP solution is based on the ideal incompressible liquid model. R.E.P.

A92-54003*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THREE-DIMENSIONAL NAVIER-STOKES HEAT TRANSFER PREDICTIONS FOR TURBINE BLADE ROWS
R. J. BOYLE (NASA, Lewis Research Center, Cleveland, OH) and P. W. GIEL (Sverdrup Technology, Inc.; NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 15 p. refs
(AIAA PAPER 92-3068)

Results are shown for a three-dimensional Navier-Stokes analysis of both the flow and the surface heat transfer for turbine applications. Heat transfer comparisons are made with the experimental shock-tunnel data of Dunn and Kim, and with the data of Blair for the rotor of the large scale rotating turbine. The analysis was done using the steady-state, three-dimensional, thin-layer Navier-Stokes code developed by Chima, which uses a multistage Runge-Kutta scheme with implicit residual smoothing. An algebraic mixing length turbulence model is used to calculate turbulent eddy viscosity. The variation in heat transfer due to variations in grid parameters is examined. The effects of rotation, tip clearance, and inlet boundary layer thickness variation on the predicted blade and endwall heat transfer are examined. Author

A92-54004*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A COMPARISON OF THE CALCULATED AND EXPERIMENTAL OFF-DESIGN PERFORMANCE OF A RADIAL FLOW TURBINE
LIZET TIRRES (Sverdrup Technology, Inc., Brook Park, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 15 p. Previously announced in STAR as N92-29402. refs
(Contract NAS3-25266)
(AIAA PAPER 92-3069)

Off design aerodynamic performance of the solid version of a cooled radial inflow turbine is analyzed. Rotor surface static pressure data and other performance parameters were obtained experimentally. Overall stage performance and turbine blade surface static to inlet total pressure ratios were calculated by using a quasi-three dimensional inviscid code. The off design prediction capability of this code for radial inflow turbines shows accurate static pressure prediction. Solutions show a difference of 3 to 5 points between the experimentally obtained efficiencies and the calculated values. Author

A92-54005*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INCREASED HEAT TRANSFER TO ELLIPTICAL LEADING EDGES DUE TO SPANWISE VARIATIONS IN THE FREESTREAM MOMENTUM - NUMERICAL AND EXPERIMENTAL RESULTS
D. L. RIGBY (Sverdrup Technology, Inc., Brook Park, OH) and G. J. VAN FOSSEN (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 12 p. refs
(AIAA PAPER 92-3070)

A study of the effect of spanwise variation on leading edge heat transfer is presented. Experimental and numerical results are given for a circular leading edge and for a 3:1 elliptical leading edge. It is demonstrated that increases in leading edge heat transfer due to spanwise variations in freestream momentum are comparable to those due to freestream turbulence. R.E.P.

A92-54012*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FULL NAVIER-STOKES CALCULATIONS ON THE INSTALLED F/A-18 INLET AT A HIGH ANGLE OF ATTACK
JAMES E. BRUNS and C. F. SMITH (Sverdrup Technology, Inc., Brook Park, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 24 p. refs
(Contract NAS3-25266)
(AIAA PAPER 92-3175)

Major objectives of the NASA High-Alpha Technology Program are the accurate prediction of the internal (inlet) aerodynamics of an aircraft operating at attitudes of up to 60 deg pitch and 10 deg yaw and the calibration of CFD codes for predicting the internal performance of inlets. Numerical results are presented for the three cases of a full-scale model, a 20-percent scale model at design mass flow, and a scale model at reduced mass flow; attention is given to the effects of Reynolds number. All three cases are at 30 deg angle of attack and zero deg yaw. The results thus obtained are helpful to experimentalists in determining some of their instrumentation requirements. O.C.

A92-54013*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
APPLICATION OF COMPUTATIONAL FLUID DYNAMICS TO THE STUDY OF VORTEX FLOW CONTROL FOR THE MANAGEMENT OF INLET DISTORTION
BERNHARD H. ANDERSON (NASA, Lewis Research Center, Cleveland, OH) and JAMES GIBB (Defence Research Agency, Bedford, United Kingdom) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 11 p. refs
(AIAA PAPER 92-3177) Copyright

A study is presented to demonstrate that the Reduced Navier-Stokes code RNS3D can be employed effectively to develop a vortex generator installation that minimizes engine face circumferential distortion by controlling the development of secondary flow. The necessary computing times are small enough to show that similar studies are feasible within an analysis-design environment with all its constraints of costs and time. This study establishes the nature of the performance enhancements that can be realized with vortex flow control, and indicates a set of aerodynamic properties that can be utilized to arrive at a successful vortex generator installation design. R.E.P.

A92-54016*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NAVIER-STOKES ANALYSIS OF THREE-DIMENSIONAL UNSTEADY FLOWS INSIDE TURBINE STAGES
C. HAH (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 10 p. refs
(AIAA PAPER 92-3211)

This study presents a numerical method for solving the 3D Navier-Stokes equations for unsteady, viscous flow through multiple turbomachinery blade rows. The method solves the fully 3D Navier-Stokes equations with an implicit scheme which is based on a control volume approach. A two-equation turbulence model with a low Reynolds number modification is employed. A third-order accurate upwinding scheme is used to approximate convection terms, while a second order accurate central difference scheme is used for the discretization of viscous terms. A second-order accurate scheme is employed for the temporal discretization. The numerical method is applied to study the unsteady flowfield of the High Pressure Fuel side Turbo-Pump (HPFTP) of the Space Shuttle Main Engine (SSME). The stage calculation is performed by coupling the stator and the rotor flowfields at each time step through an over-laid grid. Numerical results for the complete geometry with the vane trailing edge cutback are presented and compared with the available experimental data. Author

A92-54090*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN EXPERIMENTAL INVESTIGATION OF THE FLOW IN A DIFFUSING S-DUCT
S. R. WELLBORN (Iowa State University of Science and Technology, Ames), B. A. REICHERT (NASA, Lewis Research Center, Cleveland, OH), and T. H. OKIISHI (Iowa State University of Science and Technology, Ames) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 12 p. refs
(Contract NAG3-1275)
(AIAA PAPER 92-3622) Copyright

Compressible, subsonic flow through a diffusing S-duct has been experimentally investigated. Benchmark aerodynamic data are presented for flow through a representative S-duct configuration. The collected data would be beneficial to aircraft inlet designers and is suitable for the validation of computational codes. Measurements of the 3D velocity field and total and static pressures were obtained at five cross-sectional planes. Surface static pressures and flow visualization also helped to reveal flowfield characteristics. All reported tests were conducted with an inlet centerline Mach number of 0.6 and a Reynolds number, based on the inlet centerline velocity and duct inlet diameter, of 2.6 x 10 exp 6. The results show that a large region of streamwise flow separation occurred within the duct. Transverse velocity components indicate that the duct curvature induces strong pressure driven secondary flows, which evolve into a large pair of counter-rotating vortices. These vortices convect the low momentum fluid of the boundary layer toward the center of the duct, degrading both the uniformity and magnitude of the total pressure profile. Author

A92-54091#
RESULTS OF A PERTURBATION ANALYSIS CORRELATING FLOWS ENTERING AND EXITING AN AIRCRAFT INLET SYSTEM
P. G. KELLY (Sverdrup Technology, Inc., Arnold AFB, TN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 10 p. refs
(AIAA PAPER 92-3624)

The use of parameters measured at a certain inlet reference plane (IRP) is considered for controlling flight simulations in ground tests of inlet/engine compatibility. The analysis utilizes an F-15 inlet model and varied flow conditions at the inlet entrance to determine the performance sensitivity of the model. The IRP is defined by means of the angle of attack, sideslip angle, and Mach number, and inlet performance is measured by means of the inlet total pressure recovery. The perturbation analysis is based on multivariable least-squares regression, and the results indicate that some IRP parameters do not affect inlet pressure recovery over some of the ranges. This lack of sensitivity suggests that pressure recovery is not a satisfactory characterization of the sensitivity of inlet performance. Parameters describing total pressure distortion can be incorporated into the analysis to accurately study inlet sensitivity to changes at the IRP. C.C.S.

A92-54092#
MACH 3 WIND TUNNEL TEST OF MIXED COMPRESSION SUPERSONIC INLET
AKIRA MURAKAMI, RYOJI YANAGI, SHIGEMI SHINDO, KIMIO SAKATA (National Aerospace Laboratory, Tokyo, Japan), SHINJI HONAMI (Tokyo, Science University, Japan), ATSUSHIGE TANAKA, and KAZUO SHIRAISHI (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 7 p. Research supported by Agency of Industrial Science and Technology and New Energy and Industrial Technology Development Organization. refs
(AIAA PAPER 92-3625) Copyright

Two supersonic inlet models, designed in a 2D mixed compression configuration with a multishock system, were tested in a Mach 4 supersonic wind tunnel at the National Aerospace Laboratory in Japan. The first model was a fixed geometry with an 8-shock system, and the second one was a variable geometry with a 5-shock system and isentropic compression surfaces. The design Mach number for both models was 3. Pressure measurements and flow visualization, applying Schlieren method, oil-flow and vapor screen techniques, were conducted in the tests. Pressure recovery performance, stability of the shock associated flows, and the basic feature of the internal flows were investigated. Importance of establishing the shock systems and eliminating the shock-induced boundary layer separations were notified for the aerodynamic performance of the model from the test results. A consideration for the passage design of subsonic diffusers was also discussed. Author

A92-54110*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HEAT TRANSFER MEASUREMENTS AND CFD COMPARISON OF SWEPT SHOCK WAVE/BOUNDARY-LAYER INTERACTIONS
Y. LEE, G. S. SETTLES (Pennsylvania State University, University Park), and C. C. HORSTMAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 12 p. refs
(Contract NAG2-592)
(AIAA PAPER 92-3665) Copyright

An experimental research program providing basic knowledge and establishing new data on the heat transfer in swept shock wave/boundary-layer interactions is described. An equilibrium turbulent boundary-layer on a flat plate is subjected to impingement by swept planar shock waves generated by a sharp fin. Five different interactions with fin angles ranging from 10 to 20 deg at freestream Mach numbers of 3.0 and 4.0 produce a variety of interaction strengths from weak to very strong. A foil heater generates a uniform heat flux over the flat plate surface and miniature thin-film-resistance sensors mounted on it are used to measure the local surface temperature. The heat convection equation is then solved for the heat transfer distribution within an interaction, yielding a total uncertainty of about +/- 10 percent. These experimental data are compared with the results of numerical Navier-Stokes solutions which employ a kappa-epsilon turbulence model. Finally, a simplified form of the peak heat transfer correlation for fin interactions is suggested. Author

A92-54111*# National Aeronautics and Space Administration, Washington, DC.
AN EXPERIMENTAL EXAMINATION OF THE EFFECTS OF INCOMING BOUNDARY LAYER MODIFICATIONS ON THE DYNAMICS OF A TURBULENT COMPRESSION CORNER INTERACTION
W. B. MCCLURE and D. S. DOLLING (Texas, University, Austin) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 15 p. refs
(Contract NAGW-964; DAAL03-91-G-0023)
(AIAA PAPER 92-3667) Copyright

This experimental study examines the effects of modifications to the incoming turbulent boundary layer on the highly separated shock wave/boundary layer interaction generated by an unswept compression corner. Particular focus is placed on the motion of the unsteady separation shock wave. The flowfield was generated by a 28 deg ramp in a Mach 5 flow with a freestream Reynolds number of 50 x 10 exp 6/m. The incoming turbulent boundary layer transitioned naturally and developed under near-adiabatic wall conditions. Modification of the flow entering the interaction was effected through either a single plate boundary layer manipulator (BLM) or riblets. The BLM reduced the length of separation by 35-45 percent and reduced the streamwise extent of the separation shock motion by 36-74 percent. Examination of the flowfield downstream of the BLM showed this result to be due to the inviscid preturning of the flow by the BLM, and not by changes to the boundary layer dynamics. The riblets had no measurable effect on the compression corner interaction. Author

A92-54113#
STRUCTURE OF CROSSING-SHOCK WAVE/TURBULENT BOUNDARY-LAYER INTERACTIONS
T. J. GARRISON, G. S. SETTLES (Pennsylvania State University, University Park), N. NARAYANSWAMI, and D. D. KNIGHT (Rutgers University, Piscataway, NJ) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 13 p. refs
(Contract AF-AFOSR-89-0315; AF-AFOSR-86-0266)
(AIAA PAPER 92-3670) Copyright

A detailed comparison of experimental and computational results on the flowfield structure of a Mach 4, 15 degree symmetric crossing-shock wave/turbulent boundary layer interaction is presented. Experimentally obtained Planar Laser Scattering images are compared with static pressure contours predicted by the computation, with the computational results showing good overall agreement with the experimental data. The experimental and computational results are used in a complementary manner to develop a detailed flowfield model of the crossing shock interaction. The flowfield structure is found to consist of a complex shock structure overlying a large viscous separated region. This region occupies a significant portion of the outflow duct and consists of an accumulation of low-Mach-number, low-stagnation-pressure fluid. This region may have significant implications for sidewall compression inlets. Author

A92-54116#
OPTIMIZATION OF A 2D SCRAMJET-VEHICLE USING CFD AND SIMPLIFIED APPROXIMATE FLOW ANALYSIS TECHNIQUES
PETER D. MCQUADE, SCOTT EBERHARDT, and ELI LIVNE (Washington, University, Seattle) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 16 p. refs
(AIAA PAPER 92-3673) Copyright

A direct numerical optimization methodology combining nonlinear programming and approximation concepts is studied in the context of CFD based engine/airframe integration. It aims at reducing the number of full CFD analyses required in the course of optimization, by replacing the original optimization problem by a set of approximate problems, thus reducing computational cost considerably. The performance of Global Local Approximations is tested and compared to that of a more common first-order Taylor series approximation. These approximations are obtained with alternative simplified aerodynamic analysis techniques corrected by CFD computations. A 2D NASP-like configuration serves as a test case. In this paper the basic procedure is reviewed and results based on optimization studies of the nozzle and forebody are presented. Problems associated with the application of Global-Local Approximations to CFD based optimization are discussed and some solutions and insights are provided. Author

A92-54117*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPARISON OF TURBULENCE MODELS FOR POWERED-LIFT FLOW FIELDS
DONALD W. ROBERTS and SCOTT T. IMLAY (Amtec Engineering, Inc., Bellevue, WA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 13 p. refs
(Contract NAS2-13357)
(AIAA PAPER 92-3674) Copyright

The development of a practical turbulence model for the complex flows with strong streamline curvature associated with powered-lift aircraft was investigated. The approach was to modify existing models that were compatible with the widely used kappa-epsilon model already available in an existing 3D Navier-Stokes code. The state-of-the-art of current turbulence models was examined. Several models that provide curvature corrections to the kappa-epsilon model were numerically investigated. An algebraic Reynolds stress model, which provides additional physics, was also examined. Test cases including an impinging jet, an impinging jet in a crossflow, and two adjacent impinging jets with the resultant upwash fountain were calculated. The first two test cases could be modeled reasonsbly well with some of the models. The upwash fountain could not be modeled with sufficient accuracy, which is consistent with the findings of other investigators. Author

A92-54118#
NUMERICAL STUDY OF THE 3-D FLOWFIELD FOR A SUPERSONIC JET EXITING INTO A HYPERSONIC STREAM FROM A CONICAL SURFACE
R. P. ROGER and S. C. CHAN (Teledyne Brown Engineering, Huntsville, AL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 12 p. Research supported by U.S. Army. refs
(AIAA PAPER 92-3675) Copyright

Steady-state CFD analyses are being performed to determine the angle of attack dependence for the extent of the recirculation region upstream of a lateral c.g. thruster on conical terminal stage hypersonic interceptors. Initially comparisons are being made to wind tunnel data to determine the optimum computational grid and to isolate possible turbulence model effects. A triconic configuration for which Schlieren and shadowgraph photographs, surface pressure measurements, and force and moment data are available was chosen for this calibration part of the study. Preliminary results show that proper grid resolution of the separated region upstream of the thruster is critical to obtaining predictions which closely match test measurements. Symmetry plane computations have been performed which necessitated the use of close to 2M computational grid points. Author

A92-54160#
NUMERICAL CALCULATIONS OF PROPFAN/SWIRL RECOVERY VANE FLOW FIELD
O. YAMAMOTO (Sverdrup Technology, Inc., Brook Park, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 9 p. refs
(AIAA PAPER 92-3771) Copyright

The inviscid flowfield of a propfan/swirl-recovery vane is presently computed by means of a 3D Euler code for multiblade-row turbomachinery. Good agreement is obtained between these numerical predictions and experimental measurements; in addition, flow-related information obtained by this numerical scheme is used to conduct detailed analyses of blade surface pressures and both

rotor blade and swirl-recovery vane wakes. The presence of the swirl-recovery vane is shown to have little effect on rotor performance. O.C.

A92-54161*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
UNSTEADY BLADE PRESSURES ON A PROPFAN - PREDICTED AND MEASURED COMPRESSIBILITY EFFECTS
M. NALLASAMY (Sverdrup Technology, Inc., Brook Park; NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 15 p. refs
(Contract NAS3-25266)
(AIAA PAPER 92-3774)

The effect of compressibility on unsteady blade pressures is studied by solving the 3D Euler equations. The operation of the eight-bladed SR7L propfan at 4.75 deg angle of attack was considered. Euler solutions were obtained for three Mach numbers, 0.6, 0.7, and 0.8 and the predicted blade pressure waveforms were compared with flight data. In general, the effect of Mach number on pressure waveforms are correctly predicted. The change in pressure waveforms are minimal when the Mach number is increased from 0.6 to 0.7. Increasing the Mach number from 0.7 to 0.8 produces significant changes in predicted pressure levels. The predicted amplitudes, however, differ from measurements at some transducer locations. Also the predicted appearance of a shock in the highly loaded portion of the blade revolution is not indicated by the measurements. At all the three Mach numbers, the measured (installed propfan) pressure waveforms show a relative phase lag compared to the computed (propfan alone) waveforms due to installation effects. Measured waveforms in the blade tip region show nonlinear variations which are not captured by the present numerical procedure. Author

A92-54179*# National Aeronautics and Space Administration, Washington, DC.
COMPARISON BETWEEN COMPUTATIONAL AND EXPERIMENTAL DATA FOR A HYPERSONIC LASER PROPELLED VEHICLE
D. G. MESSITT, P. C. DALLEMAGNE, L. N. MYRABO, and H. T. NAGAMATSU (Rensselaer Polytechnic Institute, Troy, NY) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 11 p. Research supported by NASA. refs
(AIAA PAPER 92-3808) Copyright

A 3-D axisymmetric hypersonic engine inlet was investigated using PARC2D, an ideal gas Computational Fluid Dynamics code. The code was used to predict the results of tests conducted in the Rensselaer Polytechnic Institute Hypersonic Shock Tunnel which measured surface and pitot pressures, and shock positions (through Schlieren photography) at freestream Mach numbers of 10, 13, and 15. A strong viscous/shock interaction was observed in both the experiment and the CFD results, due to the model's parabolic compression ramp. Good agreement was found between the experimental results and the CFD solution both for surface pressures and shock positions. Agreement between pitot pressures was less reliable. Author

A92-54308
DETECTING 3-D, TURBULENT SEPARATION REGIONS USING UNSTEADY COMPUTERIZED THERMOGRAPHIC TECHNIQUE
RODOLFO MONTI and GENNARO ZUPPARDI (Napoli, Universita, Naples, Italy) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 49-59. refs
Copyright

Flow separation regions were detected in incompressible low-Reynolds-number turbulent 3D flows via the implementation of an unsteady computerized thermographic technique. The technique takes advantage of the dependence of the heat transfer coefficient on the flow conditions on the body surface. The experimental equipment consists of a thermocamera, an A/D converter, and a personal computer. Tests were performed both on a bluff cylinder and a hemisphere cylinder. The bluff cylinder was tested in axisymmetric flow at Reynolds numbers ranging from 61,000 to 86,000. Tests on a hemisphere cylinder in axisymmetric flow compare well with theoretical data. Tests on a bluff cylinder in axisymmetric flow compare well with experimental data. P.D.

A92-54489
UNSTEADY SHOCK PROPAGATION IN A STEADY FLOW NOZZLE EXPANSION
R. J. STALKER (Queensland, University, Brisbane, Australia) and N. R. MUDFORD (Australian National University, Canberra, Australia) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 241, Aug. 1992, p. 525-548. Research supported by Australian Research Grants Scheme. refs
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The flowfield produced when a strong shock wave propagates into a steady flow expansion was investigated numerically, analytically, and experimentally, with experiments conducted in a shock tube modified to allow steady flow to be established in a hypersonic nozzle prior to the arrival of the shock. Results show that the prior steady flow allows the starting shock system to propagate through the nozzle at nearly the same velocity as the incident primary shock, therefore providing a convenient method of ensuring rapid steady flow initiation on shock tunnel nozzles. It is shown that the flow behavior can be understood in terms of two approximate models. The first is applicable to a wide range of flow conditions, allowing calculations of the trajectory of the center of mass of the starting shock system; the second is applicable to cases involving a prior steady flow, and is able of predicting detailed features of the flow structure. I.S.

A92-54498
THREE-DIMENSIONAL CALCULATION OF RADIATIVE FIELD IN HYPERSONIC AIR SHOCK LAYERS
AKIHIRO SASOH, XIN-YU CHANG, TOSHIYUKI MURAYAMA, and TOSHI FUJIWARA (Nagoya University, Japan) Nagoya University, Faculty of Engineering, Memoirs (ISSN 0027-7657), vol. 43, no. 2, 1991, p. 179-224. refs

The method of numerical calculation of three-dimensional radiative transfer from nonequilibrium air shock layers over a body is presented with some reviews on radiative transfer and molecular physics. A numerical technique, which reduces the necessitating memory size of a computational resource, thereby enabling one to conduct three-dimensional calculation, has been developed. This method is applied to radiative heat transfer problems under a reentry condition. The radiative structure of the hypersonic air shock layer generated around a body is closely related to the thermally nonequilibrium structure of the shock layer. A radiative heat transfer which is comparable with the convective one is calculated at such a high Mach number as 35 at an altitude 70 km. This result suggests the importance of radiative heat transfer in thermal design of a reentry vehicle. Author

A92-54569
EXPERIMENTAL INVESTIGATION OF THE REFLECTION OF A SHOCK WAVE ON A HEATED SURFACE IN PRESENCE OF A TURBULENT BOUNDARY LAYER
JEAN DELERY (ONERA, Chatillon, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 1, 1992, p. 1-23. Research supported by DRET. refs
Copyright

The aim of the present study was to investigate the properties of the interaction between a plane oblique shock wave and a turbulent boundary layer developing on a strongly heated wall. The experiments were carried out on a planar two-dimensional test arrangement for an upstream Mach number equal to 2.4. Two intensities of the incident shock wave were considered, the first corresponding to incipient separation conditions and the second to the formation of an extensive separated region. Each interaction was investigated for the adiabatic case and for a wall raised to temperature twice as high as the recovery temperature.

Measurements include a large number of surveys using static pressure and stagnation temperature probes, as well as two-component Laser Doppler Velocimetry. The results obtained have shown that wall heating strongly influences the interaction, by causing a marked dilatation of the interaction domain. The observed tendencies are in agreement with the well known influence of wall cooling where the contrary occurs - the interaction region shrinks. Author

A92-54571
EFFICIENT METHODS FOR INVISCID NON-EQUILIBRIUM HYPERSONIC FLOW FIELDS
M. C. CICCOLI, L. FEZOUI, and J. A. DESIDERI (INRIA, Valbonne, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 1, 1992, p. 37-52. refs
Copyright

Different methods are used for simulating steady, inviscid, nonequilibrium reactive flows governed by the Euler equations. The approximations employed are based on a conservative mixed finite-volume/finite-element formulation. The aim of the study is to improve the covergence rate of the iterative time integration. Variants of the implicit scheme (semiimplicit and fully implicit) are compared with another algorithm of the type of Newton's method which directly discretizes the stationary system. Special attention is paid to the update of the temperature in the solution of the species convection equation. Several computations of external blunt-body hypersonic flows have demonstrated the robustness and efficiency of the implicit scheme even when the Mach number is large or when the global Damkohler number is varied. Author

A92-54905* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ASSESSMENT OF COMPRESSIBILITY CORRECTIONS TO THE K-EPSILON MODEL IN HIGH-SPEED SHEAR LAYERS
JOHN R. VIEGAS and MORRIS W. RUBESIN (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2369, 2370. Previously cited in issue 17, p. 2859, Accession no. A91-42590. refs
Copyright

A92-54906* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLOWFIELD OF A LIFTING ROTOR IN HOVER - A NAVIER-STOKES SIMULATION
G. R. SRINIVASAN (NASA, Ames Research Center, Moffett Field; JAI Associates, Inc., Mountain View, CA), J. D. BAEDER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), S. OBAYASHI (NASA, Ames Research Center, Moffett Field; MCAT Institute, San Jose, CA), and W. J. MCCROSKEY (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2371-2378. Previously announced in STAR as N91-15128. refs
(Contract DAAL03-88-C-0006; DAAL03-90-C-0013)
Copyright

The viscous, three-dimensional flowfield of a lifting helicopter rotor in hover is calculated by using an upwind, implicit, finite-difference numerical method for solving the thin layer Navier-Stokes equations. The induced effects of the wake, including the interaction of tip vortices with successive blades, are calculated as part off the overall flowfield solution without using any ad hoc wake models. Comparison of the numerical results for the subsonic and transonic conditions show good agreement with the experimental data and with the previously published Navier-Stokes calculations using a simple wake model. Some comparisons with Euler calculations are also presented, along with some discussions of the grid refinement studies. Author

A92-54910
LINEAR STABILITY OF SUPERSONIC CONE BOUNDARY LAYERS
GREG STUCKERT and HELEN REED (Arizona State University, Tempe) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2402-2410. Research supported by NSF and General Dynamics Corp. refs
(Contract F49620-88-C-0076)
Copyright

The effect of the variable surface geometry of a cone on the linear stability of a supersonic boundary layer flowing over it is investigated subject to different quasiparallel flow approximations. It is shown that, if a suitable set of disturbance state variables is chosen for the normal mode analysis, these effects can accurately be accounted for. In fact, a planar coordinate system can be used for the stability analysis of the cone boundary-layer profiles and a simple 'correction' can subsequently be applied to obtain an accurate approximation to the spatial growth rates. Author

A92-54911* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
METHODOLOGY FOR CALCULATING AERODYNAMIC SENSITIVITY DERIVATIVES
ARTHUR C. TAYLOR, III, GENE W. HOU, and VAMSHI M. KORIVI (Old Dominion University, Norfolk, VA) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2411-2419. Previously cited in issue 12, p. 1904, Accession no. A91-31880. refs
(Contract NSF DMC-86-57917; NAG1-1265)
Copyright

A92-54914
NUMERICAL SIMULATION OF SLOT INJECTION INTO A TURBULENT SUPERSONIC STREAM
DONALD P. RIZETTA (USAF, Wright Laboratory, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2434-2439. Research supported by USAF. Previously cited in issue 11, p. 1718, Accession no. A92-29595. refs

A92-54916* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF A PARALLEL DIRECT SIMULATION MONTE CARLO METHOD TO HYPERSONIC RAREFIED FLOWS
RICHARD G. WILMOTH (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2447-2452. Previously cited in issue 06, p. 803, Accession no. A91-19461. refs
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A92-54918
REDUCTION OF THE SIDE FORCE ON POINTED FOREBODIES THROUGH ADD-ON TIP DEVICES
V. J. MODI, C. W. CHENG, A. MAK (British Columbia, University, Vancouver, Canada), and T. YOKOMIZO (Kanto Gakuin University, Kanagawa, Japan) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2462-2468. Previously cited in issue 21, p. 3285, Accession no. A90-45854. refs
(Contract NSERC-A-2181)
Copyright

A92-54919* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ANALYSIS OF THE ONSET OF DYNAMIC STALL
JEFFREY M. CURRIER and K.-Y. FUNG (Arizona, University, Tucson) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2469-2477. Research supported by National Cheng Kung University, University of Arizona, and NASA. Previously cited in issue 06, p. 794, Accession no. A91-19102. refs
(Contract AF-AFOSR-88-0163)
Copyright

A92-54922* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VORTICAL FLOW COMPUTATIONS ON A FLEXIBLE BLENDED WING-BODY CONFIGURATION
GURU P. GURUSWAMY (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2497-2503. Previously cited in issue 12, p. 1904, Accession no. A91-31903. refs
Copyright

A92-54933
EFFICIENT ITERATIVE METHODS FOR THE TRANSONIC SMALL DISTURBANCE EQUATION
A. S. LYRINTZIS, A. M. WISSINK, and A. T. CHRONOPOULOS (Minnesota, University, Minneapolis) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2556-2558. Research supported by Minnesota Supercomputing Institute and U.S. Army. refs
Copyright

A new and efficient algorithm for the solution of the 2D transonic small disturbance equation is introduced. The algorithm uses Newton's method to solve the nonlinear system of equations resulting from the discretization using finite differences. An efficient iterative linear solver is used for the solution of the sparse linear system of equations in each Newton step. The proposed algorithm is compared with a traditionally used approximate factorization algorithm with monotone switches. The results show 2.1 and 4.5 speedups for various cases and mesh sizes. These speedups are expected to be higher in very large systems. The results justify the availability of the algorithm, whose concept can be extended for different switches and more complex flow models and configurations. C.D.

A92-54935
GRID STUDIES FOR THIN-LAYER NAVIER-STOKES COMPUTATIONS OF AIRFOIL FLOWFIELDS
D. W. ZINGG (Toronto, University, Canada) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2561-2564. Previously cited in issue 08, p. 1169, Accession no. A92-23794. refs
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A92-54936
EFFECT OF STREAMWISE PRESSURE GRADIENT ON THE SUPERSONIC MIXING LAYER
TAKASHI ABE, KATSUSHI FUNABIKI (Institute of Space and Astronautical Science, Sagamihara, Japan), HIRONOBU ARIGA (Musashi Institute of Technology, Tokyo, Japan), and KATSUMI HIRAOKA (Tokai University, Kanagawa, Japan) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2564-2566. refs
Copyright

The effect of the streamwise pressure gradient of the flow on the growth rate of the mixing layer formed at the interface of parallel supersonic flows is studied. The structure of the mixing layer is examined by in situ measurement of the concentration ratio of the gas mixture. It is found that, when a streamwise pressure gradient exists, the growth rate of the mixing layer is enhanced compared to the one without the gradient. The baroclinic torque produced by the streamwise pressure gradient may be the cause of the enhancement. C.D.

A92-55344#
THE FLOW FIELD CHARACTERISTICS ABOUT A FIGHTER CONFIGURATION AT HIGH ANGLES OF ATTACK
ZHIYONG LU, HONGYU LU, YIDONG LI, and ZHILI YANG (Beijing University of Aeronautics and Astronautics, China) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 182-187. refs
(AIAA PAPER 92-4358) Copyright

The flow field characteristics around a fighter configuration with double delta wing at medium to large angles of attack have been studied. It is found that the flow patterns can be attributed to the following factors: the wing leading edge vortex and the body vortex, and the broken down vortex flow and the full separation flow. When the burst point of the wing vortex approaches the apex of the exposed wing, the dimension of the low energy flow is 5-8 times greater than the diameter of the body near the trailing edge of the wing. O.G.

A92-55345#
PULSATING SPANWISE BLOWING ON A FIGHTER AIRCRAFT
J. MEYER and A. SEGINER (Technion - Israel Institute of Technology, Haifa) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 188-198. refs
(AIAA PAPER 92-4359) Copyright

Periodic leading-edge spanwise blowing was tested on a 60 deg-swept delta wing fighter aircraft model in a low-speed wind tunnel, up to an angle of attack of alpha = 60 deg. At low frequencies, lift and drag coefficients correspond to the pulsating blowing pressure; when the value is open, they reach the same values as with continuous blowing, and when it is closed, they agree with the no-blowing values. A lag in the response time is observed, which is equal at low incidences to the freestream convective time, but increases to 30 convective times at alpha = 30-40 deg. This response time is much longer when the valve closes than when the valve opens, at alpha = 20-30 deg. These features are similar to those of delta wings in unsteady flows, such as in pitching or plunging motions. They are insensitive to the flow parameters, and are valid at low blowing frequencies. At high frequencies, lift and drag coefficients do not correspond to the pulsating pressure, but remain at an intermediate value between those of continuous and no blowing. In both cases, the mean lift and drag coefficients are equal to the values obtained by continuous blowing at the same mean momentum coefficient. Author

A92-55350*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACTIVE CONTROL OF ASYMMETRIC VORTICAL FLOWS AROUND CONES USING INJECTION AND HEATING
OSAMA A. KANDIL, HAZEM H. SHARAF (Old Dominion University, Norfolk, VA), and C. H. LIU (NASA, Langley Research Center, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 244-253. refs
(Contract NAG1-994)
(AIAA PAPER 92-4426) Copyright

The effectiveness of certain active-control methods for asymmetric flows around circular cones is investigated by using computational solution of the unsteady, compressible full Navier-Stokes equations. Two main methods of active control which include flow injection and surface heating are used. For the flow-injection-control method, flow injection is used either in the normal direction to the surface or in the tangential direction to the surface. For the surface-heating-control method, the temperature of the cone surface is increased. The effectiveness of a hybrid method of flow control which combines normal injection with surface heating has also been studied. The Navier-Stokes equations, subjected to various surface boundary conditions, are solved by using an implicit, upwind, flux-difference splitting, finite-volume scheme for locally-conical flow solutions. Author

A92-55353*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATION OF VORTEX WAKE FLOWS AND CONTROL OF THEIR EFFECTS ON TRAILING WINGS
TIN-CHEE WONG, OSAMA A. KANDIL (Old Dominion University, Norfolk, VA), and C. H. LIU (NASA, Langley Research Center, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 280-292. refs
(Contract NAG1-994)
(AIAA PAPER 92-4429) Copyright

The near-vortex-wake flow of a large aspect-ratio rectangular wing is accurately computed by using the thin-layer and full Navier-Stokes (NS) equations. The chordwise section of the wing is a NACA-0012 airfoil and its tip is round. The computations have been carried out on a fine C-O grid using an implicit, upwind, flux-difference splitting, finite-volume scheme. The thin-layer NS results have been obtained with and without flux limiters, and the full NS results have been obtained without flux limiters. Flow transition from laminar to turbulent is mimicked by turning-on the

Baldwin-Lomax algebraic model at an experimentally prescribed chord-station location of 0.05. Comparison of computed results and experimental data shows that the full NS results give the best resolution of the near-vortex-wake flow. Next, the strength of the wing-tip vortex has been reduced substantially without reducing the lift coefficient by using flow-injection from a slot along a portion of the wing tip. The flow injection is directed in the wing plane at 45 deg with the wing-tip chord. Author

A92-55355*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NAVIER-STOKES COMPUTATIONS FOR OSCILLATING CONTROL SURFACES
SHIGERU OBAYASHI and GURU P. GURUSWAMY (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 304-312. refs
(Contract NCC2-605)
(AIAA PAPER 92-4431) Copyright

Unsteady Navier-Stokes computations have been performed for simulating transonic flows over wings with oscillating control surfaces using a locally moving grid and a stationary-mismatched zoning scheme. An F-5 wing and a clipped delta wing are chosen for the present study. The computed unsteady pressures and the response characteristics to the control surface motions are compared with experimental data. The results successfully predict main features of the unsteady pressure profiles, such as the double peaks at the shock wave and at the hinge line. Author

A92-55364#
THE VORTICAL STRUCTURE IN THE WAKE DURING DYNAMIC STALL
I. P. ITTY and J. R. LEITH (New Mexico, University, Albuquerque) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 391-395. Research supported by University of Illinois. refs
(Contract F29601-85-C-0038)
(AIAA PAPER 92-4496) Copyright

The behavior of the stable near wake pattern following an oscillating airfoil in the stall regime is investigated via computations of the near-wake flow field using the stream function-vorticity formulation of the Navier-Stokes equations. It was found that the curvature of the vortex street always tends to be toward the suction side, unlike in the near-wake behavior for the case of oscillation under static stall. The stable near-wake pattern observed during the pitch-up motion is comprised of vortices which alternate in their directions. The center points of these vortices align along a straight line, and their maximum width follows the square-root law behavior. I.S.

A92-55365*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A DISCRETE VORTEX MODEL FOR PREDICTING WING ROCK OF SLENDER WINGS
ANDREW S. ARENA, JR. and ROBERT C. NELSON (Notre Dame, University, IN) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 396-406. refs
(Contract NCA2-406)
(AIAA PAPER 92-4497) Copyright

The fluid mechanism responsible for generating wing rock of slender sharp-edged delta wings was investigated using an unsteady discrete vortex model developed for that purpose, which is based on results of experimental investigations. Combined experimental and computational results indicate that wing rock is sustained by a lag in the position of the leading edge vortices normal to the surface. Results of comutations also indicate that certain complex aerodynamic problems may be governed primarily by unsteady inviscid phenomena. I.S.

A92-55367#
TOW-TANK STUDY OF NONLINEAR AERODYNAMICS OF A 2-D AIRFOIL
G. M. GRAHAM, M. ISLAM, and K. C. FANG (Ohio University, Athens) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 416-426. refs
(Contract AF-AFOSR-89-0502)
(AIAA PAPER 92-4499) Copyright

The normal and axial force loading on a 2D NACA 0015 airfoil undergoing small 'step' changes in angle of attack due to rotation have been measured in a tow tank. The Reynolds number was near 10 exp 5 and the airfoil was pitched about the quarter chord. The step amplitude was approximately +/- 1 deg and the angle of attack at the onset of the step was varied between 0 and 60 deg. The force data have been used to compute experimental nonlinear normal and axial force indicial responses. The experimental indicial responses are numerically integrated using a convolution integral for certain trial motions, and the resulting integrated loads are compared with baseline data for the same motion taken with the same airfoil. In an effort to study pitch rate effects on the indicial response, two types of tests were conducted: a 'first order' test in which the angle of attack prior to the step onset was held constant, and a 'second order' test in which the airfoil was ramped up from a low angle of attack to the step onset angle. Author

A92-55368#
EXPERIMENTAL EVALUATION OF A 50-PERCENT THICK AIRFOIL WITH BLOWING AND SUCTION BOUNDARY LAYER CONTROL
S. P. DIRLIK, K. R. KIMMEL, A. SEKELSKY, and J. F. SLOMSKI (U.S. Navy, Naval Surface Warfare Center, Bethesda, MD) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 427-445. refs
(AIAA PAPER 92-4500)

A 1-foot chord, 46-percent-thick symmetrical airfoil section using simultaneous blowing and suction for active boundary layer control was tested in the 3-by-8-foot Subsonic Airfoil Test Facility at the David Taylor Research Center. The section characteristics were determined for Reynolds numbers of 0.7 x 10 exp 6 and 0.9 x 10 exp 6 and angles of attack from 0 to 15 deg. Blowing air mass flows ranged from 0.2 to 0.9 lbm/s and suction flows from 0.5 to 2.2 lbm/s. The experimental setup is described and characteristic data points are analyzed. The suction slot appears to be ineffective as a boundary layer control device, although the blowing was effective. Author

A92-55369#
UNDERSTANDING AND DEVELOPMENT OF A PREDICTION METHOD OF TRANSONIC LIMIT CYCLE OSCILLATION CHARACTERISTICS OF FIGHTER AIRCRAFT
JOS J. MEIJER (National Aerospace Laboratory, Amsterdam, Netherlands) and ATLEE M. CUNNINGHAM, JR. (General Dynamics Corp., Fort Worth, TX) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 446-457. Research supported by USAF, General Dynamics Corp., Netherlands Ministry of Defence, et al. refs
(AIAA PAPER 92-4501) Copyright

An analysis of steady wind tunnel data, obtained for a fighter type aircraft, has indicated that shock-induced and trailing-edge separation play a dominant role in the development of Limit Cycle Oscillations (LCO) at transonic speeds. On the basis of these data a semi-empirical LCO prediction method is being developed. Its preliminary version has been applied to several configurations and has correctly identified those which have encountered LCO. It has already shown the potential for application early in the design process of new aircraft to determine and understand the

nonlinear aeroelastic characteristics. The method has been upgraded since. It will be described in its present form and results of the latest predictions will be used to further assess various parametric effects. The ultimate refinements are expected from recent unsteady wind tunnel force and pressure measurements for which a few preliminary analyses are presented. Author

A92-55372#
PARAMETER IDENTIFICATION OF UNSTEADY AERODYNAMIC FORCES FOR ELASTIC VEHICLES
CHEN SHILU and XIAOFEI XIONG (Northwestern Polytechnical University, Xian, China) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 474-476. Research supported by NNSFC, Aeronautical Science Fund, and China National Education Committee. refs
(AIAA PAPER 92-4505) Copyright

A method is presented for identifying unsteady aerodynamic forces of elastic vehicles. It is shown that, in comparison with other methods, this method has the advantages of convenience of taking into account the effect of structure deformations, the capability to identify the unsteady aerodynamic parameters of the whole vehicle, the ease of collecting initial data, and the simplicity of calculations. I.S.

A92-55373#
PARAMETER IDENTIFICATION OF AV-8B WINGBORNE AERODYNAMICS FOR FLIGHT SIMULATOR MODEL UPDATES
SCOTT W. STEVENSON, DAVID HOLL, and ALAN ROMAN (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 477-493. refs
(AIAA PAPER 92-4506) Copyright

A two-step method is used to perform aerodynamic parameter identification analysis on AV-8B aircraft flight test data. The method consists of signal reconstruction of the flight test data used in the analysis, followed by regression analysis of the aerodynamic coefficients. Two nonlinear modeling techniques used to create the aerodynamic regression models are described. Flight test data gathered during three different flight test programs were used for the analysis. The aircraft configurations examined are the AV-8B with a 65 percent and 100 percent leading edge root extension, and the 65-percent configuration with an infight refueling probe. The aerodynamic coefficients for all six degrees of freedom are examined. The flight envelope investigated includes the normal operating envelope from -16 to 30 degrees angle of attack and 0.4 to 0.85 Mach number, and the high angle-of-attack departure/spin region below 0.6 Mach number. Parameter identification results and model validation results from the analysis are presented. The final simulator data-base model produced by this analysis provided very good representation of the aircraft throughout the flight envelope examined. Author

A92-55375*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EVALUATION OF A MULTIGRID-BASED NAVIER-STOKES SOLVER FOR AEROTHERMODYNAMIC COMPUTATIONS
VEER N. VATSA (NASA, Langley Research Center, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 507-516. refs
(AIAA PAPER 92-4563) Copyright

A multigrid acceleration technique developed for solving the three-dimensional Navier-Stokes equations is used for computing high Mach number flows over configurations of practical interest. An explicit multistage Runge-Kutta type of time-stepping scheme is used as the basic algorithm. Solutions are presented for a spherically blunted cone at Mach 10 and a modified shuttle orbiter at Mach 6. The computed surface heat-transfer distributions are shown to compare favorably with the experimental data. Effect of grid-refinement on computed heat-transfer distributions is also examined to assess the numerical accuracy of the computed solutions. The rapid convergence rate associated with multigrid schemes in previous applications at transonic speeds is observed at the higher Mach number flows investigated here. Author

A92-55377*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATIONS OF THE UNSTEADY FLOW ABOUT A GENERIC WING/PYLON/FINNED-STORE CONFIGURATION
ROBERT L. MEAKIN (Overset Methods, Inc.; NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 564-580. refs
(Contract NCC2-692)
(AIAA PAPER 92-4568) Copyright

An overset grid approach is used to carry out a set of computations of the unsteady flow about a generic wing, pylon, and finned-store configuration. The geometry, discretization procedure, and governing equations are presented. Thin-layer Navier-Stokes solutions are presented for four store separation cases: store in carriage position, store at two different separation positions, and a time-accurate simulation of the forced store separation from the wing pylon carriage. Computational results are compared with wind tunnel data for the three 'static store' cases. Dynamic loads and trajectory data are presented for the forced separation case. Author

A92-55382#
AERODYNAMIC ANALYSIS OF THE PIONEER UNMANNED AIR VEHICLE
ROBERT M. BRAY, DANIEL F. LYONS, and RICHARD M. HOWARD (U.S. Naval Postgraduate School, Monterey, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 625-630. refs
(AIAA PAPER 92-4635)

Wind-tunnel tests and a numerical study were performed of the Pioneer Remotely Piloted Vehicle for static longitudinal and lateral-directional stability-and-control characteristics. Longitudinal derivatives were generally well predicted by the panel method. Directional response showed discrepancies in the determined derivatives, though rudder-with-sideslip correlated well between the two methods. Drag predictions using the panel method for inviscid drag and build-up methods for viscous drag were poor. The number of panels was insufficient to accurately model the induced drag behavior. Overall, accuracies were suitable for a personal-computer-based prediction method for preliminary design or analysis purposes. Author

A92-55387#
APPROXIMATE AERODYNAMIC ANALYSIS OF JET INTERACTION
G. T. CHRUSCIEL and D. A. KUDLICK (Lockheed Missiles & Space Co., Inc., Sunnyvale, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 677-692. refs
(AIAA PAPER 92-4640) Copyright

An engineering model for predicting the jet interaction effects of flow issuing from circular sonic nozzles on axisymmetric bodies is described. The approach simulates the jet flowfield with an equivalent blunt body flowfield superimposed on the basic body flow structure. Flow separation produced by the jet is included as an effective boundary layer jet trip determined by empirical correlations for laminar and turbulent flows. Comparisons with test data are provided for a sharp and blunt nose slender cone at Mach numbers of 6 and 8 for a range of jet to local pressure ratios and locations of the jet relative to the base. The analytic method, intended for application as a design tool, was found

adequate for prediction of jets located near the base of the body. Author

A92-55394#
COMPARATIVE NUMERICAL STUDY OF TWO TURBULENCE MODELS FOR AIRFOIL STATIC AND DYNAMIC STALL
DONALD P. RIZZETTA and MIGUEL R. VISBAL (USAF, Wright Laboratory, Wright-Patterson AFB, OH) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 745-758. refs
(AIAA PAPER 92-4649)

Steady and unsteady high Reynolds number flows about airfoils at large angles of attack were simulated numerically by integation of the time-dependent compressible Navier-Stokes equations. Effects of turbulence were accounted for by either a two-equation (k-epsilon) closure model which included a generalized formulation and low-Reynolds number terms, or by a commonly employed algebraic representation. Details of the numerical procedure are summarized and a grid mesh step-size study is provided in order to assess resolution requirements of the computations. Comparisons for a number of steady flow results, up to and beyond the static stall angle of attack, are made between solutions utilizing the respective models and with experiment in terms of aerodynamic force coefficients and surface pressure distributions. In the case of unsteady motions, numerical solutions for flows about airfoils which were pitched at a nominally constant rate from zero incidence to a high angle of attack, are compared with each other and with instantaneous experimental lift, drag, moment, and surface pressure data. Author

A92-55395#
STATE-SPACE REPRESENTATION OF AERODYNAMIC CHARACTERISTICS OF AN AIRCRAFT AT HIGH ANGELS OF ATTACK
M. GOMAN and A. KHRABROV (Central Aerohydrodynamic Institute, Moscow, Russia) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 759-766. refs
(AIAA PAPER 92-4651) Copyright

A state-variable concept is presented which is aimed at deriving a concise but conprehensive description of unsteady and nonlinear aerodynamic behavior of an aircraft. A mathematical model is proposed which is based on internal dynamical variables of the state of separated and vortex flow around the aircraft. The model describes different unsteady effects which have been observed in experiment, including the dependence of aerodynamic characteristics on motion prehistory and the influence of reduced frequency and oscillation amplitude on unsteady aerodynamic derivatives. O.G.

A92-55397*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTING HIGH-SPEED FLOWS PAST AN OSCILLATING CYLINDER NEAR A VERTICAL WALL
GUAN-WEI YEN and OKTAY BAYSAL (Old Dominion University, Norfolk, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 776-785. refs
(Contract NAG1-1150)
(AIAA PAPER 92-4653) Copyright

A computational method to simulate unsteady flows involving moving rigid boundaries and interference has been developed. The method is used to solve inviscid equations governing the fluid flow and the dynamic equations governing the motion of rigid bodies. A second-order accurate, upwind-biased, and alterating-direction-implicit method is used to solve the governing equations of the flow. A kinematic domain decomposition (KDD) procedure is extended to treat 3D problems with a high degree of accuracy and generality. The method under consideration is applied to both transonic and supertransonic flows. Both cases involve flow past a cylinder which is forced to pitch sinusoidally near a vertical wall. Benefits of the proposed approach include accurate calculation of the flow around 3D moving multiple bodies with interference; reduction of a numerical error; in particular, the dispersion error which strongly affects wave propagation; and minimization of the phase error which is accumulated according to the time advance procedure. O.G.

A92-56006
SUPERSONIC WIND TUNNEL TEST OF AIRINTAKE/AIRFRAME INTEGRATED MODELS
T. ITO, A. MURAKAMI, J. NODA, S. SHINDO, K. SAKATA (National Aerospace Laboratory, Chofu, Japan), and A. TANAKA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 24-27. In Japanese.

A series of Mach 3 tests of the first model for the intake-airframe integration problem was performed in NAL's M4 supersonic wind tunnel and the data was analyzed aerodynamically. The model of the air-intake with diverter is installed on the bottom surface of the airframe which was designed for Mach 3 flight. Schlieren method and oil-flow technique were applied for considering the flow structure around and on the model. Qualitative and some quantitative considerations on the effects of existence of the air-intake to the airframe aerodynamic coefficients are made clear and influence of the forebody boundary layer to the air-intake was also analyzed. Author

A92-56007
A HYPERSONIC WIND TUNNEL TEST OF A MIXED-COMPRESSION AIR INLET MODEL
HIDEKI NOMOTO and TADASHI KATSURAHARA (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 28-31. In Japanese. refs

A hypersonic wind tunnel test was performed for a mixed-compression type air inlet model. The model was a two-dimensional, mixed-compression type air inlet with a simulated forebody. Pressure recovery and pressure distributions on ramps and duct walls were measured at free stress Mach number of 7.1. Effects of shock/boundary layer interaction were assessed quantitatively under various conditions of duct flow rate and boundary layer bleed. This hypersonic wind tunnel test of a mixed-compression air inlet proved the feasibility of an inlet of this type which can be operated at Mach numbers up to 7.1. Author

A92-56008
WIND TUNNEL TEST OF M = 2.5 MIXED COMPRESSION INLET
AKIRA FUJIMOTO, TAKASHI UCHIDA, HAJIME ISAJI, KEN-ICHI TAKAHIRA, and NOBUO NIWA (Kawasaki Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 32-35. In Japanese. refs

Wind tunnel test of a two-dimensional mixed-compression inlet, designed for M = 2.5, was performed. Our CFD prediction about the mechanism of improving pressure recovery ahead of an inlet 'unstart' was confirmed by the schlieren observation. Comparison of the pressure distribution between the experiment and two-dimensional Navier-Stokes solution suggested strong three-dimensionality downstream of the terminal shock. The effect of a throat by-pass and vortex generators were also investigated. The total pressure recovery factor with and without vortex generators was found to be comparable. But distortion was remarkably improved when the vortex generators were attached on the subsonic diffuser. Author

A92-56009
THREE-DIMENSIONAL SHOCK WAVE-TURBULENT BOUNDARY LAYER INTERACTION INDUCED BY BLUNT BODY AND PROTUBERANCE
SHIGERU ASO, SHOUZO MAEKAWA (Kyushu University, Japan), SHIGEHIDE NAKAO (Japan Air Lines Co., Ltd., Tokyo), KAZUO ARASHI, KENJI TOMIOKA (NASDA, Tokyo, Japan), and HIROYUKI YAMAO (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 36-39. In Japanese. refs

Three-dimensional shock wave/turbulent boundary layer interactions induced by blunt body and protuberance have been investigated carefully. The structures of the flowfields are studied in detail by oil flow technique and surface pressure measurements. For the interaction induced by blunt body the effects of the displacement between blunt body and flat plate to the interacting flowfields are investigated. The results suggest that the flowfield changes quite significantly due to displacement. For the interaction induced by protuberance the effects of the height of protuberance to the flowfields are investigated. The results show that the height of protuberance is the primary scale factor of the flowfields. However, detailed pressure profiles change due to the height of the protuberance. Author

A92-56010
ON THE STRUCTURE OF UNSTEADY SHOCK INDUCED SEPARATION OF THE TRANSONIC AIRFOIL IN THE NAL TWO-DIMENSIONAL WIND TUNNEL
HITOSHI MIWA, MAMORU SATO, HIROSHI KANDA, and SHIGEO BABA (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 40-43. In Japanese. refs

The structure of the shock wave system and the separating region on the airfoil in the test section of NAL two-dimensional wind tunnel was considered at the transonic buffeting condition. The wind tunnel test was carried out by means of measurements of pressure fluctuation on the surface of the airfoil and a position in the wake. At the same time, oil flow pattern observation on the surface of the airfoil and the side wall, observation of schlieren pictures of the oscillating shock wave system by using the high speed video camera and high speed optical camera were also performed. Author

A92-56040
THREE-DIMENSIONAL NUMERICAL ANALYSIS OF IMPINGING CIRCULAR JET - DISCRETE VORTEX METHOD
TERUHIKO KIDA (Osaka Prefecture, University, Sakai, Japan), TOSIYUKI MORIMOTO (Sumitomo Denko Co., Osaka, Japan), TOMOYA NAKAJIMA (Osaka Prefecture, University, Sakai, Japan), and ZENSABURO YASUTOMI (Kinki University, Osaka, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 166-169. In Japanese. refs

The problem of a ring jet impinging to the ground is important for the aerodynamics of the ACV. This problem is simulated by using a discrete vortex method. The uniform ring jet at the nozzle exit is simulated by distributing ring sources. The distribution of vortex segments and the pressure distribution on the ground are shown for the transient cases. It is shown that the brim-length of the cushion chamber is very sensitive for the cushion pressure. Author

A92-56042
A SHOCK TUNNEL EXPERIMENT ON AERODYNAMIC INTERFERENCE INDUCED BY RCS JET
TAKASHI YANAZAKI, KUNIO SOGA (National Aerospace Laboratory, Chofu, Japan), HIROSHI WAKAI, TADASHI ISHIKAWA, and KOUHEI TANAKA (Fuji Heavy Industries, Ltd., Aerospace Div., Utsunomiya, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 182-185. In Japanese. refs

During the reentry of a spaceplane, it is necessary to use a reaction control system (RCS) for attitude control augmentation in flight regions where the control surfaces are not fully effective. A shock tunnel experiment was performed on aerodynamic interference induced by RCS jets in hypersonic flow in order to establish test techniques and to understand basic characteristics of aerodynamic interference of a delta-winged spaceplane with tipfins. Author

A92-56044
BGK1 AIRFOIL OILFLOW TESTS IN THE NAL TWO-DIMENSIONAL WIND TUNNEL. II
MAMORU SATO, HIROSHI KANDA, NORIKAZU SUDANI, SHIGEO BABA, HITOSHI MIWA, and KENICHI MATSUNO (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 190-193. In Japanese. refs

Oilflow visualization tests were conducted to investigate sidewall boundary-layer effects on models with different aspect ratios in a 2D wind tunnel. Tests with sidewall boundary-layer suction were also conducted. Aspect ratios of the models were 1.2, 1.5, and 2.5, and the Reynolds number based on the airfoil chord was 21 x 10 exp 6. The flows on the BGK1 airfoil models are grouped into four patterns. At high angles of attack and/or Mach numbers over 0.75 (the design point), shock-wave behavior becomes completely 3D, and a pair of vortices appears on the airfoil surface. Author

A92-56045
HIGH SUBSONIC WIND TUNNEL TEST OF A TWO-DIMENSIONAL HYBRID-LAMINAR-FLOW-CONTROL AIRFOIL WITH SLOTTED SURFACE
YOJI ISHIDA, MASAYOSHI NOGUCHI, MAMORU SATO, and HIROSHI KANDA (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 194-197. In Japanese.

A wind-tunnel test in high-subsonic and high-Reynolds-number flows was made for a 2D hybrid-laminar-flow-control airfoil with slotted surface suction to study the drag-reduction effect of the airfoil. The Mach number was varied from 0.6 to 0.86 and Reynolds number from 8 to 20 million. It was found that the net drag reduction as high as 7 percent was realized for these conditions. Author

A92-56046
EXPERIMENTAL INVESTIGATION OF THE BOUNDARY LAYER IN A CORNER FORMED BY TWO CIRCULAR ARC AIRFOILS
MUTSUO KOTAKE, TADASHI MIKAMI, and YASUHIKO TANAKA (National Defense Academy, Yokosuka, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 198-201. In Japanese. refs

A corner boundary layer which is formed by two circular-arc airfoils of the same shape intersecting at right angles to each other was investigated experimentally. The properties of the corner flow with pressure gradient was obtained from velocity profiles, lines of equal velocity, and other quantities. Author

A92-56047
DESIGN AND WIND TUNNEL TEST OF LOW-REYNOLDS-NUMBER AIRFOIL
HIDEHIRO HIROSE and TETSUO YAMAZAKI (Fuji Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 202-205. In Japanese. refs

A low-Reynolds-number airfoil design for an unmanned high-altitude vehicle is presented. The wind tunnel test of the FLA1M airfoil is discussed, and wing shape and pressure distribution on the wing surface are examined. Y.P.Q.

A92-56048
NUMERICAL SIMULATION OF SUPERSONIC UNSTEADY FLOW USING A PANEL METHOD
YUICHI OKAYAMA and TERUO SAWADA (Okayama University of Science, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 218-221. In Japanese. refs

A panel method for unsteady supersonic flows is developed. The outline of the theoretical formulation and the numerical procedure is given, and the results of calculations of flows around oscillating cones and wings are reported. The fundamental formulation is based on Morino's method, the application of which to unsteady supersonic flows is realized in the present work. Author

A92-56049
CALCULATIONS OF AERODYNAMIC FORCES ON A WING WITH THRUST USING B.E.M
MITSUNORI YANAGIZAWA (Tokyo, Science University, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 222-225. In Japanese. refs

This paper presents a BEM for wings with thrust in potential flow. The effect of thrust is represented by doublet singularities. The method employs an aerodynamic panel code to simulate the flow of fan jet stream around an aircraft configuration. A configuration of a VTOL transport in a multijet lifting system is composed of lifting fans nested in the wing planform. The aerodynamic forces was calculated with the fundamental shape of fan in wing. The result is that there are regions of negative lift behind the position of the lift fan on which they interact with the wing to produce the aerodynamic forces. Author

A92-56050
GENERALIZED AERODYNAMICS ANALYSIS BY THE BOUNDARY ELEMENT METHOD
MITSUNORI MATSUSHITA, KENJI FUJII, and MITSUNORI YANAGIZAWA (Tokyo, Science University, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 226-229. In Japanese. refs

The computer code for analyzing rigid-body oscillating aerodynamic forces by the boundary element method (the panel method) is extended to compute the generalized aerodynamic forces for oscillating aircraft. The boundary condition portions of the original program are modified to adapt to the results of the FEM vibration analysis. Some example calculations for the flexible wing are shown. Author

A92-56052
ON THE EFFECT OF CANARDS ON NAL SPACEPLANE MODEL (0 ORDER) IN LOW SPEED AREA
SEIZO SUZUKI, HIROHUMI KONDO, HIDEO HOSINO, and MASAAKI YANAGIHARA (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 234-237. In Japanese. refs

This paper describes on effect of NAL spaceplane model with canards in low speed areas. The static wind-tunnel test of the spaceplane model was conducted in the NAL Low-speed Wind Tunnel (5.5 M x 6.5 M). Canards were effective to improvement of CLmax, L/D, Cn-beta, CL-delta e, and Cm-delta(e). Author

A92-56053
MOTION ANALYSIS OF 2-DIMENSIONAL FLAT PLATE IN GROUND EFFECT
KYOKO NITTA and HIROBUMI OHTA (Nagoya University, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 238-241. In Japanese. refs

Some analysis of the instability of aircraft flying in the ground effect, which is the aerodynamic effect with proximity to the ground, is shown in this report. In most cases, ground effects work favorably, as is typically seen for ACV. We calculated some cases using a finite difference method modified from NASA Ames code LTRAN2, changing the parameters concerning the aeroelastic feature of the motion of the airfoil. Only the cases of 2D flat plate are dealt with this time. Author

A92-56054
LOW-SPEED WIND TUNNEL TESTING FOR THE HIGH-SPEED PROPELLER AT HIGH SHAFT ANGLE OF ATTACK
MASATAKA HASHIDATE and SHIGERU SAITO (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 242-245. In Japanese. refs

The high-speed propeller characteristics at high shaft angle of attack is measured in a large-scale low-speed wind tunnel. The propeller (SR-3) was run over a range of blade setting angles from 40 to 50 deg, rotor speed from 1000 to 1600rpm, and wind speed from 0 to 45 m/s. The results obtained are as follows. (1) Theoretical predictions by local circulation method are in good agreement with measurements. (2) The thrust and power coefficient correspond to each other when plotted by perpendicular velocity to the rotor rotational plane. Author

A92-56058
A PHYSICAL APPROACH TO THE ESTIMATION OF AERODYNAMIC CHARACTERISTICS FROM FLIGHT DATA
OSAMU KOBAYASHI and FUMIKAZU KAINUMA (Kawasaki Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 258-261. In Japanese. refs

Flight data are given for the estimation of aerodynamic characteristics. The equation error method and the output error method are distinguished. Y.P.Q.

A92-56078
A LOW SPEED WIND TUNNEL INVESTIGATION OF A JOINED-WING AIRCRAFT WITH AN OVERHANGING FIN
AKIHITO IWASAKI, TOSHIMI FUJITA, HIROTOSHI FUJIEDA (National Aerospace Laboratory, Chofu, Japan), HISASI SATO (Tokai University, Japan), and NAOTO TAKIZAWA IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 346-349. In Japanese.

The aerodynamic characteristics of a joined-wing aircraft are presented. The lift, drag, and pitching moment coefficients, the side force rolling moment, and the yawing moment coefficients are analyzed. Y.P.Q.

A92-56154* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AEROELASTIC EFFECTS OF SPOILER SURFACES ON A LOW-ASPECT-RATIO RECTANGULAR WING
STANLEY R. COLE (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 768-773. Previously cited in issue 11, p. 1606, Accession no. A90-29371. refs

A92-56157* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
UNSTEADY SHOCK-VORTEX INTERACTION ON A FLEXIBLE DELTA WING
SHIGERU OBAYASHI and GURU P. GURUSWAMY (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 790-798. Previously cited in issue 12, p. 1905, Accession no. A91-32024. refs

A92-56159
DIRECT SIMULATION OF LOW-DENSITY FLOW OVER AIRFOILS
TSZE C. TAI (U.S. Navy, Naval Surface Warfare Center, Bethesda,

MD) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 806-810. Research supported by U.S. Navy. Previously cited in issue 16, p. 2482, Accession no. A90-38683. refs

A92-56161
DRAG COMPUTATION BY VORTEX METHODS
MAYER HUMI (Worcester Polytechnic Institute, MA) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 819-822. refs
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The vortex method in two dimensions is applied to compute the drag coefficients for flat and concave plates near zero angle of attack. It is shown numerically that near this angle the drag undergoes a bifurcation due to the symmetry breaking. An extension to the vortex algorithm which takes into account viscous effects outside the wall region is developed, and its results are compared with those of the k-epsilon model. Author

A92-56163* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NAVIER-STOKES SIMULATION OF A CLOSE-COUPLED CANARD-WING-BODY CONFIGURATION
EUGENE L. TU (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 830-838. Previously cited in issue 07, p. 969, Accession no. A91-21356. refs
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A92-56164* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EULER/EXPERIMENT CORRELATION OF A GENERIC FIGHTER
AGA M. GOODSELL (NASA, Ames Research Center, Moffett Field, CA) (ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1, p. 755-769) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 839-846. Previously cited in issue 09, p. 1307, Accession no. A91-24385. refs
Copyright

A92-56165* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TWO-FENCE CONCEPT FOR EFFICIENT TRAPPING OF VORTICES ON AIRFOILS
VERNON J. ROSSOW (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 847-855. refs
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Previous work on the use of a vortex trapped above a wing in order to produce high lift at low angles of attack is extended here. It is first postulated that the optimum way to trap a vortex is to design the airfoil section and wing so that the flow along the vortex core is minimized. It is then shown that a vertical fence both in front of and behind the separation bubble generated by the trapped vortex is an effective way to reduce the mass flow removal and its associated drag to a negligible amount. In order to show that vertical surfaces upstream and downstream of the vortex separation bubble have an opposite effect on the source requirements for vortex trapping, conformal mapping methods are used to obtain the solutions for a variety of simple two-dimensional, inviscid, incompressible flow configurations. Trapped-vortex flowfield solutions for the flow over flat plate and Clark-Y airfoils are then used to demonstrate that the heights of the fences can be tailored to make the required mass withdrawal (and therefore, the drag due to trapping) to be vanishingly small. Author

A92-56166
PHYSICS OF VORTICAL FLOWS
JEAN M. DELERY (ONERA, Chatillon, France) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 856-876. Research supported by CNES, DRET, and Service Technique des Programmes Aeronautiques. refs
Copyright

Separation in three-dimensional flows leads to the formation of vortical structures resulting from rolling up of the viscous flow 'sheet', initially contained in a thin boundary layer, which springs up from the surface into the outer perfect fluid flow. A clear physical understanding of this phenomenon must be based on a rational analysis of the flowfield structure using the critical-point theory. With the help of this theory, it is possible to interpret correctly the surface flow patterns that constitute the imprints of the outer flow and to give a rational and coherent description of the vortical system generated by separation. This kind of analysis is applied to separated flows forming on typical obstacles, the field of which has been thoroughly studied by means of visualizations and probings using multihole pressure probes and laser velocimetry. Thus, the skin friction line patterns of a transonic channel flow and of a multibody launcher are interpreted. Then, the vortical systems of a delta wing and an afterbody at an incidence are considered. The last two configurations are a missile fuselage-type body and an oblate ellipsoid. Author

A92-56170
SMALL TWO-DIMENSIONAL SURFACE EXCRESCENCES ON AIRCRAFT WINGS APPROACHING SEPARATION
MAHMOUD A. ALHUSEIN (Mu'tah University, Al-Karak, Jordan) and DAVID J. COCKRELL (Leicester, University, United Kingdom) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 899-906. Research supported by Mu'tah University. refs
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When studying the performance of aircraft wings at high-lift configurations it is important to appreciate the effects that discontinuities in the surface can cause in promoting premature flow separation. Having caused two-dimensional incompressible fluid flow to separate from the floor of a specially-designed wind tunnel in an experimental research program, small two-dimensional surface excrescences were introduced on the wind-tunnel floor, some distance upstream of this flow separation region. The techniques used to establish that the clean-surface flow was separating, to measure its gross characteristics, and then to make the necessary measurements when the excrescences were present are described. Provided that the excrescences were small, having $y+$ values that were less than 500, and were as far upstream of the separation region as at least 14 excrescence heights, the investigation showed that the downstream separation process was unaffected by their upstream presence. Author

A92-56173* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATION OF COMPUTATIONAL FLUID DYNAMICS TO SONIC BOOM NEAR- AND MID-FIELD PREDICTION
SAMSON H. CHEUNG, THOMAS A. EDWARDS, and SCOTT L. LAWRENCE (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 920-926. Previously cited in issue 02, p. 140, Accession no. A91-12512. refs
Copyright

A92-56179
IMPROVED CALCULATION OF TRANSONIC POTENTIAL FLOW PAST SWEPT WINGS
LIXIA WANG and DAVID A. CAUGHEY (Cornell University, Ithaca, NY) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 961-964. Research supported by Douglas Aircraft Co. refs
Copyright

An improved version of Flo-22 for calculating the transonic potential flow past swept wings is described. The new chordwise scaling and improved symmetry plane treatment are shown to result in a truly boundary conforming coordinate system for 3D wings and consistent treatment of the no-flux condition on the symmetry plane. It is demonstrated that improvements have been made in the accuracy of the solution near the wing tip and wing root. L.M.

A92-56331
ANALYSIS OF HELICOPTER ROTOR-FUSELAGE INTERFERENCE WITH TIME AVERAGED PRESSURE DISTRIBUTION
S. R. AHMED, J. RADDATZ (DLR, Braunschweig, Germany), and W. HOFFMANN (Braunschweig, Technical University, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 26 p. Research supported by BMFT and EEC. refs

The aerodynamic interference between main rotor and fuselage of a helicopter is investigated experimentally with the help of time averaged pressures measured on the fuselage surface. A total of 450 pressure taps were distributed over the fuselage surface in regions where the interference effects were expected to be severe. The facility used was 1:6.5 geometrically scaled down model of BO 105 helicopter operated in open test section of DLR 3.25 m x 2.8 m subsonic wind tunnel in Braunschweig. The rotor of the model has a diameter of 1.5 m and is mach-scaled. Parameters varied are thrust ratio, advance ratio and fuselage incidence. Some global flow visualization with smoke filaments was also performed. Author

A92-56332
CURRENT EUROPEAN ROTORCRAFT RESEARCH ACTIVITIES ON DEVELOPMENT OF ADVANCED CFD METHODS FOR THE DESIGN OF ROTOR BLADES (BRITE/EURAM 'DACRO' PROJECT)
G. POLZ (MBB GmbH, Munich, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 10 p. Research supported by EEC. refs

The present status of the BRITE/EURAM Pilot Phase project DACRO is described. The project focuses on the development and validation of new CFD codes for application to the aerodynamic environment of helicopter rotor blades. Additional tasks are the reviewing of the current computational methods, the definition of possible improvements, and the selection of appropriate data bases for code validation. Achievements discussed include the development of a range of CFD design tools for advanced helicopter rotor blade airfoils and tip shades, and a better understanding and prediction of the complex flow phenomena. DACRO activities should lead to a reduction in rotor power consumption with improved helicopter operational economy, and to reduced vibrator loads and noise. C.A.B.

A92-56349
AERODYNAMIC FEATURES OF A COAXIAL ROTOR HELICOPTER
V. A. ANIKIN (Kamov Helicopter Scientific and Technology Co., Russia) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 19 p. refs

The aerodynamic features of coaxial helicopter components are discussed. The influence of the induced interaction of the rotors on the rotor system aerodynamics in hover and forward flight is shown and compared with the equivalent single rotor characteristics. The effect of the coaxial rotors' aerodynamics symmetry on the helicopter vibration and trim characteristics is addressed. The coaxial rotor aerodynamic features in the gliding mode and the unsteady flapping characteristics of a blade are described. Coaxial-type helicopter fuselage layout features are presented. Numerical simulation problems of coaxial helicopter aerodynamics and its elements are discussed. C.A.B.

A92-56351
MEASUREMENTS OF THE DYNAMIC STALL VORTEX CONVECTION SPEED
R. B. GREEN, R. A. MCD. GALBRAITH, and A. J. NIVEN (Glasgow, University, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 12 p. Research supported by SERC, Defence Research Agency, and Department of Energy of United Kingdom. refs
(Contract AF-AFOSR-89-0397)

This paper considers the dynamic stall vortex of importance in helicopter rotor aerodynamics and discusses previous measurements of its convection speed. It emerges that an anomaly exists between the available data sets, i.e., that some workers find that the convection speed is dependent upon the aerofoil motion, while others find that this is not the case. Measurements of the convection speed from data gathered at Glasgow University for a variety of aerofoil shapes and motion types are then presented, which support the conclusion that the dynamic stall vortex convection speed is independent of aerofoil type and motion type to a first order. Author

A92-56352
NUMERICAL SIMULATION OF UNSTEADY ROTOR WAKES
A. BARON and M. BOFFADOSSI (Milano, Politecnico, Milan, Italy) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 19 p. Research supported by MURST. refs

A nonlinear unsteady vortex lattice scheme is presented. It is capable to predict the instantaneous configuration of the wake and the distribution of the aerodynamic load on rotor blades during impulsive starts or arbitrarily unsteady flight conditions. Any number of independent blades, with general planform and twist distribution, moving with assigned pitch and flap angles can be treated. Rankine vortices are used to discretize vorticity. Turbulent diffusion of their cores is modeled in order to cope with the rapid roll-up process of unsteady and closely interfering wakes, without any form of tuning of the numerical parameters. The capabilities of the code are verified by comparing numerical predictions with available steady state experimental data. Also reported are some results related to realistic unsteady flight conditions. Author

A92-56747*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EXPERIMENTAL RESULTS FOR A HYPERSONIC NOZZLE/AFTERBODY FLOW FIELD
FRANK W. SPAID (McDonnell Douglas Corp., Saint Louis, MO) and EARL R. KEENER (Eloret Institute, Palo Alto; NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 22 p. refs
(Contract NCC2-553)
(AIAA PAPER 92-3915) Copyright

The flow field created by the interaction of a single-expansion-ramp-nozzle (SERN) flow with a hypersonic external stream has been experimentally characterized using a generic nozzle/afterbody model in the 3.5-foot hypersonic wind tunnel of the NASA Ames Research Center. The presented results include oil-flow and shadowgraph flow visualization photographs, afterbody surface-pressure distributions, boundary layer rake measurements, and Preston-tube skin-friction measurements. The design, construction, and operation of the model was found to be successful. Surface oil-flow patterns show that the jet-plume flow attaches to the afterbody surface at jet pressure ratios between 154 and 234. The oil flow also shows the pattern of lines where the jet flow separates from the ramp, apparently as a result of interaction of the jet-plume internal shock wave with the ramp boundary layer. O.G.

A92-56750#
AN ACCEPTANCE PROCESS FOR THE EVALUATION OF INLET DISTORTION
WILLIAM J. DARDIS, ELLEN R. MAYHEW (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH), and DAVID K. BEALE (Sverdrup Technology, Inc., Arnold AFB, TN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 11 p. refs
(AIAA PAPER 92-3918)

The evolution of an acceptance process for the comparison of freejet/wind tunnel results is discussed. It is concluded that the numerical criteria developed for inlet distortion screen acceptance are useful for establishing a first-order determination of freejet simulation success. These include steady-state pressure recovery, steady-state probe-to-probe, and turbulence index criteria. Qualitative measures of comparison, namely, visual comparison of total pressure maps and the review of multiple dynamic pressure maps, are considered to be necessary to determine the total

success of a freejet simulation. To establish boundaries for a valid comparison it is necessary to estimate measurement system/data processing uncertainty and its effect on the comparison process. O.G.

A92-56752#
DEVELOPMENT AND VALIDATION OF A FREEJET TECHNIQUE FOR INLET-ENGINE COMPATIBILITY TESTING
D. K. BEALE (Sverdrup Technology, Inc., AEDC Group, Arnold AFB, TN) and M. ZELENAK (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 19 p. refs
(AIAA PAPER 92-3921)

A subscale experimental program aimed at developing and validating a freejet method for evaluating inlet-engine compatibility is presented that was performed at the Arnold Engineering Development Center. Freejet and wind tunnel test results obtained through the F-16 and F-15 inlet configurations models were compared. Inlet distortion measurements were evaluated using an acceptance process designed to determine the suitability of the method for fighter aircraft inlet-engine compatibility testing. It is concluded that free-stream inlet characteristics can be simulated using the freejet method. Forebody simulators can be used to simulate the presence of the complete forebody. The inlet reference plane can be used to set freejet parameters for the simulation. O.G.

A92-56771*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PREDICTED AERODYNAMIC CHARACTERISTICS FOR HL-20 LIFTING-BODY USING THE AERODYNAMIC PRELIMINARY ANALYSIS SYSTEM (APAS)
CHRISTOPHER I. CRUZ and GEORGE M. WARE (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 15 p. refs
(AIAA PAPER 92-3941) Copyright

The aerodynamic characteristics of the HL-20 lifting body configuraiton obtained through the APAS and from wind-tunnel tests have been compared. The APAS is considered to be an easy-to-use, relatively simple tool for quick preliminary estimation of vehicle aerodynamics. The APAS estimates are found to be in good agreement with experimental results to be used for preliminary evaluation of the HL-20. The APAS accuracy in predicting aerodynamics of the HL-20 varied over the Mach range. The speed ranges of best agreement were subsonic and hypersonic, while least agreement was in the Mach range from 1.2 to about 2,5. O.G.

A92-56776*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PERFORMANCE DATA OF THE NEW FREE-PISTON SHOCK TUNNEL AT GALCIT
HANS G. HORNUNG (California Institute of Technology, Pasadena) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 9 p. refs
(Contract N00014-90-J-1305; NAG1-1209)
(AIAA PAPER 92-3943) Copyright

The new free-piston shock tunnel has been partially calibrated, and a range of operating conditions has been found. A large number of difficulties were encountered during the shake-down period, of which the ablation of various parts was the most severe. Solutions to these problems were found. The general principles of high-enthalpy simulation are outlined, and the parameter space covered by T5 is given. Examples of the operating data show that, with care, excellent repeatability may be obtained. The temporal uniformity of the reservoir pressure is very good, even at high enthalpy, because it is possible to operate at tailored-interface and tuned-piston conditions over the whole enthalpy range. Examples of heat transfer and Pitot-pressure measurements are also presented. Author

A92-56810#
HIGH-LIFT TESTING AT HIGH REYNOLDS NUMBERS
WALTER O. VALAREZO (Douglas Aircraft Co., Long Beach, CA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 8 p. refs
(AIAA PAPER 92-3986) Copyright

Some problems associated with high-lift testing at high Reynolds numbers are examined with particular reference to the development and wind tunnel testing of an advanced multielement airfoil at representative flight conditions for a medium-range transport aircraft. Model considerations, instrumentation, and data acquisition are discussed, and sample results of 2D high Reynolds number testing. Issues to be addressed for the extension of the current test approaches to 3D testing are defined. V.L.

A92-56832*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CAN-DO, CFD-BASED AERODYNAMIC NOZZLE DESIGN AND OPTIMIZATION PROGRAM FOR SUPERSONIC/HYPERSONIC WIND TUNNELS
JOHN J. KORTE, AJAY KUMAR (NASA, Langley Research Center, Hampton, VA), D. J. SINGH, and J. A. WHITE (Analytical Services and Materials, Inc., Hampton, VA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 15 p. refs
(AIAA PAPER 92-4009) Copyright

A design program is developed which incorporates a modern approach to the design of supersonic/hypersonic wind-tunnel nozzles. The approach is obtained by the coupling of computational fluid dynamics (CFD) with design optimization. The program can be used to design a 2D or axisymmetric, supersonic or hypersonic, wind-tunnel nozzles that can be modeled with a calorically perfect gas. The nozzle design is obtained by solving a nonlinear least-squares optimization problem (LSOP). The LSOP is solved using an iterative procedure which requires intermediate flowfield solutions. The nozzle flowfield is simulated by solving the Navier-Stokes equations for the subsonic and transonic flow regions and the parabolized Navier-Stokes equations for the supersonic flow regions. The advantages of this method are that the design is based on the solution of the viscous equations eliminating the need to make separate corrections to a design contour, and the flexibility of applying the procedure to different types of nozzle design problems. Author

A92-56834*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL AND NUMERICAL ANALYSIS OF HYPERSONIC NOZZLE FLOWS WITH COMPARISONS TO WIND TUNNEL CALIBRATION DATA
CHARLES M. HACKETT (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 12 p. refs
(AIAA PAPER 92-4011) Copyright

Navier-Stokes (NS), parabolized NS codes, and classical method of characteristics prediction techniques are employed to compute hypersonic nozzle flowfields for the 15 in Mach 6 High Temperature Tunnel and the 16 in Mach 17 Nitrogen Tunnel, which are part of the Langley Research Center. The study focuses on defining the accuracy of these techniques by comparing the computational results to wind tunnel pitot pressure measurements conducted in the newly designed nozzle of the Mach 6 tunnel and in the original nozzle of the Mach 17 tunnel. The comparisons between predicted results and test section pitot surveys for the Mach 6 nozzle are in good agreement and show highly uniform flow over a range of reservoir pressures and temperatures. R.E.P.

A92-56835#
HYPERSONIC WIND TUNNEL NOZZLE STUDY
NORMAN E. SCAGGS (USAF, Wright Laboratory, Wright-Patterson AFB, OH), RICHARD D. NEUMANN (Science Applications International Corp., Dayton, OH), and ANTHONY L. LAGANELLI (Science Applications International Corp., Fort Washington, PA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN,

July 6-8, 1992. 37 p. refs
(AIAA PAPER 92-4012)

One of the basic problems in hypersonics is the understanding of hypersonic nozzle flows from both the numerical and experimental points of view. The Wright Laboratory Mach 12 facility presents a valuable test case for both experimentation and computation. This paper discusses the quality and nature of experimental instrumentation as well as computational solutions. The selection, design and integration of nozzle instrumentation are discussed with emphasis on the proper selection of heat transfer sensing elements and integration of the dynamic pressure transducers into the nozzle wall. Details of experiments performed, data obtained and numerical computations generated are given. The CFD simulations are briefly described as well as the numerical boundary conditions which form the interface between the experimental and computational elements of the problem. Results are presented and indicate a need for multiple types of instrumentation to correctly match results of computations with experimentation. The sensitivity of wall temperature boundary conditions to the derived test section flow conditions is demonstrated. Recommendations are presented for the testing and design of future hypersonic nozzle flowfields from CFD simulations of real-world hypersonic nozzle hardware. A.O.

A92-56836*# National Aeronautics and Space Administration, Washington, DC.
BOUNDARY LAYER STUDY ON NOZZLE WALL AT HYPERSONIC VELOCITIES
KENNETH M. JONES, FRED R. DEJARNETTE, WAYLAND C. GRIFFITH (North Carolina State University, Raleigh), and WILLIAM J. YANTA (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 12 p. Research supported by USAF. refs
(Contract NAGW-1072)
(AIAA PAPER 92-4013) Copyright

The boundary layer on the wall of the Hypervelocity Tunnel 9 was investigated with pitot pressure and total temperature measurements. Experimental results are presented for standard and supercooled Mach 14 runs. The boundary layer data at supercooled conditions are compared to numerical predictions made with a Navier-Stokes algorithm including vibrational nonequilibrium and intermolecular force effects. For standard tunnel conditions, the numerical solutions agree well with experimental data. For the supercooled cases, the numerical code predicts the total temperature but overpredicts the pitot pressure. Author

A92-56845*# National Aeronautics and Space Administration, Washington, DC.
A DATABASE OF AEROTHERMAL MEASUREMENTS IN HYPERSONIC FLOW FOR CFD VALIDATION
M. S. HOLDEN and J. R. MOSELLE (Calspan-State University of New York Research Center, Buffalo) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 52 p. Research supported by USAF and NASA. refs
(AIAA PAPER 92-4023)

This paper presents an experimental database selected and compiled from aerothermal measurements obtained on basic model configurations on which fundamental flow phenomena could be most easily examined. The experimental studies were conducted in hypersonic flows in 48-inch, 96-inch, and 6-foot shock tunnels. A special computer program was constructed to provide easy access to the measurements in the database as well as the means to plot the measurements and compare them with imported data. The database contains tabulations of model configurations, freestream conditions, and measurements of heat transfer, pressure, and skin friction for each of the studies selected for inclusion. The first segment contains measurements in laminar flow emphasizing shock-wave boundary-layer interaction. In the second segment, measurements in transitional flows over flat plates and cones are given. The third segment comprises measurements in regions of shock-wave/turbulent-boundary-layer interactions. Studies of the effects of surface roughness of nosetips and conical afterbodies are presented in the fourth segment of the database. Detailed measurements in regions of shock/shock boundary layer interaction are contained in the fifth segment. Measurements in regions of wall jet and transpiration cooling are presented in the final two segments. Author

A92-56846*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CFD VALIDATION EXPERIMENTS FOR HYPERSONIC FLOWS
JOSEPH G. MARVIN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 15 p. refs
(AIAA PAPER 92-4024) Copyright

A roadmap for CFD code validation is introduced. The elements of the roadmap are consistent with air-breathing vehicle design requirements and related to the important flow path components: forebody, inlet, combustor, and nozzle. Building block and benchmark validation experiments are identified along with their test conditions and measurements. Based on an evaluation criteria, recommendations for an initial CFD validation data base are given and gaps identified where future experiments could provide new validation data. Author

A92-56851*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL SIMULATION OF UNSTEADY FLOW IN A HYPERSONIC SHOCK TUNNEL FACILITY
JEAN-LUC CAMBIER (Eloret Institute, Palo Alto; NASA, Ames Research Center, Moffett Field, CA), SUSAN TOKARCIK, and DINESH K. PRABHU (Eloret Institute, Palo Alto, CA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 24 p. refs
(AIAA PAPER 92-4029)

This paper describes the computational work performed on the simulation of a 16-in shock-tunnel facility. The numerical problems encountered during the computation of these flows are discussed along with the validity of some approximations used, notably concerning the reduction of the problem into problems of smaller dimensionality. Quasi-1D simulations can be used to help design experiments, or to better understanding the characteristics of the facility. An application to the design of a nonintrusive diagnostic is shown. The multidimensional flow transients computed include the shock reflection at the end of the driven tube, the shock propagation down the nozzle, and the breaking of the main diaphragm. Author

A92-56855*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECTS OF EXTERNAL INFLUENCES IN SUBSONIC DELTA WING VORTICES
ANTHONY E. WASHBURN (Vigyan, Inc., Hampton, VA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 13 p. refs
(Contract NAS1-18585)
(AIAA PAPER 92-4033)

An experimental investigation was conducted to examine inconsistencies in reported studies for the vortical flow over highly-swept delta wings. A 76-deg swept delta wing was tested in three facilities with open and closed test sections and different model-support systems. The results obtained include surface oil-flow patterns, off-body laser-light-sheet flow visualization, and aerodynamic load measurements. Parameters such as the wall boundaries and model-support systems can drastically alter the loads. The effect of a high level of free-stream turbulence on the delta-wing flowfield was also examined and found to be significant. The increase in free-stream turbulence caused boundary-layer transition, unsteadiness in the vortex core positions, and altered the loads and moments. Author

A92-56857*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL UNSTEADY PRESSURES ON AN OSCILLATING CASCADE WITH SUPERSONIC LEADING EDGE LOCUS
DANIEL ERWIN, G. M. GREGOREK (Ohio State University, Columbus), and JOHN RAMSEY (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 15 p. refs
(AIAA PAPER 92-4035) Copyright

The first experimental data for an oscillating cascade with a supersonic leading edge locus (SLEL) at zero stagger angle is presented which were obtained in the NASA/OSU supersonic oscillating cascade facility. Reduced frequencies from .093 to .146, based on half chord were investigated. An influence coefficient technique for a linear oscillating cascade with constant interblade phase angle has been extended to a cascade with a SLEL.
O.G.

A92-56858*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NUMERICAL MODELING OF TRANSONIC JUNCTURE FLOW
WILLIAM E. MILHOLEN, II and NDAONA CHOKANI (North Carolina State University, Raleigh) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 27 p. refs
(Contract NCC1-98)
(AIAA PAPER 92-4036) Copyright

A numerical investigation of the interaction between a wind tunnel sidewall boundary layer and a thin low-aspect-ratio wing has been performed for transonic speeds and flight Reynolds numbers. A three-dimensional Navier-Stokes code was applied to calculate the flowfields. The results indicated that the sidewall boundary layer had a strong influence on the flowfield around the wing. The computed wing pressure distributions showed vast improvements over previous free-air computations, and were in excellent agreement with experimental data. The low momentum of the sidewall boundary layer resulted in higher pressures in the juncture region, which decreased the favorable spanwise pressure gradient. This significantly decreased the spanwise migration of the wing boundary layer. Weak vortices were predicted in both the upper and lower surface juncture regions. These vortices are believed to have been generated by lateral skewing of the streamlines in the approaching boundary layer. Author

A92-56861*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EFFECT OF A SIMULATED GLAZE ICE SHAPE ON THE AERODYNAMIC PERFORMANCE OF A RECTANGULAR WING
ABDI KHODADOUST (Illinois, University, Urbana) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 17 p. Research supported by NASA. refs
(AIAA PAPER 92-4042) Copyright

The effect of a simulated glaze-ice accretion on the flowfield of a 3D wing is studied experimentally. The model used for these tests was a semispan wing of effective aspect ratio five, mounted from the sidewall of a subsonic wind tunnel. The model has a NACA 0012 airfoil section on a rectangular untwisted planform with interchangeable leading edges to allow for testing both the baseline and the iced-wing geometry. A four-beam two-color fiberoptic laser Doppler velocimeter (LDV) was used to map the flowfield along three spanwise cuts on the model. Measurements on the centerline of the clean model compared favorably with theory and centerline measurements on the iced model compared well with measurements on a similar 2D model. The flow has the largest separation bubble at the model midspan with the smallest separation bubble occurring near the root and the wing tip.
Author

A92-56862#
PREDICTION OF THE PRESSURE LOSS COEFFICIENT OF WIND TUNNEL TURBULENCE REDUCING SCREENS
SAMER ALJABARI (Arizona State University, Tempe) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 14 p. refs
(AIAA PAPER 92-4043) Copyright

A mathematical model for predicting the pressure loss coefficient (K) of a screen was derived based on the work of Davis (1964), Strouhal, and Von Karman. The results are valid for single and multiple screens with solidities greater than 0.2 and less than 0.6 at wire Reynolds numbers below 600. When comparing the derived mathematical model results against the measured and collected data, the average error was 0.1 percent and the standard deviation was 13 percent. One percent error in the prediction of the coefficient of pressure loss results only in 0.25 to 0.3 percent error in the prediction of the turbulence-reduction factor. Author

A92-57034*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN INTEGRATED ANALYTICAL AEROPROPULSIVE/AEROELASTIC MODEL FOR THE DYNAMIC ANALYSIS OF HYPERSONIC VEHICLES
FRANK R. CHAVEZ and DAVID K. SCHMIDT (Arizona State University, Tempe) IN: AIAA, Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 551-563. refs
(Contract NAG1-1341)
(AIAA PAPER 92-4567) Copyright

The development of an approach to the determination of the dynamic characteristics of hypersonic vehicles which is intentionally generic and basic is given. The approach involves a 2D hypersonic aerodynamic analysis utilizing Newtonian theory, coupled with a 1D aero/thermoanalysis of the flow in a scramjet-type propulsion system. In addition, the airframe is considered to be elastic, and the structural dynamics are characterized in terms of a simple lumped-mass model of the invacuo vibration modes. The vibration modes are coupled to the rigid-body modes through the aero/propulsive forces acting on the structure. The control effectors considered on a generic study configuration include aerodynamic pitch-control surfaces, as well as engine fuel flow and diffuser area ratio. The study configuration is shown to be highly statically unstable in pitch, and to exhibit strong airframe/engine/elastic coupling in the aeroelastic and attitude dynamics, as well as the engine responses. Author

A92-57035#
AERODYNAMIC CALCULATION OF AN ELLIPTIC RING WING
T. WAN (Tamkang University, Taipei, Taiwan) and H. E. SARAVIA (California Polytechnic State University, San Luis Obispo) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0068) Copyright

In this study the Biot-Savart law was applied to develop the governing equations for the circulation distribution around a general elliptic ring wing. The governing equations allow for variable elliptic semi-axes, chord distribution around the wing and angle of attack. The governing equations included a multi-variable integral-differential equation for which no analytical or series solution has been found. To overcome this difficulty, an algorithm for a general numerical solution of these equations was developed and a FORTRAN program for its implementation was written. The output of this program can be used to predict the performance and structural requirements for different configurations of elliptic ring wings at different angles of attack. In addition, lift and induced drag for the whole wing are calculated. Author

A92-57499
INCREASING THE ACCURACY OF THE GODUNOV SCHEME FOR CALCULATING STEADY-STATE SUPERSONIC GAS FLOWS BY SOLVING THE GENERALIZED RIEMANN PROBLEM [POVYSHENIE TOCHNOSTI SKHEMY GODUNOVA DLIA RASCHETA STATSIONARNYKH SVERKHZVUKOVYKH TECHENII GAZA NA OSNOVE RESHENIIA OBOBSHCHENNOI ZADACHI RIMANA]

I. S. MEN'SHOV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 32, no. 2, Feb. 1992, p. 311-319. In Russian. refs
Copyright

The classical self-similar problem of interaction between two homogeneous steady-state supersonic gas flow is extended to inhomogeneous flows, i.e., to the case of an arbitrary variable distribution of the gasdynamic parameters. An explicit analytical solution is obtained in the vicinity of the flow-mixing line. This solution is then used to improve the accuracy of the Godunov scheme for calculating steady-state supersonic gas flows. V.L.

N92-32422*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
POTENTIAL FLOW THEORY AND OPERATION GUIDE FOR THE PANEL CODE PMARC
DALE L. ASHBY, MICHAEL R. DUDLEY, STEVE K. IGUCHI (San Diego State Univ., CA.), LINDSEY BROWNE (San Diego State Univ., CA.), and JOSEPH KATZ (San Diego State Univ., CA.) Jan. 1991 86 p
(Contract RTOP 505-61-71)
(NASA-TM-102851; A-90244; NAS 1.15:102851) Avail: CASI HC A05/MF A01

The theoretical basis for PMARC, a low-order potential-flow panel code for modeling complex three-dimensional geometries, is outlined. Several of the advanced features currently included in the code, such as internal flow modeling, a simple jet model, and a time-stepping wake model, are discussed in some detail. The code is written using adjustable size arrays so that it can be easily redimensioned for the size problem being solved and the computer hardware being used. An overview of the program input is presented, with a detailed description of the input available in the appendices. Finally, PMARC results for a generic wing/body configuration are compared with experimental data to demonstrate the accuracy of the code. The input file for this test case is given in the appendices. Author

N92-32479 ESDU International Ltd., London (England).
AERODYNAMIC CENTRE OF WING-BODY COMBINATIONS Abstract Only
Jul. 1992 17 p
(ISSN 0141-397X)
(ESDU-92024; ISBN-0-85679-829-0) Avail: ESDU

ESDU 92024 applies to a parallel-sided axisymmetric body with a truncated rear-end and a straight-tapered mid-set wing in subsonic or supersonic flow at low angles of attack. The wing may have moderate trailing-edge sweep of up to 10 degrees. The calculation of the aerodynamic center requires the pitching-moment-curve slope for the body alone (for which ESDU 89008 or 90034 may be used), the wing-alone lift-curve slope (for which at subsonic speeds ESDU 70011 may be used or supersonically ESDU 70012), and the lift-curve of the configuration together with interference factors for the effect of body-lift on the wing and wing-lift on the body (for which ESDU 91007 may be used). The other quantity required is the aerodynamic center of the interference load, for which this document provides both graphically and as a complete set of equations the required data. For missile-type configurations the method is accurate to within 2 percent of body length. The use of the method is illustrated by means of a fully worked example. For configurations with smoothly tapered afterbodies, such as found on transport aircraft, ESDU 76015 provides a method for subcritical speeds. ESDU

N92-32480*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A METHOD FOR DESIGNING BLENDED WING-BODY CONFIGURATIONS FOR LOW WAVE DRAG
RAYMOND L. BARGER Sep. 1992 19 p
(Contract RTOP 505-59-53-01)
(NASA-TP-3261; L-17095; NAS 1.60:3261) Avail: CASI HC A03/MF A01

A procedure for tailoring a blended wing-body configuration to reduce its computed wave drag is described. The method utilizes an iterative algorithm within the framework of first-order linear theory. Four computed examples are included. In each case, the zero-lift wave drag was reduced without an increase in the drag due to lift. Author

N92-32494*# Pennsylvania State Univ., University Park. Dept. of Mechanical Engineering.
SWEPT SHOCK/BOUNDARY LAYER INTERACTION EXPERIMENTS IN SUPPORT OF CFD CODE VALIDATION Final Report, 15 Jan. 1989 - 14 Jan. 1992
G. S. SETTLES and Y. LEE Jul. 1992 21 p
(Contract NAG2-592)
(NASA-CR-190583; NAS 1.26:190583) Avail: CASI HC A03/MF A01

Research on the topic of shock wave/turbulent boundary-layer interaction was carried out during the past three years at the Penn State Gas Dynamics Laboratory. This report describes the experimental research program which provides basic knowledge and establishes new data on heat transfer in swept shock wave/boundary-layer interactions. An equilibrium turbulent boundary-layer on a flat plate is subjected to impingement by swept planar shock waves generated by a sharp fin. Five different interactions with fin angle ranging from 10 deg to 20 deg at freestream Mach numbers of 3.0 and 4.0 produce a variety of interaction strengths from weak to very strong. A foil heater generates a uniform heat flux over the flat plate surface, and miniature thin-film-resistance sensors mounted on it are used to measure the local surface temperature. The heat convection equation is then solved for the heat transfer distribution within an interaction, yielding a total uncertainty of about +/- 10 percent. These experimental data are compared with the results of numerical Navier-Stokes solutions which employ a k-epsilon turbulence model. Finally, a simplified form of the peak heat transfer correlation for fin interactions is suggested. Author

N92-32648*# Arizona Univ., Tucson. Dept. of Aerospace and Mechanical Engineering.
LEADING-EDGE RECEPTIVITY FOR BLUNT-NOSE BODIES Semiannual Progress Report
P. W. HAMMERTON and E. J. KERSCHEN Jul. 1992 10 p
(Contract NAG1-1135)
(NASA-CR-190563; NAS 1.26:190563) Avail: CASI HC A02/MF A01

Boundary-layer receptivity in the leading edge region for bodies with blunt leading edges is investigated in this research program. Receptivity theory provides the link between the unsteady disturbance environment in the freestream and the initial amplitudes of instability waves in the boundary layer. This is a critical problem which must be addressed in order to develop more accurate prediction methods for boundary-layer transition. D.R.D.

N92-32651# Wright Lab., Wright-Patterson AFB, OH.
VORTEX FLOW VISUALIZATION USING COLORED AND FLUORESCENT DYES ON FLAT PLATE DELTA WING WITH LEADING EDGE EXTENSION
SCOTT P. LEMAY May 1992 22 p
(AD-A251139; WL-TM-92-323) Avail: CASI HC A03/MF A01

A water tunnel study was conducted in the Wright Laboratory 2ft x 2ft water tunnel to examine the vortex flowfield about a 60 deg flat plate diamond delta wing with an 80 deg leading edge extension (LEX). Flood light illuminated colored dye and laser light sheet illuminated fluorescent dye were used to visualize light sheet illuminated fluorescent dye were used to visualize the wing and LEX vortex core trajectories and vortex breakdown locations. The fluorescent dye flow visualization technique proved to be an excellent tool for examining the structure of vortex breakdown in detail. Angle of attack was varied between 10 deg and 45 deg for sideslip angles of 0 deg, 5 deg, and 10 deg, and the freestream Reynolds number was approximately 31,000 based upon model length. At angles of attack above 10 deg and zero sideslip, interaction was observed between the LEX and wing vortices. At 30 deg angle of attack, asymmetric breakdown of the LEX vortices

occurred. At sideslip angles of 5 deg and 10 deg, large asymmetries in the vortex flowfield were present. GRA

N92-32673# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
MODELING AND NUMERICAL SIMULATION OF VORTEX FLOW IN AERODYNAMICS
H. W. M. HOEIJMAKERS 15 Dec. 1990 53 p Presented at the AGARD Fluid Dynamics Panel Symposium on Vortex Flow Aerodynamics, Scheveningen, Netherlands, 1-4 Oct. 1990 Previously announced as N92-12997 Sponsored by Netherlands Agency for Aerospace Programs
(NLR-TP-91154-U; ETN-92-92000) Avail: CASI HC A04/MF A01

A review of mathematical models of different levels of approximation for and their application to the numerical simulation of vortical type of flows occurring in subsonic and transonic aircraft aerodynamics is presented. Computational methods for predicting the downstream development of vortex wakes as well as methods for simulating the detailed characteristics of configurations with leading edge or body vortices are covered with the emphasis on the latter. Developments of the methods used at present are discussed. The possibilities, limitations and prospects of improvement of the methods are indicated and results of different methods are discussed. Some more fundamental aspects of the numerical simulation such as separation at sharp and round leading edges, separation at a smooth part of the surface, the structure of the leading edge vortex and the merging of the vortices, are considered. ESA

N92-32730# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
NEW CONCEPTS FOR MULTI-BLOCK GRID GENERATION FOR FLOW DOMAINS AROUND COMPLEX AERODYNAMIC CONFIGURATIONS
S. P. SPEKREIJSE, J. W. BOERSTOEL, and P. L. VITAGILANO (Alenia Spazio S.p.A., Naples, Italy) 15 Feb. 1991 17 p Presented at the 3rd International Conference on Numerical Grid Generation in Computational Fluid Mechanics and Related Fields, Barcelona, Spain, 3-7 Jun. 1991 Previously announced in IAA as A92-47079
(Contract NIVR-01604-N)
(NLR-TP-91046-U; ETN-92-91994) Avail: CASI HC A03/MF A01

A multiblock grid generation procedure that is suitable for the construction of multiblock grids for numerical simulations of flows around complex aerodynamic configurations is described. The major new concepts are topology and geometry of block decomposition specified first by an interactive domain model, the use of compound edges and faces, grid embedding, grid lines only C continuous over block faces, and the use of a biharmonic solver for grid generation in faces. ESA

N92-32732# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
AN EXPERIMENTAL STUDY OF THE FLOW OVER A SHARP-EDGED DELTA WING AT SUBSONIC AND TRANSONIC SPEEDS
A. ELSENAAR and H. W. M. HOEIJMAKERS 28 Feb. 1991 25 p Presented at the AGARD Fluid Dynamics Panel Symposium on Vortex Flow Aerodynamics, Scheveningen, Netherlands, 1-4 Oct. 1990 Previously announced as N92-13011 Sponsored by Netherlands Agency for Aerospace Programs
(NLR-TP-91117-U; ETN-92-91997) Avail: CASI HC A03/MF A01

The flow about a sharp edged cropped delta wing is investigated experimentally. The experiment comprised detailed surface pressure measurements at low subsonic, transonic and low supersonic freestream Mach numbers for angles of attack up to 27 deg. The major part of the measurements were carried out at a Reynolds number of 9 million, but some data was also obtained at lower and at higher Reynolds numbers. The investigation included continuous schlieren flow field visualization as well as surface flow visualizations at a limited number of free stream conditions. The analysis of the measured data embraced flow field phenomena such as primary separation and the formation of the leading edge vortex, secondary separation and the formation of the secondary vortex, shock waves and the onset of vortex breakdown. The influence of Mach number, incidence and Reynolds number on these flow features is considered. ESA

N92-32769# Institut de Mecanique de Grenoble (France).
NUMERICAL SIMULATION OF TURBULENCE AT THE BACK OF THE AIRPLANE Final Report [SIMULATION NUMERIQUE DE LA TURBULENCE DANS LES ARRIERE-CORPS. RAPPORT FINAL]
M. LESIEUR 1991 39 p In FRENCH
(Contract DRET-89-204)
(ETN-92-91664) Avail: CASI HC A03/MF A01

Numerical experiments for a two dimensional flat jet and for a three dimensional circular jet were performed. The results revealed that the effect of compressibility, and of the density gradient on the initial flow profile produce, during the formation of the first vortices, the same effects as those observed in the case of the two dimensional mixture layer. It was also observed that the cold jet develops more rapidly than the hot jet, and that when the Mach number increases, the time required to form and to develop vortices increases. After the formation of the Karman vortex street, the description of the flat jet as a double mixture layer is not justified. The compression zones tend to disappear. Shocks were observed for M(sub r) = 2.5. In the circular jet experiment, a helical mode was observed. From M(sub r) = 0.6 to M(sub r) = 2, the time required to observe the first helical structures and the wavelength of the fundamental mode are two fold. Following the development structures, the flow becomes locally turbulent and an energy cascade at (K(sub x)exp -5/3) is established. A simulation study is carried out at high Reynolds number for the three dimensional circular jet at 0.6 Mach number. ESA

N92-32773# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de l'Aerodynamique.
RESEARCH ON SOME CENTERED IMPLICIT METHODS FOR CALCULATING TRANSONIC FLOWS BY SOLVING NAVIER-STOKES EQUATIONS Final Summary Report [RECHERCHES SUR DES METHODES IMPLICITES CENTREES POUR LE CALCUL D'ECOULEMENTS TRANSSONIQUES A PARTIR DE LA RESOLUTION DES EQUATIONS DE NAVIER-STOKES. RAPPORT DE SYNTHESE FINAL]
SYLVIE PLOT-LOCATELLI Oct. 1991 59 p In FRENCH
(Contract DRET-89-34-001)
(ONERA-RSF-24/1408-AY-150A; ETN-92-91671) Avail: CASI HC A04/MF A01

The development and operation of a simplified implicit phase, occurring during the solution of two dimensional Navier-Stokes equations, are presented. The equations to be solved and the resolution method are described. The numerical calculation of the implicit phase is presented. Two cases involving turbulent transonic flows are studied. The improvement of the accuracy concerning the convergence towards a steady solution was tested. These results and those from the explicit code are compared, with and without multiple grid accelerators. The time required by the central processing unit to calculate the converging solution by using the implicit method is: equal to 3, when compared to the explicit method with multiple grid phases; and of about 1.4 when compared to the explicit method with multiple grid phase. ESA

N92-32782 ESDU International Ltd., London (England).
LIFT AND ROLLING MOMENT DUE TO SPOILERS ON WINGS WITH TRAILING-EDGE FLAPS DEFLECTED AT SUBSONIC SPEEDS
1 Jan. 1992 16 p Supplement to ESDU-90030
(ISSN 0141-397X)
(ESDU-92002-SUPPL; ESDU-90030; ISBN-0-85679-807-X) Avail: ESDU

ESDU 92002 provides an empirical method of estimating the lift and rolling moment due to upper-surface spoiler deflection on a wing with flaps deployed. The method is to determine the additional decrement over that obtained when the spoiler is

deflected on the plain wing (calculated using ESDU 90030) and the corresponding change in rolling moment. The method applies to the same range of wing planform and spoiler parameters as the methods of 90030 for plain, single- or double-slotted flaps having flap/wing chord ratio of 0.2 to 0.4 and with flap deflections up to 60 degrees. It applies for practical Reynolds number and Mach number up to 0.25, although it will apply up to Mach numbers of 0.5 for flap deflections of 10 degrees or less. From a comparison with test data, the method predicts total lift coefficient decrement within 0.1 and total rolling moment coefficient within 0.01 with no venting from the lower to the upper wing surface. Some guidance is included on the effect of venting, which can increase spoiler effectiveness by 30 percent for large spoiler deflections. Two worked examples illustrated the use of the data. ESDU

N92-32811# Bombardier, Inc., Montreal (Quebec). Canadair Div.

FURTHER DEVELOPMENT OF THE CANAERO COMPUTER CODE TO INCLUDE PROPULSOR MODELLING

JOHN T. CONWAY Mar. 1990 130 p

(Contract DREA-W7707-8-1140-01-SC)

(DREA-CR-90-425; CTN-92-60357) Avail: CASI HC A07/MF A02

This report documents the development at Canadair of a propeller model for the CANAERO code. The CANAERO code is a low order panel method which uses a vortex sheets lifting model. CANAERO represents the geometry of a configuration by replacing the external surface with a large number of flat quadrilateral panels. This document reports on further development, implementation, and testing of the CANAERO computer code to include propulsor modelling. The formulation, implementation, and testing of the CANAERO actuator disk with swirl propulsor model is described, and the mathematical details of a theory of slipstream contraction used in the model are given. This now enables the code to calculate the propeller effects on overall aircraft or submarine performance without great increases in computer time compared to the non-propeller case. Results are given for the code for a submarine hull plus sail configuration with an aft-mounted propeller, a simple wing immersed in a propeller slipstream, and for an axisymmetrical shrouded propeller configuration. No convergence difficulties were encountered with any of these configurations. An updated user's guide and input data description are included in the report, together with sample datasets. Author (CISTI)

N92-32900# Army Cold Regions Research and Engineering Lab., Hanover, NH.

EFFECTS OF THE ABRASIVENESS OF TEST AND TRAINING SITE SOILS ON PARACHUTE LIFE

AUSTIN W. HOGAN May 1992 33 p

(AD-A252389; CRREL-SR-92-11) Avail: CASI HC A03/MF A01

The failure of individual parachutes, as a function of service life and exposure, has long been of interest. Examination of a sampling of parachutes used by the U.S. Army and the U.S. Forest Service 'Smokejumpers' indicates that suspension lines begin to degrade during the first 30 users. Laboratory tests confirmed that suspension line degradation is the most common way that parachutes fail, and that this degradation is primarily a result of the accumulation of grit within the suspension lines. It was concluded that inherent geological differences in soil properties would alter the service life of personnel parachutes deployed in varying geographic locales. This report describes the physical properties of surface soil samples collected in varying locales, at established drop zones, maneuver areas, test centers and from the test pit used by Rodier et al. (1989). Table 1 presents the soil specimens provided for analysis. Representative specimens were collected from the surface, sealed in plastic bags and transported to the laboratory. GRA

N92-33063*# Texas A&M Univ., College Station.

FURTHER WIND TUNNEL INVESTIGATION OF THE SM701 AIRFOIL WITH AILERON AND TURBULATORS Final Report

GREGORY STEEN, ORAN NICKS, and MICHAEL HEFFNER Aug. 1992 17 p

(Contract NAG1-1260; TEES PROJ. 30540-AE)

(NASA-CR-190702; NAS 1.26:190702) Avail: CASI HC A03/MF A01

Wind tunnel tests were performed on a two-dimensional model of the SM701 airfoil designed for use on the World Class gliders. The test covered a range of Reynolds numbers from 500,000 to 1.7 million. Aerodynamic forces and moments were measured with an external balance. Momentum loss method measurements of the section drag coefficient were also made. Flow visualization techniques provided information on transition from laminar to turbulent flow. Lift, drag, and pitching moment were analyzed and comparisons were made with predicted and previously obtained experimental data. The effects of V-tape turbulators for use in turbulent drag reduction were studied. The performance of a 25 percent chord aileron deflected through plus or minus 20 degrees was researched. The model was designed, constructed, and tested by students at Texas A&M University. Author

N92-33304*# Tennessee Univ. Space Inst., Tullahoma.

DYNAMIC INTERACTIONS BETWEEN HYPERSONIC VEHICLE AERODYNAMICS AND PROPULSION SYSTEM PERFORMANCE Final Technical Report, 3 Jan. 1991 - 31 Jul. 1992

G. A. FLANDRO, R. L. ROACH (Georgia Inst. of Tech., Atlanta.), and H. BUSCHEK (Georgia Inst. of Tech., Atlanta.) Jul. 1992 205 p

(Contract NAG1-1205)

(NASA-CR-190638; NAS 1.26:190638) Avail: CASI HC A10/MF A03

Described here is the development of a flexible simulation model for scramjet hypersonic propulsion systems. The primary goal is determination of sensitivity of the thrust vector and other system parameters to angle of attack changes of the vehicle. Such information is crucial in design and analysis of control system performance for hypersonic vehicles. The code is also intended to be a key element in carrying out dynamic interaction studies involving the influence of vehicle vibrations on propulsion system/control system coupling and flight stability. Simple models are employed to represent the various processes comprising the propulsion system. A method of characteristics (MOC) approach is used to solve the forebody and external nozzle flow fields. This results in a very fast computational algorithm capable of carrying out the vast number of simulation computations needed in guidance, stability, and control studies. The three-dimensional fore- and aft body (nozzle) geometry is characterized by the centerline profiles as represented by a series of coordinate points and body cross-section curvature. The engine module geometry is represented by an adjustable vertical grid to accommodate variations of the field parameters throughout the inlet and combustor. The scramjet inlet is modeled as a two-dimensional supersonic flow containing adjustable sidewall wedges and multiple fuel injection struts. The inlet geometry including the sidewall wedge angles, the number of injection struts, their sweepback relative to the vehicle reference line, and strut cross-section are user selectable. Combustion is currently represented by a Rayleigh line calculation including corrections for variable gas properties; improved models are being developed for this important element of the propulsion flow field. The program generates (1) variation of thrust magnitude and direction with angle of attack, (2) pitching moment and line of action of the thrust vector, (3) pressure and temperature distributions throughout the system, and (4) performance parameters such as thrust coefficient, specific impulse, mass flow rates, and equivalence ratio. Preliminary results are in good agreement with available performance data for systems resembling the NASP vehicle configuration. Author

N92-33306*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

ON THE ANOMALIES IN SINGLE-JET HOVER SUCKDOWN DATA

RICHARD E. KUHN (STO-VL Technology, San Diego, CA.), DAVID C. BELLAVIA, DOUGLAS A. WARDWELL, and VICTOR R. CORSIGLIA Aug. 1991 42 p

(Contract RTOP 505-61-71)
(NASA-TM-102261; A-90021; NAS 1.15:102261) Avail: CASI HC A03/MF A01

The data from nine different investigations of the suckdown induced in ground effect by a single jet issuing from plates of various sizes and shapes have been examined and compared. The results show that the generally accepted method for estimating suckdown significantly underestimated the suckdown for most of the configurations. The study identified several factors that could contribute to the differences. These include ground board size, plate edge effects, jet flow quality, jet impingement angle, the size of the chamber in which the tests were run, and obstructions in the region above the model. Most of these factors have not been investigated and in many cases items such as the size of the test chamber, jet flow quality, ground board size, etc., have not even been shown in the documents reporting the investigation. A program to investigate the effects of these factors is recommended. Author

N92-33413*# University of Southern California, Los Angeles. Dept. of Aerospace Engineering.
PERSPECTIVES ON HYPERSONIC VISCOUS AND NONEQUILIBRIUM FLOW RESEARCH
H. K. CHENG Aug. 1992 49 p
(Contract NAGW-1061; AF-AFOSR-0104-91)
(NASA-CR-190817; NAS 1.26:190817; USCAE-151) Avail: CASI HC A03/MF A01

An attempt is made to reflect on current focuses in certain areas of hypersonic flow research by examining recent works and their issues. Aspects of viscous interaction, flow instability, and nonequilibrium aerothermodynamics pertaining to theoretical interest are focused upon. The field is a diverse one, and many exciting works may have either escaped the writer's notice or been abandoned for the sake of space. Students of hypersonic viscous flow must face the transition problems towards the two opposite ends of the Reynolds or Knudsen number range, which represents two regimes where unresolved fluid/gas dynamic problems abound. Central to the hypersonic flow studies is high-temperature physical gas dynamics; here, a number of issues on modelling the intermolecular potentials and inelastic collisions remain the obstacles to quantitative predictions. Research in combustion and scramjet propulsion will certainly be benefitted by advances in turbulent mixing and new computational fluid dynamics (CFD) strategies on multi-scaled complex reactions. Even for the sake of theoretical development, the lack of pertinent experimental data in the right energy and density ranges is believed to be among the major obstacles to progress in aerothermodynamic research for hypersonic flight. To enable laboratory simulation of nonequilibrium effects anticipated for transatmospheric flight, facilities capable of generating high enthalpy flow at density levels higher than in existing laboratories are needed (Hornung 1988). A new free-piston shock tunnel capable of realizing a test-section stagnation temperature of 10(exp 5) at Reynolds number 50 x 10(exp 6)/cm is being completed and preliminary tests has begun (H. Hornung et al. 1992). Another laboratory study worthy of note as well as theoretical support is the nonequilibrium flow experiment of iodine vapor which has low activation energies for vibrational excitation and dissociation, and can be studied in a laboratory with modest resources (Pham-Van-Diep et al. 1992). Author

N92-33424*# MCAT Inst., San Jose, CA.
HIGH SPEED TRANSITION PREDICTION Progress Report
GEDIMINIS GASPERAS Sep. 1992 26 p Original contains color illustrations
(Contract NCC2-704)
(NASA-CR-190836; NAS 1.26:190836; MCAT-92-017) Avail: CASI HC A03/MF A01; 3 functional color pages

The main objective of this work period was to develop, acquire and apply state-of-the-art tools for the prediction of transition at high speeds at NASA Ames. Although various stability codes as well as basic state codes were acquired, the development of a new Parabolized Stability Equation (PSE) code was minimal. The time that was initially allocated for development was used on other tasks, in particular for the Leading Edge Suction problem, in acquiring proficiency in various graphics tools, and in applying these tools to evaluate various Navier-Stokes and Euler solutions. The second objective of this work period was to attend the Transition and Turbulence Workshop at NASA Langley in July and August, 1991. A report on the Workshop follows. From July 8, 1991 to August 2, 1991, the author participated in the Transition and Turbulence Workshop at NASA Langley. For purposes of interest here, analysis can be said to consist of solving simplified governing equations by various analytical methods, such as asymptotic methods, or by use of very meager computer resources. From the composition of the various groups at the Workshop, it can be seen that analytical methods are generally more popular in Great Britain than they are in the U.S., possibly due to historical factors and the lack of computer resources. Experimenters at the Workshop were mostly concerned with subsonic flows, and a number of demonstrations were provided, among which were a hot-wire experiment to probe the boundary layer on a rotating disc, a hot-wire rake to map a free shear layer behind a cylinder, and the use of heating strips on a flat plate to control instability waves and consequent transition. A highpoint of the demonstrations was the opportunity to observe the rather noisy 'quiet' supersonic pilot tunnel in operation. Author

N92-33484*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATIONS OF A DIRECT/ITERATIVE DESIGN METHOD TO COMPLEX TRANSONIC CONFIGURATIONS
LEIGH ANN SMITH and RICHARD L. CAMPBELL Sep. 1992 36 p
(Contract RTOP 505-59-10-03)
(NASA-TP-3234; L-16962; NAS 1.60:3234) Avail: CASI HC A03/MF A01

The current study explores the use of an automated direct/iterative design method for the reduction of drag in transport configurations, including configurations with engine nacelles. The method requires the user to choose a proper target-pressure distribution and then develops a corresponding airfoil section. The method can be applied to two-dimensional airfoil sections or to three-dimensional wings. The three cases that are presented show successful application of the method for reducing drag from various sources. The first two cases demonstrate the use of the method to reduce induced drag by designing to an elliptic span-load distribution and to reduce wave drag by decreasing the shock strength for a given lift. In the second case, a body-mounted nacelle is added and the method is successfully used to eliminate increases in wing drag associated with the nacelle addition by designing to an arbitrary pressure distribution as a result of the redesigning of a wing in combination with a given underwing nacelle to clean-wing, target-pressure distributions. These cases illustrate several possible uses of the method for reducing different types of drag. The magnitude of the obtainable drag reduction varies with the constraints of the problem and the configuration to be modified. Author

N92-33581*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DYNAMIC RESPONSE OF INDUCED PRESSURES, SUCKDOWN, AND TEMPERATURES FOR TWO TANDEM JET STOVL CONFIGURATIONS
DOUGLAS A. WARDWELL, VICTOR R. CORSIGLIA, and RICHARD E. KUHN Jul. 1992 204 p
(Contract RTOP 505-68-32)
(NASA-TM-103934; A-90290; NAS 1.15:103934) Avail: CASI HC A10/MF A03

NASA Ames Research Center has been conducting a program to improve the methods for predicting the jet-induced lift loss (suckdown) and hot gas ingestion on jet Short Takeoff and Vertical Landing (STOVL) aircraft during hover near the ground. As part of that program, small-scale hover tests were conducted to expand the current data base and to improve upon the current empirical methods for predicting jet-induced lift loss and hot gas ingestion (HGI) effects. This report is one of three data reports covering

data obtained from hover tests conducted at Lockheed Aeronautical Systems, Rye Canyon Facility. It will include dynamic (time dependent) test data for both lift loss and HGI parameters (height, nozzle temperature, nozzle pressure ratio, and inlet location). The flat plate models tested were tandem jet configurations with three planform variations and variable position side-by-side sucking inlets mounted above the planform. Temperature time lags from 8-15 seconds were observed before the model temperatures stabilize. This was larger than the expected 1.5-second lag calculated from literature. Several possible explanations for the flow temperatures to stabilize may include some, or all, of the following: thermocouple lag, radiation to the model surface, and heat loss to the ground board. Further investigations are required to understand the reasons for this temperature lag. Author

N92-33618*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ON THE ESTIMATION OF JET-INDUCED FOUNTAIN LIFT AND ADDITIONAL SUCKDOWN IN HOVER FOR TWO-JET CONFIGURATIONS Final Report
RICHARD E. KUHN (STO-VL Technology, San Diego, CA.), DAVID C. BELLAVIA, VICTOR R. CORSIGLIA, and DOUGLAS A. WARDWELL Aug. 1991 53 p
(Contract RTOP 505-61-71)
(NASA-TM-102268; A-90040; NAS 1.15:102268) Avail: CASI HC A04/MF A01

Currently available methods for estimating the net suckdown induced on jet V/STOL aircraft hovering in ground effect are based on a correlation of available force data and are, therefore, limited to configurations similar to those in the data base. Experience with some of these configurations has shown that both the fountain lift and additional suckdown are overestimated but these effects cancel each other for configurations within the data base. For other configurations, these effects may not cancel and the net suckdown could be grossly overestimated or underestimated. Also, present methods do not include the prediction of the pitching moments associated with the suckdown induced in ground effect. An attempt to develop a more logically based method for estimating the fountain lift and suckdown based on the jet-induced pressures is initiated. The analysis is based primarily on the data from a related family of three two-jet configurations (all using the same jet spacing) and limited data from two other two-jet configurations. The current status of the method, which includes expressions for estimating the maximum pressure induced in the fountain regions, and the sizes of the fountain and suckdown regions is presented. Correlating factors are developed to be used with these areas and pressures to estimate the fountain lift, the suckdown, and the related pitching moment increments. Author

N92-33625*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A NOZZLE INTERNAL PERFORMANCE PREDICTION METHOD
JOHN R. CARLSON Oct. 1992 50 p
(Contract RTOP 505-62-30-01)
(NASA-TP-3221; L-16965; NAS 1.60:3221) Avail: CASI HC A03/MF A01

A prediction method was written and incorporated into a three-dimensional Navier-Stokes code (PAB3D) for the calculation of nozzle internal performance. The following quantities are calculated: (1) discharge coefficient; (2) normal, side, and axial thrust ratios; (3) rolling, pitching, and yawing moments; and (4) effective pitch and yaw vector angles. Four different case studies are presented to confirm the applicability of the methodology. Internal and, in most situations, external flow-field regions are required to be modeled. The computed nozzle discharge coefficient matches both the level and the trend of the experimental data within quoted experimental data accuracy (0.5 percent). Moment and force ratios are generally within 1 to 2 percent of the absolute level of experimental data, with the trends of data matched accurately. Author

N92-33631*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL STUDY OF A GENERIC HIGH-SPEED CIVIL TRANSPORT
PAMELA S. BELTON and RICHARD L. CAMPBELL Sep. 1992 115 p
(Contract RTOP 505-59-10-03)
(NASA-TM-4382; L-17046; NAS 1.15:4382) Avail: CASI HC A06/MF A02

An experimental study of generic high-speed civil transport was conducted in the NASA Langley 8-ft Transonic Pressure Tunnel. The data base was obtained for the purpose of assessing the accuracy of various levels of computational analysis. Two models differing only in wingtip geometry were tested with and without flow-through nacelles. The baseline model has a curved or crescent wingtip shape, while the second model has a more conventional straight wingtip shape. The study was conducted at Mach numbers from 0.30 to 1.19. Force data were obtained on both the straight wingtip model and the curved wingtip model. Only the curved wingtip model was instrumented for measuring pressures. Selected longitudinal, lateral, and directional data are presented for both models. Selected pressure distributions for the curved wingtip model are also presented. Author

N92-33656*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SURVEY AND ANALYSIS OF RESEARCH ON SUPERSONIC DRAG-DUE-TO-LIFT MINIMIZATION WITH RECOMMENDATIONS FOR WING DESIGN
HARRY W. CARLSON (Lockheed Engineering and Sciences Co., Hampton, VA.) and MICHAEL J. MANN Sep. 1992 158 p
(Contract RTOP 505-68-70-02)
(NASA-TP-3202; L-16963; NAS 1.60:3202) Avail: CASI HC A08/MF A02

A survey of research on drag-due-to-lift minimization at supersonic speeds, including a study of the effectiveness of current design and analysis methods was conducted. The results show that a linearized theory analysis with estimated attainable thrust and vortex force effects can predict with reasonable accuracy the lifting efficiency of flat wings. Significantly better wing performance can be achieved through the use of twist and camber. Although linearized theory methods tend to overestimate the amount of twist and camber required for a given application and provide an overly optimistic performance prediction, these deficiencies can be overcome by implementation of recently developed empirical corrections. Numerous examples of the correlation of experiment and theory are presented to demonstrate the applicability and limitations of linearized theory methods with and without empirical corrections. The use of an Euler code for the estimation of aerodynamic characteristics of a twisted and cambered wing and its application to design by iteration are discussed. Author

N92-33678# Naval Postgraduate School, Monterey, CA.
STATIC AND DYNAMIC FLOW VISUALIZATION STUDIES OF TWO DOUBLE-DELTA WING MODELS AT HIGH ANGLES OF ATTACK M.S. Thesis
FENG-HSI LI Mar. 1992 107 p
(AD-A252878) Avail: CASI HC A06/MF A02

A water tunnel flow visualization was performed to study the vortex development and bursting phenomena on a baseline double delta wing model and a modified double delta wing model. The primary focus of this study was two-fold: (1) to study the static and dynamic effects or pitch and pitch rate on the vortical flowfield of the individual models; and (2) to compare the vortex breakdown characteristics of these two models under static and dynamic conditions. Results indicate that the vortex burst location moves forward with increasing AOA for both the models relative to the static case, the bursting is delayed during pitch-up motion with the vortex burst lag increasing with the pitch rate. Compared with the baseline model, the small geometry modification at the strake/wing junction of the modified model changes the local flowfield by developing the wing vortex earlier and promoting earlier coiling-up of strake and wing vortices. High angle of attack

aerodynamics, effect of static AOA, pitch rate dynamic motion, flow visualization by dye injection, vortex development and bursting,water tunnel studies,effect of fillet, baseline or modified double-delta wing. GRA

N92-33699# Ballistic Research Labs., Aberdeen Proving Ground, MD.
ANALYSIS OF THE FLIGHT PERFORMANCE OF THE 155 MM M864 BASE BURN PROJECTILE
JAMES E. DANBERG Apr. 1990 52 p
(Contract DA PROJ. 1L1-62618-AH-80)
(BRL-TR-3083) Avail: CASI HC A04/MF A01

An engineering model was developed to compute the flight performance of the M864 base burn projectile. This model includes the coupled performance of the gas generator, effects of injected mass flow on the aerodynamics, and a modified point mass trajectory simulation. The gas generator model is based on measured burn rates and basic fluid dynamics. The discharge rate of the generator is calibrated against laboratory experiments. Effects of spin on burn rate are deduced from comparison of analysis with spin fixture tests. Linear and first order nonlinear effects of mass injection on base pressure are the basis for evaluation of base drag. Navier-Stokes solutions near the base with air injection provide essential data. Correlation equations predict base pressure as a function of Mach number, injection rate, and propellant gas temperature. Temperature effects on base pressure are a unique feature of the analysis. The base bleed model was applied to an instrumented flight test case with good qualitative agreement. There is disagreement with burnout measurements of four percent at low altitudes and much stronger dependence on elevation than observed in flight. The technique predicted range within four percent. Author

N92-33706*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF AFTERBODY GEOMETRY ON AERODYNAMIC CHARACTERISTICS OF ISOLATED NONAXISYMMETRIC AFTERBODIES AT TRANSONIC MACH NUMBERS
LINDA S. BANGERT and GEORGE T. CARSON, JR. Sep. 1992 265 p
(Contract RTOP 505-62-30-01)
(NASA-TP-3236; L-17034; NAS 1.60:3236) Avail: CASI HC A12/MF A03

A parametric study was conducted in the Langley 16-Foot Transonic Tunnel on an isolated nonaxisymmetic fuselage model that simulates a twin-engine fighter. The effects of aft-end closure distribution (top/bottom) nozzle-flap boattail angle versus nozzle-sidewall boattail angle) and afterbody and nozzle corner treatment (sharp or radius) were investigated. Four different closure distributions with three different corner radii were tested. Tests were conducted over a range of Mach numbers from 0.40 to 1.25 and over a range of angles of attack from -3 to 9 degrees. Solid plume simulators were used to simulate the jet exhaust. For a given closure distribution in the range of Mach numbers tested, the sharp-corner nozzles generally had the highest drag, and the 2-in. corner-radius nozzles generally had the lowest drag. The effect of closure distribution on afterbody drag was highly dependent on configuration and flight condition. Author

N92-33837 North Carolina State Univ., Raleigh.
AN APPROXIMATE VISCOUS SHOCK LAYER TECHNIQUE FOR CALCULATING CHEMICALLY REACTING HYPERSONIC FLOWS ABOUT BLUNT-NOSED BODIES Ph.D. Thesis
FOY MCNEIL CHEATWOOD 1991 250 p
Avail: Univ. Microfilms Order No. DA9130603

An approximate axisymmetric method was developed which can reliably calculate fully viscous hypersonic flows over blunt-nosed bodies. By substituting Maslen's second order pressure expression for the normal momentum equation, a simplified form of the viscous shock layer (VSL) equations is obtained. This approach can solve both the subsonic and supersonic regions of the shock layer without a starting solution for the shock shape. The approach is applicable to perfect gas, equilibrium, and nonequilibrium flowfields. Since the method is fully viscous, the problems associated with coupling a boundary-layer solution with an inviscid-layer solution are avoided. This procedure is significantly faster than the parabolized Navier-Stokes (PNS) or VSL solvers and would be useful in a preliminary design environment. Problems associated with a previously developed approximate VSL technique are addressed before extending the method to nonequilibrium calculations. Perfect gas (laminar and turbulent), equilibrium, and nonequilibrium solutions were generated for air flows over several analytic body shapes. Surface heat transfer, skin friction, and pressure predictions are comparable to VSL results. In addition, computed heating rates are in good agreement with experimental data. The present technique generates its own shock shape as part of its solution, and therefore could be used to provide more accurate initial shock shapes for higher-order procedures which require starting solutions. Dissert. Abstr.

N92-33839 Ohio State Univ., Columbus.
COMPUTATION AND STABILITY ANALYSIS OF LAMINAR FLOW OVER A BLUNT CONE IN HYPERSONIC FLOW Ph.D. Thesis
VAHID ESFAHANIAN 1991 396 p
Avail: Univ. Microfilms Order No. DA9130471

The computation and stability of laminar flow over a 7 degree half-angle blunt cone at M sub infinity = 8 are investigated. The basic flow is obtained by solving the thin-layer Navier-Stokes equations using the Beam and Warming method. The linear-stability equations are derived in body-fitted orthogonal curvilinear coordinates. The usual asymptotic boundary conditions for the disturbance equations are replaced with linearized Rankine-Hugoniot jump conditions. The disturbance equations are solved using a spectral collocation and 4th-order finite-difference compact method. The results of the present computation are compared to those of the STDS experiment. Dissert. Abstr.

N92-33851 Lehigh Univ., Bethlehem, PA.
UNSTEADY RESPONSE OF THE LEADING-EDGE VORTICES ON A PITCHING DELTA WING Ph.D. Thesis
CHARLES LEE MAGNESS 1991 205 p
Avail: Univ. Microfilms Order No. DA9129999

The unsteady flow past a delta wing undergoing pitching maneuvers to high angle of attack is investigated. The pitching maneuvers are constant-rate motions between initial and final angles of attack. Pitch-up, pitch-down, and consecutive pitch-up/pitch-down maneuvers are considered for a range of non-dimensional pitch rates of practical interest. The primary focus of this investigation is on two aspects of the instantaneous, unsteady flow: the response of the location of vortex breakdown; and the response of the crossflow velocity field and its interpretation in terms of instantaneous streamlines and vorticity distributions. Vortex breakdown is investigated by flow visualization of its instantaneous location for a variety of pitching maneuvers. The vortex breakdown response can lag substantially the motion of the wing. It is classified into regimes based on angle-of-attack criteria for a stationary wing. Particle image velocimetry (PIV) techniques are employed to study the unsteady flow structure on the pitching delta wing. The first implementation of a high resolution, PIV laser-scanning system for three-dimensional flows allows characterization of the unsteady leading-edge vortex. This PIV technique generates detailed, instantaneous velocity fields over the crossflow plane that in turn provide sectional streamline patterns and vorticity fields. Consideration of the instantaneous streamline patterns reveals a new topological structure of the leading-edge vortex that exists over a wide range of pitch rates. It exhibits an unstable focus, i.e. an outward-spiraling motion, of the leading-edge vortex during pitch-up motion to high angle of attack. This vortex structure is fundamentally different from the classical leading-edge vortex on a stationary wing at low angle-of-attack. These characterizations of the instantaneous structure of the leading-edge vortex, provide a new basis for interpreting and controlling the flow past a delta wing during high angle of attack maneuvers. Dissert. Abstr.

N92-34029 Oregon State Univ., Corvallis.
TURBULENCE-INDUCED LOADS ON A TEETERED ROTOR Ph.D. Thesis
TIMOTHY LAVERN WEBER 1991 149 p
Avail: Univ. Microfilms Order No. DA9130927

Development of variable speed horizontal axis wind turbines has resulted in a need for an analysis code with a rotor speed degree-of-freedom. This study develops a five degree-of-freedom time domain computer code that evaluates blade and rotor, mean and cyclic loads with nonlinear aerodynamics together with atmospheric turbulence as a forcing function. Verification of the model is made by comparison of loads predictions between ESI-80 wind turbine data and analytical solutions. Results show good agreement for mean and cyclic loads and teeter angle excursions. A single-blade point turbulence simulation model is optimized using a three-blade point turbulence simulation model. The optimum point is the 80 percent radius location, although a multiplying factor is needed to make conservative fatigue cycle predictions of blade bending. ESI-80 start-up and shutdown scenarios are examined, and prediction trends matched ESI-80 data. Three generator models are investigated. Results show that generator torque cycles are reduced and yearly energy capture increased by 24 percent when a variable speed generator is implemented. Dissert. Abstr.

N92-34144*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ANALYSIS OF ICED WINGS
T. CEBECI (California State Univ., Long Beach.), H. H. CHEN (California State Univ., Long Beach.), K. KAUPS (California State Univ., Long Beach.), S. SCHIMKE (California State Univ., Long Beach.), and J. SHIN Jan. 1992 14 p Presented at the 30th Aerospace Sciences Meeting and Exhibit, Reno, NV, 6-9 Jan. 1992; sponsored in part by AIAA Previously announced in IAA as A92-29972
(Contract RTOP 505-68-10)
(NASA-TM-105773; E-7201; NAS 1.15:105773) Avail: CASI HC A03/MF A01

A method for computing ice shapes along the leading edge of a wing and a method for predicting its aerodynamic performance degradation due to icing is described. Ice shapes are computed using an extension of the LEWICE code which was developed for airfoils. The aerodynamic properties of the iced wing are determined with an interactive scheme in which the solutions of the inviscid flow equations are obtained from a panel method and the solutions of the viscous flow equations are obtained from an inverse three-dimensional finite-difference boundary-layer method. A new interaction law is used to couple the inviscid and viscous flow solutions. The application of the LEWICE wing code to the calculation of ice shapes on a MS-317 swept wing shows good agreement with measurements. The interactive boundary-layer method is applied to a tapered ice wing in order to study the effect of icing on the aerodynamic properties of the wing at several angles of attack. Author

N92-34147*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PRESSURE MEASUREMENTS ON A RECTANGULAR WING WITH A NACA0012 AIRFOIL DURING CONVENTIONAL FLUTTER
JOSE A. RIVERA, JR., BRYAN E. DANSBERRY, MICHAEL H. DURHAM, ROBERT M. BENNETT, and WALTER A. SILVA Jul. 1992 132 p
(Contract RTOP 505-63-50)
(NASA-TM-104211; NAS 1.15:104211) Avail: CASI HC A07/MF A02

The Structural Dynamics Division at NASA LaRC has started a wind tunnel activity referred to as the Benchmark Models Program. The primary objective of the program is to acquire measured dynamic instability and corresponding pressure data that will be useful for developing and evaluating aeroelastic type CFD codes currently in use or under development. The program is a multi-year activity that will involve testing of several different models to investigate various aeroelastic phenomena. The first model consisted of a rigid semispan wing having a rectangular planform and a NACA 0012 airfoil shape which was mounted on a flexible two degree-of-freedom mount system. Two wind-tunnel tests were conducted with the first model. Several dynamic instability boundaries were investigated such as a conventional flutter boundary, a transonic plunge instability region near Mach = 0.90, and stall flutter. In addition, wing surface unsteady pressure data were acquired along two model chords located at the 60 to 95-percent span stations during these instabilities. At this time, only the pressure data for the conventional flutter boundary is presented. The conventional flutter boundary and the wing surface unsteady pressure measurements obtained at the conventional flutter boundary test conditions in pressure coefficient form are presented. Wing surface steady pressure measurements obtained with the model mount system rigidized are also presented. These steady pressure data were acquired at essentially the same dynamic pressure at which conventional flutter had been encountered with the mount system flexible. Author

N92-34172* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
VAPORIZING PARTICLE VELOCIMETER Patent
LEONARD M. WEINSTEIN, inventor (to NASA) 6 Oct. 1992 6 p Filed 14 Jun. 1991 Supersedes N91-28135 (29 - 20, p 3280)
(NASA-CASE-LAR-14685-1; US-PATENT-5,153,665; US-PATENT-APPL-SN-718313; US-PATENT-CLASS-356-28; US-PATENT-CLASS-73-861.05; US-PATENT-CLASS-356-318; INT-PATENT-CLASS-G01P-3/36) Avail: US Patent and Trademark Office

A velocimeter measures flow characteristics of a flow traveling through a chamber in a given direction. Tracer particles are entrained in the flow and a source of radiant energy produces an output stream directed transversely to the chamber, having a sufficient intensity to vaporize the particles as they pass through the output stream. Each of the vaporized particles explodes to produce a shock wave and a hot core, and a flow visualization system tracks the motion of the hot cores and shock waves to measure the velocity of each tracer particle and the temperature of the flow around the tracer.

Official Gazette of the U.S. Patent and Trademark Office

N92-34193*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PARAMETRIC INVESTIGATION OF SINGLE-EXPANSION-RAMP NOZZLES AT MACH NUMBERS FROM 0.60 TO 1.20
FRANCIS J. CAPONE, RICHARD J. RE, and E. ANN BARE Oct. 1992 276 p
(Contract RTOP 505-62-30-01)
(NASA-TP-3240; L-17067; NAS 1.60:3240) Avail: CASI HC A13/MF A03

An investigation was conducted in the Langley 16-Foot Transonic Tunnel to determine the effects of varying six nozzle geometric parameters on the internal and aeropropulsive performance characteristics of single-expansion-ramp nozzles. This investigation was conducted at Mach numbers from 0.60 to 1.20, nozzle pressure ratios from 1.5 to 12, and angles of attack of 0 deg +/- 6 deg. Maximum aeropropulsive performance at a particular Mach number was highly dependent on the operating nozzle pressure ratio. For example, as the nozzle upper ramp length or angle increased, some nozzles had higher performance at a Mach number of 0.90 because of the nozzle design pressure was the same as the operating pressure ratio. Thus, selection of the various nozzle geometric parameters should be based on the mission requirements of the aircraft. A combination of large upper ramp and large lower flap boattail angles produced greater nozzle drag coefficients at Mach number greater than 0.80, primarily from shock-induced separation on the lower flap of the nozzle. A static conditions, the convergent nozzle had high and nearly constant values of resultant thrust ratio over the entire range of nozzle pressure ratios tested. However, these nozzles had much lower

aeropropulsive performance than the convergent-divergent nozzle at Mach number greater than 0.60. Author

N92-34243*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
METHOD OF REDUCING DRAG IN AERODYNAMIC SYSTEMS Patent Application
FRANK HRACH, inventor (to NASA) 11 Sep. 1992 10 p
(NASA-CASE-LEW-14791-1; NAS 1.71:LEW-14791-1;
US-PATENT-APPL-SN-943659) Avail: CASI HC A02/MF A01

In the present method, boundary layer thickening is combined with laminar flow control to reduce drag. An aerodynamic body is accelerated enabling a ram turbine on the body to receive air at velocity V sub 0. The discharge air is directed over an aft portion of the aerodynamic body producing boundary layer thickening. The ram turbine also drives a compressor by applying torque to a shaft connected between the ram turbine and the compressor. The compressor sucks in lower boundary layer air through inlets in the shell of the aircraft producing laminar flow control and reducing drag. The discharge from the compressor is expanded in a nozzle to produce thrust. NASA

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A92-56180
PREDICTING DROPLET IMPINGEMENT ON YAWED WINGS
MICHAEL B. BRAGG (Illinois, University, Urbana) and STANLEY H. MOHLER, JR. (Sverdrup Technology, Inc., Brook Park, OH) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 964-966. Research supported by B.F. Goodrich De-Icing Systems. refs
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A procedure for using 2D droplet-impingement techniques on 3D wings is presented, and evaluated against a full 3D code for straight and yawed wings. The 2D analysis is shown to predict reasonably well the droplet impingement on a 3D yawed wing on the model centerline where 3D effects are small. Near the wing tip the 2D model fails to accurately predict the droplet-impingement on a yawed wing. The results are of interest in connection with aircraft icing analysis. L.M.

N92-32455# National Transportation Safety Board, Washington, DC.
AIRCRAFT ACCIDENT REPORT: L'EXPRESS AIRLINES, INC., FLIGHT 508, BEECH C99, N7217L WEATHER ENCOUNTER AND CRASH NEAR BIRMINGHAM, ALABAMA, JULY 10, 1991
3 Mar. 1992 143 p
(PB92-910401; NTSB/AAR-92/01) Avail: CASI HC A07/MF A02

This report explains the weather encounter and crash of L'Express Flight 508 while the airplane was conducting an instrument landing system approach on runway 5 at the Birmingham Airport, Birmingham, Alabama. The safety issues discussed in this report include pilot training in recognizing thunderstorm hazards and recovering from unusual attitudes, radar interpretation, and the relaying of complete weather information to pilots by air traffic controllers. Recommendations concerning these issues were made to the Federal Aviation Administration. Author

N92-32606*# Clemson Univ., SC. Radar Systems Lab.
REAL-TIME PROCESSING OF RADAR RETURN ON A PARALLEL COMPUTER Final Report
DAVID D. AALFS Aug. 1992 84 p
(Contract NGT-50414; RTOP 505-64-12-02)
(NASA-CR-4456; NAS 1.26:4456; CU-TR-14;
DOT/FAA/RD-92/20) Avail: CASI HC A05/MF A01

NASA is working with the FAA to demonstrate the feasibility of pulse Doppler radar as a candidate airborne sensor to detect low altitude windshears. The need to provide the pilot with timely information about possible hazards has motivated a demand for real-time processing of a radar return. Investigated here is parallel processing as a means of accommodating the high data rates required. A PC based parallel computer, called the transputer, is used to investigate issues in real time concurrent processing of radar signals. A transputer network is made up of an array of single instruction stream processors that can be networked in a variety of ways. They are easily reconfigured and software development is largely independent of the particular network topology. The performance of the transputer is evaluated in light of the computational requirements. A number of algorithms have been implemented on the transputers in OCCAM, a language specially designed for parallel processing. These include signal processing algorithms such as the Fast Fourier Transform (FFT), pulse-pair, and autoregressive modelling, as well as routing software to support concurrency. The most computationally intensive task is estimating the spectrum. Two approaches have been taken on this problem, the first and most conventional of which is to use the FFT. By using table look-ups for the basis function and other optimizing techniques, an algorithm has been developed that is sufficient for real time. The other approach is to model the signal as an autoregressive process and estimate the spectrum based on the model coefficients. This technique is attractive because it does not suffer from the spectral leakage problem inherent in the FFT. Benchmark tests indicate that autoregressive modeling is feasible in real time. Author

N92-32941# Battelle Columbus Labs., OH.
A REVIEW AND DISCUSSION OF FLIGHT MANAGEMENT SYSTEM INCIDENTS REPORTED TO THE AVIATION SAFETY REPORTING SYSTEM Final Report, Oct. 1990 - Jul. 1991
ROBERT S. DODD, DONALD ELDREDGE, and SUSAN J. MANGOLD Feb. 1992 77 p Sponsored by FAA
(AD-A252438; DOT-VNTSC-FAA-92-2; DOT/FAA/RD-92/2;
PB92-200963) Avail: CASI HC A05/MF A01

This report covers the activities related to the description, classification, and analysis of the types and kinds of flight crew errors, incidents, and actions, as reported to the Aviation Safety Reporting System (ASRS) database, that can occur as a result of using the Flight Management Systems (FMS's) to fly within the National Airspace System (NAS). The analysis of the ASRS FMS-related database reports was conducted for the purpose of determining the types and kinds of design-induced problems that flight crews are having with FMS's that can result in the occurrence of errors, incidents, and other operational problems. It was believed that review of these reports would provide a useful background and understanding of the FMS use domain (i.e., the flight environment) and offer a window into the cockpit setting, enabling the identification of categories of difficulties that flight crews appear to have with the FMS and its subsystems. Those elements of the FMS operational logic that are identified as potentially problematic will then be investigated in more detail in the Description and Characterization Study that is also ongoing. Together, these two documents will result in a clearer understanding of the design-related FMS contributors to pilot error. GRA

N92-33005# Federal Aviation Administration, Atlantic City, NJ.
BIRD INGESTION INTO LARGE TURBOFAN ENGINES Interim Report
HOWARD BANILOWER and COLIN GOODALL (Princeton Univ., NJ.) May 1992 77 p
(DOT/FAA/CT-91/17) Avail: CASI HC A05/MF A01

The Federal Aviation Administration (FAA) is conducting a study of bird ingestion into certain modern, large high-bypass turbofan engines. The engines under consideration were certificated to current FAA standards and are installed in A300, A310, A320, B747, B757, B767, DC10, and MD11 aircraft in commercial service worldwide. Data were collected during 1989-1991 by the principle manufacturers of such engines. Analysis of the initial 381 aircraft

ingestion events is given, with emphasis on the kinds and numbers of ingested birds and the adverse effects of bird ingestion on aircraft engines and flights. Author

N92-33080*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CTAS: COMPUTER INTELLIGENCE FOR AIR TRAFFIC CONTROL IN THE TERMINAL AREA
HEINZ ERZBERGER Jul. 1992 6 p
(Contract RTOP 505-64-13)
(NASA-TM-103959; A-92156; NAS 1.15:103959) Avail: CASI HC A02/MF A01

A system for the automated management and control of arrival traffic, referred to as the Center-TRACON Automation System (CTAS), has been designed by the ATC research group at NASA Ames research center. In a cooperative program, NASA and the FAA have efforts underway to install and evaluate the system at the Denver and Dallas/Ft. Worth airports. CTAS consists of three types of integrated tools that provide computer-generated intelligence for both Center and TRACON controllers to guide them in managing and controlling arrival traffic efficiently. One tool, the Traffic Management Advisor (TMA), establishes optimized landing sequences and landing times for aircraft arriving in the center airspace several hundred miles from the airport. In TRACON, TMA frequencies missed approach aircraft and unanticipated arrivals. Another tool, the Descent Advisor (DA), generates clearances for the center controllers handling at crossing times provided by TMA. In the TRACON, the final approach spacing tool (FAST) provides heading and speed clearances that produce and accurately spaced flow of aircraft on the final approach course. A data base consisting of aircraft performance models, airline preferred operational procedures and real time wind measurements contribute to the effective operation of CTAS. Extensive simulator evaluations of CTAS have demonstrated controller acceptance, delay reductions, and fuel savings. Author

N92-33194*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ANALYSIS OF DELAY REDUCING AND FUEL SAVING SEQUENCING AND SPACING ALGORITHMS FOR ARRIVAL TRAFFIC
FRANK NEUMAN and HEINZ ERZBERGER Oct. 1991 44 p
Supersedes NASA-TM-102795
(Contract RTOP 505-64-13)
(NASA-TM-103880; A-91203; NAS 1.15:103880) Avail: CASI HC A03/MF A01

The air traffic control subsystem that performs sequencing and spacing is discussed. The function of the sequencing and spacing algorithms is to automatically plan the most efficient landing order and to assign optimally spaced landing times to all arrivals. Several algorithms are described and their statistical performance is examined. Sequencing brings order to an arrival sequence for aircraft. First-come-first-served sequencing (FCFS) establishes a fair order, based on estimated times of arrival, and determines proper separations. Because of the randomness of the arriving traffic, gaps will remain in the sequence of aircraft. Delays are reduced by time-advancing the leading aircraft of each group while still preserving the FCFS order. Tightly spaced groups of aircraft remain with a mix of heavy and large aircraft. Spacing requirements differ for different types of aircraft trailing each other. Traffic is reordered slightly to take advantage of this spacing criterion, thus shortening the groups and reducing average delays. For heavy traffic, delays for different traffic samples vary widely, even when the same set of statistical parameters is used to produce each sample. This report supersedes NASA TM-102795 on the same subject. It includes a new method of time-advance as well as an efficient method of sequencing and spacing for two dependent runways. Author

N92-33249# Naval Research Lab., Washington, DC.
LIGHTNING STRIKE TESTS OF COMPOSITE CONNECTORS Final Report
C. D. BOND, F. J. CAMPBELL, and D. P. SMITH 19 Jun. 1992 72 p
(AD-A252281; NRL/MR/4654-92-6986) Avail: CASI HC A04/MF A01

Test results are presented on the lightning strike effects on composite and hybrid type multipin aircraft connectors in comparison with the standard all metal connectors. These tests were performed using a unipolar double exponential long duration pulse recommended by the SAE-AE4L committee at peak current levels of 3 kA, 10 kA, 15 kA, and 20 kA. Such peak current levels might be found in all-composite or partially composite aircraft or in exposed areas of all-metal aircraft. GRA

N92-33288# Dynamics Research Corp., Wilmington, MA. Systems Div.
DEVELOPMENT OF RATING INSTRUMENTS AND PROCEDURES FOR AVIATION MISHAP INVESTIGATION Final Report, Jan. - Sep. 1990
SIMON R. PAWLIK, SR., EUGENE A. BRONKHORST, and TINA M. BRONKHORST Jun. 1992 86 p
(Contract DAHC35-89-D-0030)
(AD-A253072; ARI-RN-92-47) Avail: CASI HC A05/MF A01

This report summarizes the development of improved techniques, procedures, measures, and reporting methods for identifying and reporting aircrew coordination errors in U.S. Army aviation mishaps. Based on an analysis of historical aviation accident data, researchers identified a number of recurring crew coordination errors that have contributed to rotary wing accidents. The errors were categorized and used, along with a theoretical framework and associated set of rating instruments, to produce a supplemental set of investigation and reporting procedures for U.S. Army aviation mishap investigations. The supplemental investigation and reporting procedures were demonstrated and validated in the field in three Class A aviation mishap investigations conducted during the summer of 1990. Participating research psychologists accompanied the U.S. Army Safety Center Accident Investigation Board to assess and refine the procedures in actual use. GRA

N92-34081# National Transportation Safety Board, Washington, DC.
AIRCRAFT ACCIDENT/INCIDENT SUMMARY REPORT: CONTROLLED FLIGHT INTO TERRAIN BRUNO'S INC., BEECHJET, N25BR, ROME, GEORGIA, 11 DECEMBER 1991
8 Jul. 1992 32 p
(PB92-910404; NTSB/AAR-92/01/SUM) Avail: CASI HC A03/MF A01

The crash of N25BR into mountainous terrain near Rome, Georgia is explained. The safety issues discussed include the policies and procedures in corporate flight operations, the role of the first officer in corporate flight operations, and the use of ground proximity warning systems in FAR Part 91 operations of turbojet-powered airplanes. Author

N92-34105*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
NUMERICAL INVESTIGATION OF THE EFFECTS OF ICING ON FIXED AND ROTARY WING AIRCRAFT Semianual Progress Report, 1 Jan. - 30 Jun. 1992
L. N. SANKAR Jul. 1992 22 p
(Contract NAG3-768)
(NASA-CR-190542; NAS 1.26:190542) Avail: CASI HC A03/MF A01

A 2-D multi-element airfoil code was modified to study the effects of icing on the aerodynamic characteristics of high lift systems. In each zone of the flow field, the solver numerically integrates the 2-D compressible Navier-Stokes equations using a time marching scheme. The surface pressure distribution is generated over a GAW 130 airfoil/flap combination for a flap setting of 25 degrees, and an angle of attack equal to 5 degrees, at a freestream Mach number equal to 0.3. A series of calculations were performed to determine the effects of small scale ice build up on the high lift characteristics of this arifoil/flap combination. The appendix summarizes this progress. Joint studies on correlation of a 3-D iced wing code with experimental data reviewed new

measured laser Doppler velocimeter data in the separated region behind the leading edge ice shape. A version of the iced wing analysis using the Roe scheme was developed to evaluate the poor correlation between the computed and measured velocities in the separated region. Work on the extension of the wing-alone analysis to wing body configuration began with modifications to the 3-D iced wing analyses to accept externally generated grids and multi-block grids. L.R.R.

N92-34151# Dayton Univ. Research Inst., OH. Structural Integrity Div.
ENGINE BIRD INGESTION EXPERIENCE OF THE BOEING 737 AIRCRAFT: EXPANDED DATA BASE Final Report, Oct. 1986 - Sep. 1989
PETER W. HOVEY, DONALD A. SKINN, and JOSEPH J. WILSON Jul. 1992 199 p
(Contract DTFA03-88-C-00024)
(DOT/FAA/CT-91/32; UDR-TR-91-125) Avail: CASI HC A09/MF A03

The Federal Aviation Administration (FAA) Technical Center initiated a study in Oct. 1986 to determine the numbers, weights, and species of birds that are being ingested into medium and large inlet area turbofan engines and to determine what damage, if any, results. Bird ingestion data were collected for the Boeing-737 model aircraft which uses either the Pratt and Whitney JT8D medium inlet area turbofan engine or the CFM International CFM56 large inlet area turbofan engine. This report analyzes the entire 3 years of data collected by the engine manufacturers, the FAA, and the International Civil Aviation Organization (ICAO) during the period from Oct. 1986 through Sep. 1989. Author

N92-34192*# Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
IMPACTS OF TECHNOLOGY ON THE CAPACITY NEEDS OF THE US NATIONAL AIRSPACE SYSTEM
RAYMOND A. AUSROTAS and ROBERT W. SIMPSON Washington Oct. 1992 65 p Sponsored by NASA. Langley Research Center
(Contract NAG1-1149; RTOP 505-69-20-01)
(NASA-CR-4470; NAS 1.26:4470; FTL-R-91-7) Avail: CASI HC A04/MF A01

A review of the U.S. air transportation system is undertaken, focusing on airspace and airport capacity. Causes of delay and congestion are investigated. Aircraft noise is identified as the fundamental hindrance to capacity improvement. Research areas for NASA are suggested to improve capacity through technology. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A92-54754
TRANSFER FUNCTION BETWEEN AIRBORNE VLF TRANSMIT AND RECEIVE LOOP ANTENNA
D. R. KILGORE and SAMEH A. MITRY (Mitre Corp., McLean, VA) IN: MILCOM '91 - IEEE Military Communications Conference, McLean, VA, Nov. 4-7, 1991, Conference Record. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 47-55. refs
Copyright

The U.S. Navy TACAMO aircraft is required to receive very low frequency/low frequency (VLF/LF) signals via a pair of orthogonal H-field loop antennas while simultaneously transmitting a 200-kW VLF signal using a half wavelength dual trailing wire antenna (DTWA). The transfer function is determined from the DTWA current, at a point were it can be measured, to the electromagnetic H-field as sensed by the receive loop antennas. The energy from the collocated VLF transmitter interferes with reception over a large portion of the VL/LF spectrum. The results of the calculations suggest that self-interference can be reduced with simple cancellation techniques. I.E.

A92-54902
THE APPLICATION OF IMAGING SENSORS TO AIRCRAFT LANDINGS IN ADVERSE WEATHER
STUART W. GREENWOOD (Maryland, University, Greenbelt) Microwave Journal (ISSN 0192-6225), vol. 35, no. 9, Sept. 1992, p. 80, 83, 87-89. refs
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Flight test data accumulated to encourage the applications of imaging sensors to aircraft landings in adverse weather are reviewed. Particular attention is given to adverse weather landing programs, technology issues, weather effects on atmospheric transmission, and an example of extinction coefficient calculation. Flight test results using a Cessna 402 aircraft show that forward-looking infrared devices are suitable for landing and taxiing under adverse weather conditions. Millimeter-wave systems are considered to have better fog penetration capability. O.G.

A92-55211*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VISION-BASED STEREO RANGING AS AN OPTIMAL CONTROL PROBLEM
P. K. A. MENON, B. SRIDHAR, and G. B. CHATTERJI (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 594-604. refs
(Contract NCC2-575)
(AIAA PAPER 92-4418) Copyright

The recent interest in the use of machine vision for flight vehicle guidance is motivated by the need to automate the nap-of-the-earth flight regime of helicopters. Vision-based stereo ranging problem is cast as an optimal control problem in this paper. A quadratic performance index consisting of the integral of the error between observed image irradiances and those predicted by a Pade approximation of the correspondence hypothesis is then used to define an optimization problem. The necessary conditions for optimality yield a set of linear two-point boundary-value problems. These two-point boundary-value problems are solved in feedback form using a version of the backward sweep method. Application of the ranging algorithm is illustrated using a laboratory image pair. Author

A92-55955
THE EFFECT OF GYRO NONORTHOGONALITY ERROR ON GYROCOMPASSING
BENI I. PRIEL (Israel Aircraft Industries, Ltd., Tamam Electronics Div., Yahud) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 28, no. 3, July 1992, p. 890-893. refs
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The effect of the gyro nonorthogonality on the two-step gyrocompassing process is analyzed. It is shown that the azimuth misalignment resulting from gyro nonorthogonality depends on the platform direction with respect to geographic frame. Cygrocompassing error is explicitly expressed in terms of gyro nonorthogonality and gyro parameters. A compensation scheme to eliminate the gyrocompassing error, which results from gyro nonorthogonality, is presented. This method can be used in cases where the gyro nonorthogonality error is beyond the standard requirements for high quality platforms. The main advantage is that it allows an increase in the tolerance of gyro nonorthogonality, and reduces the cost of inertial measurement unit manufacture. Author

A92-55968* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ANALYSIS OF IMAGE-BASED NAVIGATION SYSTEM FOR ROTORCRAFT LOW-ALTITUDE FLIGHT
BANAVAR SRIDHAR (NASA, Ames Research Center, Moffett Field, CA) and ANIL V. PHATAK (Analytical Mechanics Associates, Mountain View, CA) IEEE Transactions on Systems, Man, and Cybernetics (ISSN 0018-9472), vol. 22, no. 2, Mar.-Apr. 1992, p. 290-299. refs
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Some of the issues in the location of objects using a sequence of images from a passive sensor are examined. Image-object differential equations for a rotorcraft executing an arbitrary maneuver are developed. Assuming an onboard inertial navigation system for rotorcraft, state estimation, this study considers how object location is affected by the choice of Kalman filter estimation technique, the rotorcraft, and the object. Simulation results are presented. I.E.

A92-55973
DISCRETE EVENT FUZZY AIRPORT CONTROL
JOHN R. CLYMER (California State University, Fullerton), PHILIP D. COREY (Rockwell International Corp., Placentia, CA), and JUDITH A. GARDNER (Hughes Aircraft Co., Fullerton, CA) IEEE Transactions on Systems, Man, and Cybernetics (ISSN 0018-9472), vol. 22, no. 2, Mar.-Apr. 1992, p. 343-351. refs
Copyright

A discrete event simulation that uses a modified expert system as a controller is described. Fuzzy logic concepts from analog controllers are applied in the expert system controller to mimic human control of an airport, modeled with a combined discrete and continuous state space. The controller is adaptive so rule confidences are automatically varied to achieve near optimum system performance. An explicit formalism, called operational evaluation modeling (OpEM), is used to describe airport operations. This formalism assists a systems analyst in visualizing system operation and, in particular, greatly assists in performing the knowledge engineering required to determine control rules. I.E.

A92-56081
HEIGHT KEEPING PERFORMANCE REQUIREMENTS FOR REDUCING VERTICAL SEPARATION MINIMA USED FOR AIR TRAFFIC CONTROL
SAKAE NAGAOKA (Electronic Navigation Research Institute, Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 362-365. In Japanese. refs

The Review of the General Concept of Separation Panel of the ICAO concluded that the reduction of the current 2000-ft vertical separation minimum to 1000 ft was technically feasible at or above 29,000 ft altitude. Recently, the Panel developed a guidance material for its implementation. This paper briefly describes the Panel's works and height-keeping performance requirements. Author

A92-56088
HISTORY OF AERONAUTICAL SATELLITE COMMUNICATIONS
SHINGO OHMORI (Communications Research Laboratory, Koganei, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 398-401. In Japanese. refs

The history of aeronautical satellite communications is introduced. The trends of aeronautical satellite communications, such as air traffic control, aeronautical operational communication, and aeronautical passenger communications are discussed, and the AvSAT plan is addressed. Y.P.Q.

A92-56089
AERONAUTICAL SATELLITE COMMUNICATIONS SYSTEM
TOSHIRO KOJIMA (Kokusai Denshin Denwa Co., Ltd., Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 402-405. In Japanese.

Communications between aircraft and ground stations have employed HF and VHF bands. UHF band is also used to provide public telephone services on domestic flights. Their service quality or coverage is limited for airliners flying long distances. An aeronautical satellite communications system has been developed as innovative air-ground communications system, and inflight service trials through the Inmarsat satellite were carried out on B-747 passenger airplane in 1987-1988 and 1990. Aeronautical low-rate data communication services were commenced in December 1990 and will provide aeronautical voice services in 1991 on the Pacific Ocean region through the Inmarsat system. This paper presents an aeronautical satellite communications system composed of airborne and ground equipment and space segment. Author

A92-56090
A DATA PROCESSING SYSTEM FOR OCEANIC AIR TRAFFIC CONTROL
HIROKI SATO (Electronic Navigation Research Institute, Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 406-409. In Japanese.

The Oceanic Air Traffic Control Data Processing System (ODP) is described. ODP predicts an aircraft's movement by analyzing its flight plan data and displays information such as an aircraft's call sign, position, altitude, and flight route as reported by high frequency radio link on a 20 in x 20 in flat video display terminal. C.D.

A92-56091
AIRCRAFT SATELLITE COMMUNICATION SYSTEMS
YOSHINORI SEINO (Toshiba Corp., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 410-413. In Japanese.

An aircraft earth station (AES) system of aircraft satellite communications is presented. The communication service channels for signal link control are introduced, such as the packet mode time division multiplex channel, the random access channel reservation TDMA channel, and the circuit mode SCPC voice channel. The AES components and their configurations are discussed. Y.P.Q.

A92-56092
EVALUATION REPORT OF AN EXPERIMENTAL SATCOM OPERATION BY A JAPAN AIRLINE'S B747 PASSENGER PLANE
KEIICHI TSUCHIYA (Japan Airlines Co., Ltd., Tokyo) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 414-417. In Japanese.

An inflight Satcom service trial was carried out through the Immarsat system utilizing a Japan Airline's B747 passenger plane. A total of three digital voice/fax communication channels for Aeronautical Operational Communication, Aeronautical Administrative Communication, and Aeronautical Passenger Communication were established simultaneously by utilizing the class-A linear high power amplifier and the combination of 9.6/4.8 Kbps voice codes. Through the trial, the voice quality of 4.8 Kbps voice code was recognized as satisfactory for the application for aeronautical satellite communication. Author

A92-56093
AN EXPERIMENTAL PROGRAM CONCERNING A SATELLITE DATA LINK FOR OCEANIC ATC
KENJI NIIMI, AKIRE ISHIDE, MITSUHIRO FUJITA, KIYOSHI YUKAWA, and MASAHIKO OONUMA (Electronic Navigation Research Institute, Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 418-421. In Japanese. refs

The concept of satellite data link research is discussed. Automatic dependent surveillance (ADS) data communication is discussed, and the structures of research aircraft on-board equipment and the ground station facility are addressed. Y.P.Q.

A92-56110
A CONSIDERATION ON AIR TRAFFIC CONTROL PROCESSING CAPABILITY IN TERMINAL AREA
SACHIKO ONOZUKA, TSUKASA MATSUURA, TORU UENO, and NORIYASU TOFUKUJI (Electronic Navigation Research Institute, Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 494-497. In Japanese.

A demand for aviation has been increasing, therefore the air traffic control (ATC) system has to handle more traffic. However, there is the limit of traffic handling capability due to the controller's workload, i.e., ATC processing capability. An ATC simulation experiment in a terminal area was conducted for arrivals to examine its capability. This paper discusses the traffic handling capability in terms of the number of simultaneously controlled aircraft and communications between controllers and pseudopilots, which were analyzed using the results of two representing scenarios. Author

A92-56116
FLIGHT EVALUATION OF NAVIGATION SYSTEMS INCLUDING MLS USING NAL DO228 - OUTLINE
TAKATSUGU ONO, TOSHIHO SAKAI, YOSHIKAZU MIYAZAWA, MASAKI MURATA, AKIRA TADA, KENJI FUJII, YUKIO KAMATA, YUSHI TERUI, MASARU NAKAMURA, TADAO UCHIDA (National Aerospace Laboratory, Chofu, Japan) et al. IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 520-523. In Japanese. refs

At Sendai Airport, flight evaluation tests of navigation systems (MLS, DME/P, GPS, INS and Radio Altimeter) were conducted with NAL Do228. Reference flight path data were obtained by an ENRI laser tracking system. This paper describes the outline of the flight tests, equipment, flight data acquisition system, and laser tracking data processing. Author

A92-56117
FLIGHT EVALUATION OF NAVIGATION SYSTEMS INCLUDING MLS USING NAL DO228 - RESULTS OF MLS
TAKATSUGU ONO, YOSHINORI OKUNO, TOSHIHARU INAGAKI, YOSHITAKA MURAKAMI (National Aerospace Laboratory, Chofu, Japan), HIROHISA TAJIMA (Electronic Navigation Research Institute, Tokyo, Japan), HIROSHI IIDA, and KENICHI SHIRAKAWA (NEC Corp., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 524-527. In Japanese. refs

Flight tests for landing navigation aids including MLS were conducted with a NAL research airplane at Sendai Airport. The results are briefly reported in this paper, such as the MLS coverage and 6-degree glide path performance. The measurement data for azimuth, elevation, DME/P, and radio altitude were recorded with an onboard flight data acquisition system and afterwards compared with laser tracker's reference position data. Author

A92-56118
FLIGHT EVALUATION OF NAVIGATION SYSTEMS INCLUDING MLS USING NAL DO228 - RESULTS OF GPS
KAZUTOSHI ISHIKAWA, KOKI HOZUMI, TOSHIHARU INAGAKI, HIROKIMI SHINGU (National Aerospace Laboratory, Chofu, Japan), SOUNOSUKE FUKUSHIMA (Electronic Navigation Research Institute, Tokyo, Japan), MASAYUKI IKEUCHI, MASATOSHI HARIGAE, and HIROSHI TOMITA (Toshiba Corp., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 528-531. In Japanese. refs

In 1990, navigation systems including MLS has been flight tested at Sendai airport, Japan. A civil code single-channel Global Positioning System (GPS) receiver was installed in a NAL Do228 Airplane as one of the navigation systems. A laser tracker was used as its reference, so GPS could be evaluated continually and accurately. This paper describes the results and influence of the geometric dilution of precision and of the receiver characteristic. Author

A92-56120
MEASUREMENT OF POSITION AND ATTITUDE USING LASER AND RETRO-REFLECTORS
T. TSUMURA, T. OKUBA, N. KOMATSU, and M. NIWA IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 536-539. In Japanese. refs

This paper proposes a method for measuring the position and attitude of a vehicle by using a laser-scanner and retro-reflectors. Retro-reflectors are attached to the underside of the vehicle, and the orientation angle of the reflected beams is measured to calculate the position and attitude of the vehicle in three-dimensional space. This paper presents the theory of the measurement. Author

N92-32424*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VISION-BASED RANGE ESTIMATION USING HELICOPTER FLIGHT DATA
PHILIP N. SMITH, BANAVAR SRIDHAR, and BASSAM HUSSIEN Jun. 1992 20 p
(Contract RTOP 505-64-36)
(NASA-TM-103930; A-92085; NAS 1.15:103930) Avail: CASI HC A03/MF A01

Pilot aiding during low-altitude flight depends on the ability to detect and locate obstacles near the helicopter's intended flightpath. Computer-vision-based methods provide one general approach for obstacle detection and range estimation. Several algorithms have been developed for this purpose, but have not been tested with actual flight data. This paper presents results obtained using helicopter flight data with a feature-based range estimation algorithm. A method for recursively estimating range using a Kalman filter with a monocular sequence of images and knowledge of the camera's motion is described. The helicopter flight experiment and four resulting datasets are discussed. Finally the performance of the range estimation algorithm is explored in detail based on comparison of the range estimates with true range measurements collected during the flight experiment. Author

N92-32537# Mitre Corp., McLean, VA.
SAFETY STUDY OF TCAS 2 FOR LOGIC VERSION 6.04
MICHAEL P. MCLAUGHLIN and ANDREW D. ZEITLIN Jul. 1992 90 p
(Contract DTFA01-89-C-00001)
(DOT/FAA/RD-92/22) Avail: CASI HC A05/MF A01

A system safety study of Traffic Alert and Collision Avoidance System 2 (TCAS 2) was performed to compare the safety of logic version 6.04 with the present version 6.0. The study uses a considerable body of encounter data extracted from Automated Radar Terminal System (ARTS) ground-based radar data at eight US sites. Encounter geometries are modeled using the statistics of the observed data. The performance of TCAS logic is simulated using both complete logic versions. The perceived separation statistics are combined with altimetry error models to calculate risk for each encounter geometry. These results are combined in the proportions of encounter geometries found in the airspace at each site. Using a fault tree for the critical near midair collision event, the risk ratio is calculated for each logic version relative to the risk of not using TCAS. This result is discussed in the context of the improved compatibility of the newer logic with respect to the Air Traffic Control System, which would increase overall safety. Author

N92-32830# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
DEVELOPMENT OF NEW FLIGHT PROCEDURES FOR THE MICROWAVE LANDING SYSTEM (MLS)

L. J. J. ERKELENS 23 Apr. 1991 44 p Presented at the Sipke Wynia Symposium 1991 on Environmental Issues and Pollution in Aviation, Haarlem, Netherlands, 11 Apr. 1991
(NLR-TP-91156-U; ETN-92-92001) Avail: CASI HC A03/MF A01

The shortcomings of the current Instrument Landing System (ILS), which have led to the development of the Microwave Landing System (MLS), are summarized. The basic principles of MLS are outlined. The wide coverage volume of MLS, in both azimuth and elevation, enables new flight procedures to be defined, taking into account such patterns as noise abatement, obstacle clearance, and airspace restrictions. Research on developing approach, interception, and departure procedures for the MLS, which consists of both flight trials with laboratory aircraft and flight simulator investigations on the research flight simulator, is outlined. Focus is on a recently completed flight simulator investigation on operational curved approach feasibility for a wide body type of aircraft. The test objectives of the 1990 flight simulation program are discussed. ESA

N92-32845# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
AN EVALUATION OF DECELERATING IFR APPROACHES UTILIZING A HELICOPTER FLIGHT SIMULATOR
L. D. REID, S. ADVANI, and J. H. DELEEUW Jul. 1990 218 p
(Contract W2207-7-AF69/01-SS)
(CTN-92-60348) Avail: CASI HC A10/MF A03

This project involved development of a helicopter flight simulator and its application to study instrumented flight rules (IFR) landing approaches. The helicopter simulator was implemented on the University of Toronto Institute for Aerospace Studies (UTIAS) Flight Research Simulator. It employed all the major subsystems of that facility including the motion systems, visual display system, sound system, and computer system. In addition, the flight controls and seat of a Bell 205 helicopter were installed and interfaced with the flight computer. An electronic flight instrumentation system (EFIS) was developed to act as the pilot helicopter interface. A side arm controller was also included in the simulation. The helicopter flight equations were based on an ARMCOP software package. The system was tuned with the help of an experienced Bell 205 test pilot. The simulated flight test project was directed towards establishing the ability of the simulator to duplicate handling qualities results achieved in actual flight. The task selected was that of decelerating IFR approaches using flight control systems and a three cue flight director. A group of 6 evaluation pilots repeated flying tasks previously completed in an actual Bell 205. Good agreement between the simulator and flight test data was achieved except for one configuration. This configuration was found to be easier to fly in the simulator. The cause of this was felt to be incorrect simulation of the corresponding flight control system.
Author (CISTI)

N92-32849# Institute for Aerospace Research, Ottawa (Ontario). Flight Research Lab.
A KALMAN FILTER INTEGRATED NAVIGATION DESIGN FOR THE IAR TWIN OTTER ATMOSPHERIC RESEARCH AIRCRAFT [METHODE DE NAVIGATION INTEGREE A FILTRE DE KALMAN DESTINEE AU TWIN OTTER DE L'IRA CHARGE DES RECHERCHES ATMOSPHERIQUES]
B. W. LEACH Apr. 1991 113 p
(NRC-32148; IAR-AN-72; CTN-92-60369) Avail: CASI HC A06/MF A02

The Institute of Aerospace Research Twin Otter Atmospheric Research Aircraft requires accurate, inertially based navigation data for both track recovery and the calculation of wind gust components. The Kalman filter integrated navigation design described in this report is based on the optimal blending of data from an LTN-90-100 strapdown Inertial Reference System (IRS), a Decca Type 72 Doppler velocity sensing (DVS) system and an ARNAV R-40 airborne Loran-C receiver - sensors that are available on the Twin Otter. All three of these navigation sensors are interfaced to the onboard LSI-11/73 microcomputer system, and a complete set of navigation parameters is recorded. A major reason for the integrated navigation approach is the observation that significant velocity errors can occur in the LTN-90-100 IRS over the course of a flight, and the observed error levels can seriously degrade the accuracy of the wind calculations. The airborne Loran-C positional data has been demonstrated to be consistently more accurate than the IRS position information, in the long term. An integrated navigation system approach, using the principles of Kalman filtering, is shown to have the ability to use Loran C data (and, to a lesser extent, Doppler velocity data) to accurately track the dominant IRS errors and provide IRS error corrections at a rate appropriate for Twin Otter requirements.
Author (CISTI)

N92-32861# General Accounting Office, Washington, DC. Information Management and Technology Div.
AIR TRAFFIC CONTROL: FAA'S ADVANCED AUTOMATION SYSTEM CONTRACT
Mar. 1991 14 p
(GAO/IMTEC-91-25; B-242745) Avail: CASI HC A03/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

A report to the Chairman of the Senate Subcommittee on Transportation and Related Agencies is presented for the Federal Aviation Administration's (FAA) Advanced Automation System (AAS) contract. The AAS was awarded to IBM to complete the design and production of a new computerized air traffic control system intended to replace aging hardware, software, and air traffic controller workstations. The report addresses the development and implementation of a management control installed by IBM which provides detailed contract information and allows FAA to identify the cost and performance of AAS. I.I.C.

N92-33098# Mitre Corp., McLean, VA.
SIMULATION TEST AND EVALUATION OF TCAS 2 LOGIC VERSION 6.04
SUZANNE BRADLEY Jul. 1992 108 p
(Contract DTFA01-89-C-00001)
(DOT/FAA/RD-92/23) Avail: CASI HC A06/MF A02

The objectives of the Traffic Alert and Collision Avoidance System 2 (TCAS 2) version 6.04 logic and the testing and evaluation of it are presented. The operational problems experienced with its predecessor, version 6.0, along with the modifications that address them are described. Performance of the two logic versions were compared using simulations of encounters derived from ground radar data from eleven U.S. locations. The two major goals in comparing the logic versions were the following: to obtain an assessment of the effectiveness of the changes of the collision avoidance capability, and to characterize the effect of changes on the air traffic control. Author

N92-33308# Federal Aviation Administration, Atlantic City, NJ.
ILS MATHEMATICAL MODELING STUDY OF AN ILS LOCALIZER AND GLIDE SLOPE PROPOSED FOR RUNWAY 32R, MOFFETT FIELD AIRPORT, CALIFORNIA Technical Report, May 1992
JAMES D. RAMBONE Sep. 1992 29 p
(Contract FAA-T0603-S)
(DOT/FAA/CT-TN92/28) Avail: CASI HC A03/MF A01

Described here is the instrument landing system (ILS) math modeling performed by the Federal Aviation Administration (FAA) Technical Center at the request of the NASA-Ames Research Center Aircraft Operations Division. Computed localizer data are presented showing the effects of three large airship hangars on the performance of an ILS localizer proposed for runaway 32R at the Moffett Field Airport. There is concern that reflections from the large airship hangars may degrade the localizer course beyond Category I tolerances. A 14/6 dual-frequency localizer antenna system, a Redlich system, and a Wilcox 14/10 system (currently under development) were modeled at the proposed localizer site. Modeled course structure results for a 14/6 dual-frequency antenna exceed Category I tolerance limits. Modeled course structure results indicate that Category I localizer performance should be obtained with a Redlich antenna system or a Wilcox 14/10 antenna system installed at the proposed location. Computed clearance orbit results for the Redlich antenna and Wilcox 14/10 system indicate

satisfactory linearity, course crossover, and signal clearance levels. Data are also presented showing the computed performance for a glide slope proposed for runaway 32R at Moffett Field Airport. As requested, a capture effect system was modeled at the proposed glide slope site located 1,038 feet back from runaway threshold and 400 feet right offset of centerline. Glide slope modeling computed only the effect of terrain on glide slope performance using the Geometric Theory of Diffraction-3D (GTD-3D) model. Modeled path structure and level run plots are provided for the proposed capture effect system. Results indicate that a capture effect system modeled at the proposed site should meet Category I path structure, linearity, and symmetry tolerances. Author

N92-33351*# Bureau International des Poids et Mesures, Sevres (France).
THE NEED FOR GPS STANDARDIZATION
WLODZIMIERZ W. LEWANDOWSKI, GERARD PETIT, and CLAUDINE THOMAS *In* NASA. Goddard Space Flight Center, Proceedings of the 23rd Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting p 1-13 Jul. 1992
Avail: CASI HC A03/MF A04

A desirable and necessary step for improvement of the accuracy of Global Positioning System (GPS) time comparisons is the establishment of common GPS standards. For this reason, the CCDS proposed the creation of a special group of experts with the objective of recommending procedures and models for operational time transfer by GPS common-view method. Since the announcement of the implementation of Selective Availability at the end of last spring, action has become much more urgent and this CCDS Group on GPS Time Transfer Standards has now been set up. It operates under the auspices of the permanent CCDS Working Group on TAI and works in close cooperation with the Sub-Committee on Time of the Civil GPS Service Interface Committee (CGSIC). Taking as an example the implementation of SA during the first week of July 1991, this paper illustrates the need to develop urgently at least two standardized procedures in GPS receiver software: monitoring GPS tracks with a common time scale and retaining broadcast ephemeris parameters throughout the duration of a track. Other matters requiring action are the adoption of common models for atmospheric delay, a common approach to hardware design and agreement about short-term data processing. Several examples of such deficiencies in standardization are presented. Author

N92-33352*# Omega Navigation System Center, Alexandria, VA. Global Positioning System Information Center Branch.
US COAST GUARD GPS INFORMATION CENTER (GPSIC) AND ITS FUNCTION WITHIN THE CIVIL GPS SERVICE (CGS)
LUANN BARNDT *In* NASA. Goddard Space Flight Center, Proceedings of the 23rd Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting p 15-34 Jul. 1992
Revised
Avail: CASI HC A03/MF A04

The Global Positioning System Information Center (GPSIC) was created to provide civil users of the Global Positioning System with timely system status and other GPS satellite information. The GPSIC began providing basic services on a test and evaluation basis in March 1990. Since then we have improved these services, formalized the information gathering processes, and expanded GPSIC operations to meet GPS user needs. The GPSIC serves as a central point of contact for civil users to make their interests and needs known to the system operator, the Department of Defense (DOD) under the management of the U.S. Air Force. The GPSIC provides GPS information to civil users through Operational Advisory Broadcasts (OAB) containing GPS performance data. The OABs are disseminated through numerous sources including 24 hour access to a voice telephone recording and a computer bulletin board system (BBS). The GPSIC staff also responds to individual user inquiries, comments, or concerns about civil access to and use of the GPS during normal working hours. This paper provides an overview of the Civil GPS Service as well as the details of the type of information and services that are available through the GPSIC and how they can be obtained. It will also address the future expansion of GPSIC responsibilities. Author

N92-33353*# Aerospace Corp., El Segundo, CA.
EVALUATION OF GPS/UTC STEERING PERFORMANCE
W. A. FEESS, H. HOLTZ, A. L. SATIN, and COLLEEN H. YINGER *In* NASA. Goddard Space Flight Center, Proceedings of the 23rd Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting p 35-48 Jul. 1992
Avail: CASI HC A03/MF A04

The Global Positioning System (GPS) is required to maintain GPS time to Universal Coordinated Time (UTC) to an accuracy of one microsecond and broadcast to the user the offset between GPS and UTC to an accuracy of 100 nanoseconds (1 sigma). On 25 Jun. 1990, an automatic steering algorithm was implemented to control GPS time to synchronize it with UTC. The description of the steering laws and predicted performance results were presented at the 1989 Precise Time and Time Interval (PTTI) conference, while preliminary performance results were presented at the 1990 PTTI conference. The initial performance was not as predicted, resulting in an in-depth analysis of the observed performance and a more thorough sensitivity analysis. In addition, responses to anomalies were investigated. This paper will describe these analyses and results, and evaluate actual steering performance from Jun. 1990 to Nov. 1991. Although anomalies were observed during the initial phase of steering, recent experience is more in line with expectations. Author

N92-33354*# National Oceanic and Atmospheric Administration, Rockville, MD. Ocean and Earth Sciences Div.
GPS ORBIT DETERMINATION AT THE NATIONAL GEODETIC SURVEY
MARK S. SCHENEWERK *In* NASA. Goddard Space Flight Center, Proceedings of the 23rd Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting p 49-58 Jul. 1992
Avail: CASI HC A02/MF A04

The National Geodetic Survey (NGS) independently generates precise ephemerides for all available Global Positioning System (GPS) satellites. Beginning in 1991, these ephemerides were produced from double-differenced phase observations solely from the Cooperative International GPS Network (CIGNET) tracking sites. The double-difference technique combines simultaneous observations of two satellites from two ground stations effectively eliminating satellite and ground receiver clock errors, and the Selective Availability (S/A) signal degradation currently in effect. CIGNET is a global GPS tracking network whose primary purpose is to provide data for orbit production. The CIGNET data are collected daily at NGS and are available to the public. Each ephemeris covers a single week and is available within one month after the data were taken. Verification is by baseline repeatability and direct comparison with other ephemerides. Typically, an ephemeris is accurate at a few parts in 10(exp 7). This corresponds to a 10 meter error in the reported satellite positions. NGS is actively investigating methods to improve the accuracy of its orbits, the ultimate goal being one part in 10(exp 8) or better. The ephemerides are generally available to the public through the Coast Guard GPS Information Center or directly from NGS through the Geodetic Information Service. An overview of the techniques and software used in orbit generation will be given, the current status of CIGNET will be described, and a summary of the ephemeris verification results will be presented. Author

N92-33355*# Bureau International des Poids et Mesures, Sevres (France).
PRECISE GPS EPHEMERIDES FROM DMA AND NGS TESTED BY TIME TRANSFER
WLODZIMIERZ W. LEWANDOWSKI, GERARD PETIT, and CLAUDINE THOMAS *In* NASA. Goddard Space Flight Center, Proceedings of the 23rd Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting p 59-70 Jul. 1992
Avail: CASI HC A03/MF A04

It was shown that the use of the Defense Mapping Agency's

(DMA) precise ephemerides brings a significant improvement to the accuracy of GPS time transfer. At present a new set of precise ephemerides produced by the National Geodetic Survey (NGS) has been made available to the timing community. This study demonstrates that both types of precise ephemerides improve long-distance GPS time transfer and remove the effects of Selective Availability (SA) degradation of broadcast ephemerides. The issue of overcoming SA is also discussed in terms of the routine availability of precise ephemerides. Author

N92-33356*# Technische Univ., Graz (Austria).
COMPARISON OF TWO-WAY SATELLITE TIME TRANSFER AND GPS COMMON-VIEW TIME TRANSFER BETWEEN OCA AND TUG
DIETER KIRCHNER, U. THYR, H. RESSLER, R. ROBNIK, P. GRUDLER (Observatoire de la Cote d'Azur, Nice, France), FRANCOISE S. BAUMONT (Observatoire de la Cote d'Azur, Nice, France), CHRISTIAN VEILLET (Observatoire de la Cote d'Azur, Nice, France), WLODZIMIERZ W. LEWANDOWSKI (Bureau International des Poids et Mesures, Sevres, France), W. HANSON (National Inst. of Standards and Technology, Boulder, CO.), A. CLEMENTS (National Inst. of Standards and Technology, Boulder, CO.) et al. *In* NASA. Goddard Space Flight Center, Proceedings of the 23rd Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting p 71-88 Jul. 1992 Sponsored by Bureau Nationale de Metrologie; Academy of Sciences; and Austrian National Bank
Avail: CASI HC A03/MF A04

For about one year the time scales UTC(OCA) and UTC(TUG) were compared by means of GPS and two-way satellite time transfer. At the end of the experiment both links were independently 'calibrated' by measuring the differential delays of the GPS receivers and of the satellite earth stations by transportation of a GPS receiver and of one of the satellite terminals. The results obtained by both methods differ by about 3 ns, but reveal a seasonal variation of about 8 ns peak-to-peak which is likely the result of a temperature-dependence of the delays of the GPS receivers used. For the comparison of both methods the stabilities of the timescales are of great importance. Unfortunately, during the last three months of the experiment a less stable clock had to be used for the generation of UTC(TUG). Author

N92-33358*# Naval Observatory, Washington, DC. Time Service Dept.
LORAN-C DATA REDUCTION AT THE US NAVAL OBSERVATORY
HAROLD CHADSEY *In* NASA. Goddard Space Flight Center, Proceedings of the 23rd Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting p 103-110 Jul. 1992
Avail: CASI HC A02/MF A04

As part of its mission and in cooperation with the U.S. Coast Guard, the U.S. Naval Observatory (USNO) monitors and reports the timing of the LORAN-C chains. The procedures for monitoring and processing the reported values have evolved with advances in monitoring equipment, computer interfaces and PCs. This paper discusses the current standardized procedures used by USNO to sort the raw data according to Group Repetition Interval (GRI) rate, to fit and smooth the data points, and, for chains remotely monitored, to tie the values to the USNO Master Clock. The results of these procedures are the LORAN time of transmission values, as references to UTC(USNO) (Universal Coordinated Time) for all LORAN chains. This information is available to users via USNO publications and the USNO Automated Data Service (ADS).
Author

N92-33381*# Leeds Univ. (England). Dept. of Electronic and Electrical Engineering.
COMPARISON OF GLONASS AND GPS TIME TRANSFERS BETWEEN TWO WEST EUROPEAN TIME LABORATORIES AND VNIIFTRI
P. DALY, N. B. KOSHELYAEVSKY (Vsesoyuznyi Nauchno-Issledovatelskii Inst. Radiatsionnoi Tekhniki, Moscow, USSR), WLODZIMIERZ LEWANDOWSKI (Bureau International des Poids et Mesures, Sevres, France), GERARD PETIT (Bureau International des Poids et Mesures, Sevres, France), and CLAUDINE THOMAS (Bureau International des Poids et Mesures, Sevres, France) *In* NASA. Goddard Space Flight Center, Proceedings of the 23rd Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting p 341-350 Jul. 1992
Avail: CASI HC A02/MF A04

The University of Leeds built a Global Positioning System/Global Orbiting Navigation Satellite System (GPS/GLONASS) receiver about five years ago and since then has provided continuous information about GLONASS time and its comparison with GPS time. For the last two years, VNIIFTRI (All Union Institute for Physical, Technical and Radiotechnical Measurements) and some other Soviet time laboratories have used Soviet built GLONASS navigation receivers for time comparisons. Since June 1991, VNIIFTIR has been operating a GPS time receiver on loan from the BIPM (Bureau International des Poids et Mesures). This offered, for the first time, an opportunity for direct comparison of time transfers using GPS and GLONASS. This experiment shows that even with relatively imprecise data recording and processing, in terms of time metrology, GLONASS can provide continental time transfer at a level of several tens of nanoseconds. Author

N92-33407*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DESIGN AND EVALUATION OF AN ADVANCED AIR-GROUND DATA-LINK SYSTEM FOR AIR TRAFFIC CONTROL
WIM DENBRAVEN Jan. 1992 40 p Original contains color illustrations
(Contract RTOP 505-64-13)
(NASA-TM-103899; A-92003; NAS 1.15:103899) Avail: CASI HC A03/MF A01; 1 functional color page

The design and evaluation of the ground-based portion of an air-ground data-link system for air traffic control (ATC) are described. The system was developed to support the 4D Aircraft/ATC Integration Study, a joint simulation experiment conducted at NASA's Ames and Langley Research Centers. The experiment focused on airborne and ground-based procedures for handling aircraft equipped with a 4D-Flight Management System (FMS) and the system requirements needed to ensure conflict-free traffic flow. The Center/TRACON Automation System (CTAS) at Ames was used for the ATC part of the experiment, and the 4D-FMS-equipped aircraft was simulated by the Transport Systems Research Vehicle (TSRV) simulator at Langley. The data-link system supported not only conventional ATC communications, but also the communications needed to accommodate the 4D-FMS capabilities of advanced aircraft. Of great significance was the synergism gained from integrating the data link with CTAS. Information transmitted via the data link was used to improve the monitoring and analysis capability of CTAS without increasing controller input workload. Conversely, CTAS was used to anticipate and create prototype messages, thus reducing the workload associated with the manual creation of data-link messages.
Author

N92-33596# Federal Aviation Administration, Cambridge, MA. National Transportation Systems Center.
CONTROLLER RESPONSE TO CONFLICT RESOLUTION ADVISORY PROTOTYPE Final Report, Apr. - Dec. 1991
K. M. CARDOSI, M. WARNER, P. W. BOOLE, P. MENGERT, and R. DISARIO Jan. 1992 22 p Prepared in cooperation with EG and G Dynatrend, Inc., Woburn, MA
(PB92-190032; DOT-VNTSC-FAA-92-1; DOT/FAA/AM-92-03; AD-A252922) Avail: CASI HC A03/MF A01

Conflict Resolution Advisory (CRA) is an automated software aid for air traffic control specialists at air route traffic control centers (ARTCC's). CRA calculates, validates, and displays to the en route controller a single resolution for predicted separation violations detected by the conflict alert (CA) function. This simulation study was conducted to determine controller response time to a CRA message. The response time is the total time required for controllers to notice that the advisory is present, to read and comprehend the text message, and to decide that the resolution is acceptable.

Since only the prototype software (CRAU) was available for the test, the only other issue that was formally addressed was controller comments on the CRA message format. The implication of the results study for the calculation of the delay that is to be expected between CRA onset and pilot response is also discussed.
Author

N92-33609*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A WORKSTATION-BASED EVALUATION OF A FAR-FIELD ROUTE PLANNER FOR HELICOPTERS
DAVID N. WARNER, JR. and FRANCIS J. MORAN Jun. 1991 24 p Original contains color illustrations
(Contract RTOP 505-66-11)
(NASA-TM-102882; A-91011; NAS 1.15:102882) Avail: CASI HC A03/MF A01; 13 functional color pages

Helicopter flight missions at very low, nap of the Earth, altitudes place a heavy workload on the pilot. To aid in reducing this workload, Ames Research Center has been investigating various types of automated route planners. As part of an automated preflight mission planner, a route planner algorithm aids in selecting the overall (far-field) route to be flown. During the mission, the route planner can be used to replan a new route in case of unexpected threats or change in mission requirements. An evaluation of a candidate route planning algorithm, based on dynamic programming techniques is described. This algorithm meets most of the requirements for route planning, both preflight and during the mission. In general, the requirements are to minimize the distance and/or fuel and the deviation from a flight time schedule, and must be flyable within the constraints of available fuel and time. Author

N92-33693# Technische Univ., Delft (Netherlands). Sectie Mathematische Geodesie en Puntsbepaling.
CALIBRATION OF GPS ANTENNAS Thesis [CALIBRATIE VAN GPS-ANTENNES]
M. W. VANDERHOEK Jan. 1992 124 p In DUTCH
(ETN-92-92034) Avail: CASI HC A06/MF A02

Global Positioning System (GPS) antennas were calibrated with a view to geodetic measurements and the densification of large networks. The position of the (imaginary) phase center of the antenna was determined with respect to the terrestrial point above which the antenna is located. As an aspect of the antenna calibration the position of the imaginary phase center was further analyzed on the basis of the Weltzell receiver combination test observations using different data analysis methods. The method using the estimation of three coordinates gives better results than that which fixes latitude and longitude. The position of the imaginary phase center depends on the fixing of the ambiguity parameters on integer values. ESA

N92-33809# Coast Guard Academy, New London, CT. Center for Advanced Studies.
INTEGRATED RUSSIAN VLF/OMEGA RECEIVER DESIGN Final Report
B. PETERSON, K. GROSS, E. CHAMBERLIN, and T. MONTAGUE Jan. 1992 11 p
(PB92-193390; USCGA-TR-1-92) Avail: CASI HC A03/MF A01

With recent statements from Russian officials indicating their very long frequency (VLF) navigation system may be operated in the future for worldwide civil use, its potential use in conjunction with the existing Omega system is of renewed interest. The design of an Integrated Russian VLF/Omega Receiver implemented on a Texas Instruments TMS320C25 microprocessor based Ariel DSP 16 plug-in board installed in a PC-compatible portable computer is presented. The system also requires an external antenna, pre-amp, and frequency reference. The DSP16 board digitizes the radio frequency (RF) signal to 16 bits and then digitally mixes with the sines and cosines of the three Soviet frequencies plus 10.2, 11 1/3, and 13.6 kHz. The mixer outputs are lowpass filtered and the comb filters implemented for the respective epochs. The PC compatible computer accesses and processes the comb filter outputs, calculating and logging signal phase and amplitude. The design allows for each future expansion to include unique and VLF communications frequencies. Author

N92-34203*# California Polytechnic State Univ., San Luis Obispo. Transportation Research Group.
HUMAN FACTORS ISSUES IN THE USE OF ARTIFICIAL INTELLIGENCE IN AIR TRAFFIC CONTROL. OCTOBER 1990 WORKSHOP Final Report, Jun. 1990 - Dec. 1991
STEPHEN HOCKADAY and SHARON KUHLENSCHMIDT, ed. Dec. 1991 12 p Workshop held 3-5 Oct. 1990
(Contract NAG2-669)
(NASA-CR-190925; NAS 1.26:190925; TR-91-7) Avail: CASI HC A03/MF A01

The objective of the workshop was to explore the role of human factors in facilitating the introduction of artificial intelligence (AI) to advanced air traffic control (ATC) automation concepts. AI is an umbrella term which is continually expanding to cover a variety of techniques where machines are performing actions taken based upon dynamic, external stimuli. AI methods can be implemented using more traditional programming languages such as LISP or PROLOG, or they can be implemented using state-of-the-art techniques such as object-oriented programming, neural nets (hardware or software), and knowledge based expert systems. As this technology advances and as increasingly powerful computing platforms become available, the use of AI to enhance ATC systems can be realized. Substantial efforts along these lines are already being undertaken at the FAA Technical Center, NASA Ames Research Center, academic institutions, industry, and elsewhere. Although it is clear that the technology is ripe for bringing computer automation to ATC systems, the proper scope and role of automation are not at all apparent. The major concern is how to combine human controllers with computer technology. A wide spectrum of options exists, ranging from using automation only to provide extra tools to augment decision making by human controllers to turning over moment-by-moment control to automated systems and using humans as supervisors and system managers. Across this spectrum, it is now obvious that the difficulties that occur when tying human and automated systems together must be resolved so that automation can be introduced safely and effectively. The focus of the workshop was to further explore the role of injecting AI into ATC systems and to identify the human factors that need to be considered for successful application of the technology to present and future ATC systems. Author

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A92-54026*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SUMMARY HIGHLIGHTS OF THE ADVANCED ROTORCRAFT TRANSMISSION (ART) PROGRAM
ROBERT C. BILL (U.S. Army, Vehicle Propulsion Directorate; NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 25 p. refs
(AIAA PAPER 92-3362)

The NASA/U.S. Army Advanced Rotorcraft Transmission (ART) program is charged with the development and demonstration of lightweight, durable drivetrains for next-generation rotorcraft: (1) a Future Air Attack Vehicle for tactical ground-support and air-to-air missions, and (2) an Advanced Cargo Aircraft for heavy-lift field-support operations. Both tilt-rotor and more conventional helicopter configurations have been studied by the ART program. ART performance goals are sought through the use of advanced

component materials and lubrication systems, transmission and geartrain configurations, and airframe/drivetrain integrations.
O.C.

A92-54550
ROTARY WING STRUCTURAL DYNAMICS AND AEROELASTICITY
RICHARD L. BIELAWA Washington, American Institute of Aeronautics and Astronautics, Inc., 1992, 583 p. refs
(ISBN 1-56347-031-4) Copyright

The present volume is a comprehensive account of the fundamental concepts of structural dynamics and aeroelasticity for the conventional rotary wing aircraft as well as for the newly emerging tilt-rotor and tilt-wing aircraft. Topics addressed include basic analysis tools, rotating beams, gyroscopic phenomena, drive system dynamics, fuselage vibrations, methods for controlling vibrations, dynamic test procedures, stability analysis, mechanical and aeromechanical instabilities of rotors and rotor-pylon assemblies, unsteady aerodynamics, and flutter of rotors, as well as model testing. Other objectives of the text are to provide the practicing engineer with the fundamental knowledge in a practical format and to provide a vehicle for the teaching of the material in a university environment at the graduate level. C.A.B.

A92-54981
MIKOYAN'S MARKET-BUSTER
ALEXANDER VELOVICH Flight International (ISSN 0015-3710), vol. 142, no. 4336, Sept. 16, 1992, p. 81-84.
Copyright

A review is presented of the Mikoyan design bureau's new model, the MiG-29M, to be offered for international sales; marketing strategies include its use as a jointly developed alternative to the EFA fighter program. Attention is given to the upgraded RD-33K fan engines, the full-authority digital engine control system, the weapons-control system used for various missile packages, and the FBW analog flight-control system. R.E.P.

A92-55104
777 - THE AIRLINES' HIGHER-ORDER TECHNOLOGY AIRPLANE
PHIL CONDIT (Boeing Commercial Airplane Group, Seattle, WA) Aerospace Engineering (ISSN 0736-2536), vol. 12, no. 9, Sept. 1992, p. 36-40.
Copyright

A review is presented of the advanced technologies and the airline customer driven requirements that evolved in the development of the new 777 commercial transport aircraft. Attention is given to computer aided design, aerodynamic efficiency, new generation powerplants, advanced avionics, interior cabin flexibility, and composite structure. R.E.P.

A92-55128* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DAMVIBS LOOKS AT ROTORCRAFT VIBRATION
RAYMOND G. KVATERNIK (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 30, no. 9, Sept. 1992, p. 22-24.
Copyright

A review is presented of the NASA program of design analysis methods for vibrations (DAMVIBS) whose objective was to establish the technology base needed for developing an advanced FEM-based dynamics design capability for vibrations. New experimental/analytical studies have been performed to identify an airframe's components that require better representation in the finite element model for improved correlation with test results.
R.E.P.

A92-55131* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TURNING UP THE HEAT ON AIRCRAFT STRUCTURES
ALAN DOBYNS (Sikorsky Aircraft, Stratford, CT), CHARLES SAFF (McDonnell Aircraft Co., Saint Louis, MO), and ROBERT JOHNS (NASA, Lewis Research Center, Cleveland, OH) Aerospace America (ISSN 0740-722X), vol. 30, no. 9, Sept. 1992, p. 34-37.
Copyright

An overview is presented of the current effort in design and development of aircraft structures to achieve the lowest cost for best performance. Enhancements in this area are focused on integrated design, improved design analysis tools, low-cost fabrication techniques, and more sophisticated test methods. 3D CAD/CAM data are becoming the method through which design, manufacturing, and engineering communicate. R.E.P.

A92-55300*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ANALYSIS OF AIRFRAME/ENGINE INTERACTIONS FOR A STOVL AIRCRAFT WITH INTEGRATED FLIGHT/PROPULSION CONTROL
JOHN D. SCHIERMAN and T. A. LOWELL (Arizona State University, Tempe) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1513-1523. refs
(Contract NAG3-998)
(AIAA PAPER 92-4623) Copyright

A multivariable analysis technique is used to evaluate the effects of the dynamic cross coupling between the airframe and engine subsystems in an advanced STOVL configuration. A critical frequency range is identified along with potentially poor stability robustness due to the airframe/engine interactions. Within the critical frequency range, stability and performance are found to be sensitive to variations in the coupling between the airframe's flight path angle and the engine's fuel flow rate. A stability sensitivity study indicates that the interactions between the flight path angle and the fuel flow rate are potentially the most critical with respect to stability and performance robustness. V.L.

A92-56014
FLUTTER ANALYSIS AND WIND TUNNEL TEST WITH RESPECT TO A LOW-ASPECT-RATIO WING WITH FREE-ROTATIONAL CONTROL SURFACE
N. TODA, H. TANEDA, and M. NAGAHATA (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 56-59. In Japanese.

It is well known that the rotational mode of control surface with no balance-weight couples with wing vibrational mode, and causes control surface-wing flutter. Analytical result of our low-aspect-ratio wing with free-rotational surface shows two unstable regions, and each region corresponds to different flutter modes. A wind tunnel test has been conducted using a new test procedure, and the above phenomenon analytically predicted has proven to exist. Author

A92-56015
AN EXAMPLE OF WHIRL FLUTTER ANALYSIS
TOMIO SANDA and HIROFUMI SASHIKUMA (Kawasaki Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 60-63. In Japanese. refs

The whirl flutter analysis of a research aircraft model is presented. The damping characteristics are considered for turboprop engines are discussed. The modal damping coefficient of the entire aircraft and flutter rate are analyzed. Y.P.Q.

A92-56016
PROPELLER-NACELLE WHIRL FLUTTER ANALYSIS AND WIND TUNNEL TEST
NOBUO TODA, MASASHI NAGAHATA, NAOKO KAWAMURA (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan), SHIGERU SATO, and YUTAKA IWAHORI (NIPPI, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan

Society for Aeronautical and Space Sciences, 1991, p. 64-67. In Japanese. refs

A newly developed method of estimating the whirl flutter characteristics of propeller-nacelle system was presented. A flutter wind tunnel test was also conducted using the powered 2 DOF model, and test data was compared with the analytical results. All analytical results were slightly conservative compared with the experimental data. This method has proven to be useful to estimate the whirl flutter characteristics. Author

A92-56017
WHIRL FLUTTER ANALYSIS AND APPLICATION TO AIRCRAFT DESIGN
M. NAGAHATA (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 68-71. In Japanese.

An investigation with respect to the estimation of whirl flutter characteristics was presented using a 2 DOF analytical model. Two cases studies about structure design of nacelle system were conducted, and following guidelines were proposed. A pusher type prop.-nacelle system with high structural damping will have better whirl flutter characteristics compared with a tractor type. A nacelle design having much difference between pitch and yaw inertia will be very effective to reduce the coupling of pitch-yaw motions. Author

A92-56018
OPTIMIZATION OF COMPOSITE MATERIAL WING OF FIGHTER TYPE AIRCRAFTS
T. ONISHI and S. TAURA (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 72-75. In Japanese. refs

Composite materials have been widely used as major components of aircraft structure. Aeroelastic tailoring is one of the design techniques that would minimize weight of the structure satisfying aeroelastic requirements such as flutter speed or buckling strength etc., by controlling stiffness of the structure. MHI have been studying this area and developed aeroelastic tailoring tool called 'Miracle'. Optimizing logics adopted in Miracle and an optimization instance are shown in this paper. Author

A92-56019
RESEARCH ON AEROELASTIC TAILORING AT NAL
KOJI ISOGAI, IKUO KUMAKURA, and JIRO NAKAMICHI (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 76-79. In Japanese. refs

The research on aeroelastic tailoring at NAL is presented. Aft swept wing wind tunnel models and a full scale forward swept wing are designed using the optimization program based upon a sequential complex method, in which the derivatives of objective/constraint functions are not needed. A way of making scale models for flutter tests is also presented. The effects of the optimized fiber orientation on the flutter characteristics of forward/aft swept wing models with a core composite plate are examined experimentally. Our theoretical and experimental investigations revealed that AET can greatly improve the aerolastic characteristics of the forward/aft swept wings in the transonic range. Author

A92-56020
ANALYSIS AND WIND TUNNEL TEST OF LOW ASPECT WING GUST LOAD ALLEVIATION
YUJIRO SHIRAI, MASASHI NAGAHITA, HIROYUKI TANAKA, and AKITO TAKAGI (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 80-83. In Japanese. refs

An aeroelastic model of aircraft wings is presented. The linear quadratic Gaussian method is presented, and wing gust load alleviation control design is discussed. A comparative analysis of the effectiveness of wing gust load alleviation is presented. Y.P.Q.

A92-56051
ANALYSIS OF THE MAIN WING LIFT DISTRIBUTION OF THE STOL RESEARCH AIRCRAFT ASUKA
K. YAZAWA, H. INOKUCHI (National Aerospace Laboratory, Chofu, Japan), H. WAKAHAR et al. IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 230-233. In Japanese. refs

The airfoil and upper surface blowing (USB) flap tests of the STOL research aircraft Asuka are presented. The airfoil pressure distribution was measured. The panel method is used for the numerical calculation of the lift distribution. Y.P.Q.

A92-56061
A NOTE ON THRUST CONTROL FOR JETLINER DURING APPROACH
TSUNEHARU UEMURA (Japan Airlines Co., Ltd., Tokyo) and KANICHIRO KATO (Tokyo, University, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 270-273. In Japanese.

A method of thrust control is shown for jetliner during approach. With this method, the pilot can reduce airspeed deviation even or less compared with the operation under the auto throttle system. In this way, airspeed can be controlled with adequate thrust change, without extra acceleration or deceleration. A flight record is shown to substantiate this. Author

A92-56072
EFFICIENCY AND ACCURACY IN HELICOPTER HOVERING PERFORMANCE CALCULATION
TATSUYA MASUE (Kumamoto Institute of Technology, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 314-317. In Japanese.

The blade sectioning method is used for the calculation of helicopter hovering performance. The rotor thrust coefficient and torque shape coefficient are addressed. Flight test results are given and blade wind test data are presented. Y.P.Q.

A92-56073
SENSITIVITY ANALYSIS FOR STRUCTURAL OPTIMIZATION OF HELICOPTER ROTOR BLADES
MASATO TAKI (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) and HIROYUKI SUGIMOTO (Muroran Institute of Technology, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 318-321. In Japanese. refs

The optimal design of helicopter rotor blades using sensitivity analysis is presented. The character of natural vibration variations is discussed. Y.P.Q.

A92-56075
DESIGN AND TESTING OF A COMPOSITE HINGELESS HUB FOR ROTARY-WING AIRCRAFT
KEIZOU YAMAMOTO, TAKAHIRO ICHIHASHI (Japan Defense Agency, Technical Research and Development Institute, Tokyo), SHUNICHI BANDOU, and ASAO KAKINUMA (Kawasaki Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 326-329. In Japanese.

The structures of a composite hingeless hub for rotary-wing aircraft is presented. Strength and rigidity tests for the design of the hingeless hub are described, and tower rotation test results are analyzed. The cyclic regressive mode is discussed. Y.P.Q.

A92-56077
PILOTED SIMULATION FOR THE BK117 FBW DEMONSTRATOR

SHOJI TANASE (Kawasaki Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 334-337. In Japanese.

The flight control system design of a research helicopter is presented. The piloted simulation test is introduced, and flight control modes such as attitude command attitude hold (ACAH) and rate command attitude hold (RCAH) are addressed. The flight control computer system is described. Y.P.Q.

A92-56112
OPTIMAL DESIGN OF WING SHAPE BY USE OF NEURAL-NETWORK

WASASHI HARADA, TAKEHISA KOHDA, and KOICHI INOUE (Kyoto University, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 502-505. In Japanese. refs

It is shown that (1) the induced drag of a wing can be expressed in a tensor form by using the vortex-lattice method, (2) the above induced drag can be easily minimized by applying neural-network computing techniques, and (3) the resultant minimum-drag wing shape is similar to the crescent wing. Author

A92-56115
FLIGHT SIMULATOR TEST OF COCKPIT ADVISORY SYSTEM

KEIJI TANAKA, HIROYASU KAWAHARA, MASAHIKO NAGAYASU, KOHTARO MATSUMOTO (National Aerospace Laboratory, Chofu, Japan), ATSUSHI WATANABE, AKIHIRO ITO, and HIDEO MASUZAWA (Fujitsu, Ltd., Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 516-519. In Japanese.

This paper describes flight simulation of a cockpit human interface that timely displays aircraft conditions, warnings, and suggestions of initial actions, as well as operational procedures by monitoring aircraft utility systems. The system, called Cockpit Advisory System, is an intelligent display which behaves as a live flight manual. The current system was developed by using the utility systems of ASKA, an STOL experimental aircraft of the National Aerospace Laboratory. The system has two display units controlled by a real-time expert system. The flight simulator tests revealed that the system (1) reduced pilot workload remarkably, (2) enhanced crew coordination and situation awareness, and (3) created a completely different cockpit environment. Author

A92-56156
DYNAMIC ANALYSIS OF ROTOR BLADES WITH ROOT RETENTION DESIGN VARIATIONS

R. G. LOEWY, A. ROSEN, M. B. MATHEW, and M. ZOTTO (Rensselaer Polytechnic Institute, Troy, NY) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 782-789. Previously cited in issue 11, p. 1614, Accession no. A90-29394. refs
(Contract DAAL03-88-C-004)
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A92-56158* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MODEL FLIGHT TESTS OF A SPIN-RESISTANT TRAINER CONFIGURATION

LONG P. YIP, HOLLY M. ROSS, and DAVID B. ROBELEN (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 799-805. refs
Copyright

Powered, radio-controlled flight tests were conducted on a 1/4-scale model of a spin-resistant trainer configuration to determine the stall departure and spin resistance characteristics provided by an outboard wing leading-edge droop modification. The model was instrumented to provide quantitative as well as qualitative information on flight characteristics. Flight test results indicated that the unmodified configuration (wing leading-edge droop off) exhibited an abrupt, uncontrollable roll departure at the stall. With the outboard wing leading-edge droop installed, the modified configuration exhibited flight characteristics that were resistant to stall departure and spin entry. The stall departure and spin resistance characteristics of the modified configuration were demonstrated in flight maneuvers that included idle-power stalls, full-power stalls, sideslip stalls, and accelerated stalls. Author

A92-56160* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF ADVANCED MULTIDISCIPLINARY ANALYSIS AND OPTIMIZATION METHODS TO VEHICLE DESIGN SYNTHESIS

ROBERT D. CONSOLI (General Dynamics Corp., Fort Worth, TX) and JAROSLAW SOBIESZCZANSKI-SOBIESKI (NASA, Langley Research Center, Hampton, VA) (ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1, p. 458-467) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 811-818. Previously cited in issue 09, p. 1322, Accession no. A91-24352. refs
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A92-56171
WING MASS FORMULA FOR TWIN FUSELAGE AIRCRAFT

SERGEI V. UDIN and WILLIAM J. ANDERSON (Michigan, University, Ann Arbor) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 907-914. refs
Copyright

A formula is derived to calculate structural wing mass. This formula can be applied to twin fuselage aircraft, conventional single-body aircraft and some other unconventional aircraft (such as the Voyager). The approach is particularly useful in the first stages of preliminary aircraft design and in optimization programs where the wing-mass calculation time is an important characteristic. The concept model assumes a nontapered inboard wing section, a tapered outboard wing section and fuel stored only in the outboard wing. The theory for the wing-mass estimation is described. Unlike the other mass formulae where mass spanwise distribution is considered by an 'unloading coefficient', the present method integrates the mass spanwise distribution with the air load spanwise distribution. This allows more precise consideration of the wing geometry and mass unloading. There are no simplifications applied and the formula completely reflects the initial concept model. Good comparison with statistical data for single body aircraft is obtained. Author

A92-56174
FLIGHT MEASUREMENTS OF DOWNWASH ON THE BALL-BARTOE JETWING POWERED LIFT AIRCRAFT

U. P. SOLIES (Tennessee, University, Tullahoma) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 927-931. Previously cited in issue 14, p. 2131, Accession no. A90-33905. refs
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A92-56176* National Aeronautics and Space Administration, Washington, DC.
MULTIDISCIPLINARY OPTIMIZATION OF AEROSERVOELASTIC SYSTEMS USING REDUCED-SIZE MODELS

MORDECHAY KARPEL (Technion - Israel Institute of Technology, Haifa) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 939-946. Previously announced in STAR as N90-29385. refs
(Contract NAGW-1708)
Copyright

Efficient analytical and computational tools for simultaneous optimal design of the structural and control components of aeroservoelastic systems are presented. The optimization objective is to achieve aircraft performance requirements and sufficient flutter and control stability margins with a minimal weight penalty and without violating the design constraints. Analytical sensitivity derivatives facilitate an efficient optimization process which allows a relatively large number of design variables. Standard finite

element and unsteady aerodynamic routines are used to construct a modal data base. Minimum State aerodynamic approximations and dynamic residualization methods are used to construct a high accuracy, low order aeroservoelastic model. Sensitivity derivatives of flutter dynamic pressure, control stability margins and control effectiveness with respect to structural and control design variables are presented. The performance requirements are utilized by equality constraints which affect the sensitivity derivatives. A gradient-based optimization algorithm is used to minimize an overall cost function. A realistic numerical example of a composite wing with four controls is used to demonstrate the modeling technique, the optimization process, and their accuracy and efficiency. Author

A92-56178
FLUTTER AND STALL RESPONSE OF A HELICOPTER BLADE WITH STRUCTURAL NONLINEARITY
D. M. TANG and E. H. DOWELL (Duke University, Durham, NC) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 953-960. refs
(Contract DAAL03-87-K-0023)
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The purpose of the present paper is to study the flutter instability and forced response of a nonrotating helicopter blade model with a NACA-0012 airfoil and a pitch freeplay structural nonlinearity. In this paper, three typical combinations of linear and nonlinear structure with a linear and nonlinear (ONERA) aerodynamic model are considered. Characteristic results are used to display the limit cycle oscillation and chaotic behavior of both the flutter instability and forced response for all three cases. The effects of various initial disturbance amplitudes on the forced response behavior are discussed. Comparisons of the results for the three cases are helpful in understanding physically the nonlinear aeroelasticity phenomena and chaotic oscillations. Author

A92-56220
SOLUTIONS TO SUPPORTABILITY CONCERNS RELATED TO REDUCED-SIGNATURE AIRCRAFT
KEVIN D. WALTERS (McDonnell Aircraft Co., Saint Louis, MO) IN: Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1992, p. 210-215. refs
Copyright

It is pointed out that many of the new technologies and design philosophies associated with today's reduced-signature aircraft greatly increase the maintenance burden and limit sortie generation. To avoid this in future programs, it is imperative that R&M (reliability and maintainability) issues be addressed early and traded equally with performance requirements. By involving the R&M engineer during the conceptual design phase, balanced solutions to both low observables and supportability issues are attainable. The customer will realize a long-term cost savings with a product that meets the mission requirements. The author addresses R&M issues related to the following technologies: internal weapons bays, equipment access, moldline fasteners, gap fillers, and engine inlets. I.E.

A92-56279
FLIGHT SIMULATION MODELING IN SUPPORT OF ENGINE/AIRFRAME INTEGRATION
F. K. STRAUB, J. W. HARDING, J. M. HARRISON, and J. I. DORMAN (McDonnell Douglas Helicopter Co., Mesa, AZ) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 13 p. refs
(Contract DAAJ09-90-G-0022)

The validation of a helicopter flight simulation model, FLYRT, for investigations of engine/airframe compatibility, is presented. Typical engine response and controllability issues that can be encountered are discussed. The basis of the FLYRT model is reviewed and pertinent details of the three engine types modeled in this study are presented. The capability of FLYRT to predict engine/airframe dynamic response is validated through extensive correlation with aggressive autorotation recovery, unmask/remask, and roll reversal flight test maneuvers. FLYRT's highly efficient rotormap approach is accurate enough for most maneuvers. To capture the dynamics of roll reversals, the blade element option must be used. It is able to predict the torque spike during left roll qualitatively correctly; however, it is low in magnitude. Simulation of a large set of referee maneuvers with both the 701C Mod2 and Mod3 models is accomplished in a very short time, using a combination of the efficient rotormap and the high fidelity blade element model for the compensated and uncompensated maneuvers, respectively. C.A.B.

A92-56285* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE COMPUTATION AND VALIDATION OF HOVERING ROTOR PERFORMANCE
M. N. MBA (Marseille, Institut de Mecanique des Fluides, France), K. RAMACHANDRAN (NASA, Ames Research Center, Moffett Field, CA), and F. X. CARADONNA (U.S. Army, Aviation Systems Command; NASA, Ames Research Center, Moffett Field, CA) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 16 p. refs
(Contract DRET-89-1433-DS-SR)

Recent experience with the HELIX-I code is presented, and its ability to predict the flow and performance of both conventional rotors and the unconventional anhedral parabolic tip rotor utilized on the Super Puma MK2 is described. HELIX-I is a standard full-potential rotor code having the ability to efficiently predict the detailed flow on a rotor blade, including 3D, transonic, and weak viscous effects (using appropriate boundary layer analyses). The resulting code is the first full-potential CFD code with the ability to model free wake convection and the first CFD code of any type to predict hover performance. R.E.P.

A92-56286* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FINITE-ELEMENT ANALYSIS AND MULTIBODY DYNAMICS ISSUES IN ROTORCRAFT DYNAMIC ANALYSIS
GENE C. RUZICKA and ROBERT A. ORMISTON (U.S. Army, Aviation Systems Command; NASA, Ames Research Center, Moffett Field, CA) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 19 p. refs

There is general agreement that the development of effective rotorcraft analysis software will require the use of modern computational mechanics methodologies, especially finite element analysis and multibody dynamics. This paper examines the analysis of rotorcraft dynamics from the perspective of these methodologies. First, a general discussion of rotorcraft analysis and modeling is presented. Then, a hierarchy of rotorcraft analyses is presented, ranging from simple to complex kinematics, where it is shown that in comprehensive rotorcraft software, finite element analysis must be augmented by multibody dynamics in order to properly analyze large motions of rotorcraft components. Finally, a review of multibody dynamics is presented to further familiarize the rotorcraft community with this technology. Author

A92-56287
SIMULATION OF HELICOPTER SEE-SAW ROTOR MOTION
JANUSZ NARKIEWICZ and WIESLAW LUCJANEK (Warsaw University of Technology, Poland) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 12 p. refs

Consideration is given to a model developed to simulate the motion of a helicopter see-saw rotor which consists of two elastic blades attached to the deformable shaft with pitch and skew flap hinges. The deformable blades can bend in two perpendicular directions and twist around the straight elastic axis. Aerodynamic loads are calculated on the basis of nonlinear steady 2D airfoil data. The unsteady flow effects are described by the dynamic inflow model. The equations of motion are generated from Hamilton's principle in a semiautomatic manner with most of the algebraic manipulations done by computer. The blade deflections are discretized by free vibration modes calculated for rotating blades. The model can be incorporated into computer software for numerical integration and stability analysis. C.A.B.

A92-56288
DYNAMICS OF HELICOPTERS WITH DISSIMILAR BLADES IN FORWARD FLIGHT
JAMES M. WANG and INDERJIT CHOPRA (Maryland, University, College Park) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 11 p. Research supported by U.S. Army. refs

The realistic problem of how blade-to-blade dissimilarities modify helicopter aeromechanical stability and hub loads is examined. The effects of blade-to-blade dissimilarities, such as imbalance in blade mass, and dissimilarities in blade stiffness and aerodynamics are investigated systematically. The results are discussed quantitatively and qualitatively. Blade dissimilarity is studied using a finite element analysis that includes rotor aerodynamics, elastic blade deformations, and body pitch and roll motions. It is shown that dissimilarity in blades' in-plane stiffness improves the regressing lag stability, but with some increase in rotor side force harmonics and 1/rev torque load. Dissimilarity in flap stiffness has little effect on aeromechanical stability and hub loads. Dissimilarities in blade mass and lift do not affect aeromechanical stability, but significantly increase hub loads. C.A.B.

A92-56289
SAFETY PROVISION AGAINST 'GROUND RESONANCE' FREE VIBRATION OF A COAXIAL HELICOPTER
A. Z. VORONKOV and S. B. SOBOL' (Kamov Helicopter Scientific and Technology Co., Russia) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 15 p. refs

The problem of safety provision against the free vibration of the 'ground resonance' of a coaxial helicopter is addressed. The following function is plotted as a result of the work carried out to provide safety from 'ground resonance': relative damping moments in lag hinges of the upper and lower rotors vs the helicopter inertia-mass parameter, which can be used in a safety evaluation in the helicopter design process. C.A.B.

A92-56290
HELICOPTER TAIL ROTOR STALL FLUTTER
MIKHAIL ROZHDESTVENSKII (Mil Moscow Helicopter Plant, Russia) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 15 p. refs

The paper investigates stall flutter which occurs in helicopter tail rotor blades in hovering and which shows a sharp growth in the value of the pitching moment variable component. The values of the measured loads exceed the ordinary level encountered in operation by several orders of magnitude. An analytical and theoretical investigation of stall flutter is carried out on the basis of unsteady aerodynamics. The mechanism of the evolution of self-oscillations and the influence of various design parameters are investigated. Good qualitative and quantitative agreement of analytical and experimental data is obtained, and a method for reducing the pitching moment is found. Full-scale tests of the Mi-26 tail rotor confirm the efficiency of the implemented design solutions aimed at eliminating stall flutter. C.A.B.

A92-56297
THE APPLICATION OF MATH-DYNAMIC MODELS TO CHARACTERISE A RANGE OF HELICOPTER ROTOR SYSTEM FAULTS
MIKE ANDREW and HESHAM AZZAM (MJA Dynamics, Ltd., Southampton, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 6 p. Research supported by Bristow Helicopters, Ltd., Ministry of Defence, and Civil Aviation Authority of United Kingdom. refs

A diagnostic methodology was developed, based on a comprehensive helicopter math-dynamic model of Azzam (1990) based on an individual blade concept and on recent advances in unsupervised machine-learning techniques. An example is presented in which it is shown that five different fault classes could be separated based on two normalized vibration helicopter components. I.S.

A92-56298* National Aeronautics and Space Administration, Washington, DC.
RESEARCH NEEDS FOR A COMMERCIAL PASSENGER TILTROTOR
GEORGE UNGER (NASA, Washington) and HAROLD ALEXANDER (Boeing Helicopter Co., Philadelphia, PA) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 20 p. refs

The National Aeronautics and Space Administration (NASA) recently completed a series of contracts and studies that examined the technology needs for a tiltrotor aircraft in commercial service as well as military missions. The commercial needs arise out of market-driven requirements that include vertiport location and design, passenger comfort levels and competitive costs. The military needs are derived from time-sensitive missions and combat effectiveness. In response to these results, NASA has decided to address the commercial needs first, recognizing that there will be eventual payoff to military missions as well. Research goals were explored in acoustics, flight dynamics, human factors and displays, dynamics and loads, propulsion, safety, and configuration design. The paper describes the development of these goals from the market requirements and the implications for possible research activities. The aircraft issues that were addressed include number of blades, advanced blade planforms, steep approach requirements and pilot-cockpit interface for civil operations. Author

A92-56301
A SIMULATION STUDY OF TILTROTOR VERTICAL TAKEOFF PROCEDURES USING CONVENTIONAL AND VARIABLE DIAMETER ROTOR SYSTEMS
M. POLLACK, F. WARBURTON (Sikorsky Aircraft, Stratford, CT), and H. C. CURTISS (Princeton University, NJ) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 23 p. refs

A real-time computer simulation program was developed for studies of the tilt-rotor performance and the vertical take-off procedures of conventional and variable-diameter tilt-rotor (VDTR) aircraft designs, using aerodynamic and preliminary design methods to define a conventional tilt rotor and five unique VDTR commercial aircraft. The program was used to predict the tilt-rotor level flight performance, the helicopter-mode climb capability, and the Category A vertical takeoff performance. The results obtained indicate that, while a VDTR adds complexity and weight to the rotor system, significant benefits can be realized with a VDTR design, including improvements in the Category A performance, climb capability, power-plant efficiency, and acoustic levels. I.S.

A92-56302
SHORT TAKEOFF OPTIMIZATION FOR THE XV-15 TILTROTOR AIRCRAFT
T. M. CERBE (Deutsche Lufthansa AG, Hamburg, Germany), G. REICHERT (Braunschweig, Technische Universitaet, Germany), and D. P. SCHRAGE (Georgia Institute of Technology, Atlanta) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 20 p. Research supported by DFG. refs

The short takeoff capability of a civil tilt-rotor aircraft XV-15 is investigated by analyzing the effects of gross weight, ambient conditions, the power available, the flap setting, the nacelle tilt, and the maneuver strategy on the takeoff-related performance. It was found that a takeoff with a nacelle angle of about 20 deg and a flap deflection of 40 deg yields the shortest takeoff distance. It is noted that the calculated performance of the generic tilt rotor simulation (GTRS) used in this analysis might not accurately represent the XV-15 performance in the low-speed forward flight regime, and that further improvements of GTRS for this flight regime are required. I.S.

A92-56307
LYNX - A 50 YEAR PRODUCT?
J. C. BARKER (Westland Helicopters, Ltd., Yeovil, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 9 p.

The last two decades of continued development of the Lynx

helicopter are reviewed to demonstrate the helicopter performance and the benefits of continued modifications in aircraft. Among the key upgrades examined are those for the: undercarriage, sonar, tail, bag flotation, tail rotor, nose, general structure, and the IR and radar sensor systems. The changes are grouped into two enhancement steps with significant benefits that are listed in the areas of total weight, Vno, maximum hover height, and maximum continuous power. The results demonstrate the value of continuous upgrading processes in uprating the potential of aircraft as well as providing additional mission capabilities. Additional upgrading is expected for the Lynx helicopter which boasts several decades of utility in helicopter applications. C.C.S.

A92-56309
AEROELASTICITY OF A COAXIAL HELICOPTER ROTOR
B. N. BURTSEV (Kamov Helicopter Scientific and Technology Co., Russia) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 17 p.

Results of development work for the coaxial-rotor lifting system generalized mathematical model are presented. The coaxial-rotor system is modeled by means of aeroelastic blade couplings through signal control links and by aeroelastic blade interaction in the coaxial rotor vortex. The numerical method and algorithm development results are discussed. R.E.P.

A92-56310
A TIME-DEPENDENT TIP LOSS FORMULA FOR ROTOR BLADE DYNAMIC ANALYSIS
E. R. WOOD, R. KOLAR, and A. S. CRICELLI (U.S. Naval Postgraduate School, Monterey, CA) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 6 p. refs

Although, a constant tip loss factor is at best a crude representation of three-dimensional flow effects, it has found widespread use because of its simplicity and accuracy in both hover and forward flight performance and dynamic analysis calculations. This paper will show that a time-dependent formulation for tip loss factor, instead of a constant, is preferable for rotor blade dynamic analysis in forward flight. Substantiation for this new formulation is based upon analysis and simple reasonings that relate to H-34 flight test data, with respect to time histories of the radial distributions of blade airloads and flapwise bending moment. Author

A92-56311
OSCILLATIONS OF AN ANISOTROPIC ROTOR ON AN ELASTIC ANISOTROPIC SUPPORT
IU. A. MIAGKOV (Mil' Design Bureau, Moscow, Russia) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 14 p.

Small oscillations of rotor blades possessing anisotropic properties along with elastic support oscillations are considered. Among these rotors are two- and single-bladed rotors of wide application and multibladed rotors with nonuniform positioning of the blades over a rotor disk. Under anisotropy of the support elastic properties an equilibrium of such rotor oscillation modes in conjunction with the support occurs solely in the case of a polyharmonic nature of motion. R.E.P.

A92-56312
CREATION OF A LIVING SPECIFICATION FOR AN EXPERIMENTAL HELICOPTER ACTIVE FLIGHT CONTROL SYSTEM THROUGH INCREMENTAL SIMULATION
G. D. PADFIELD (Defence Research Agency, Aerospace Div., Bedford, United Kingdom) and R. BRADLEY (Glasgow, University, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 21 p. Research supported by Westland Helicopters, Ltd. and Theta Analysis and Systems, Ltd. refs
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The development of the requirement specification for the airborne system including crew station, sensors, processing elements, and actuation is described. In its current form the requirement is a textual and diagrammatic description of the system behavior covering functionality, operation, performance, testing, and interface requirements. The specification is based on design using the Jackson System Development (JSD) methodology. The design work resulted in a prototype Ada simulation of the system. Examples of the JSD modeling and mapping into Ada are presented. O.G.

A92-56316* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
RESEARCH ON MEASUREMENT AND CONTROL OF HELICOPTER ROTOR RESPONSE USING BLADE-MOUNTED ACCELEROMETERS 1990-91
NORMAN D. HAM (MIT, Cambridge, MA) and ROBERT M. MCKILLIP, JR. (Princeton University, NJ) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 12 p. refs
(Contract NCC2-366)

Wind tunnel testing of the full-size Model 412/IBC rotor performed at the NASA Ames Research Center is described. The use of blade-mounted accelerometers is found to be feasible for estimating or measuring blade flapping, lagging, and bending accelerations, rates, and displacements. Application of the imaginary swash plate concept to IBC systems leads to useful filtering of the blade accelerometer signals while permitting the control of a four-bladed rotor using measurements from any three blades. Rotor state measurements in the rotating system can be transformed to the corresponding nonrotating rotor states using the IBC algorithm with its associated filtering properties. O.G.

A92-56325
COMPOSITE BLADES FOR HELICOPTER MAIN AND TAIL ROTORS DEVELOPED BY MIL DESIGN BUREAU
B. S. SIROTINSKII (Mil' Moscow Helicopter Plant, Russia) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 12 p.

The design of composite blades for helicopter main and tail rotors developed at the Mil Helicopter Plant, Moscow, for the Mi-12 experimental and Mi-26 production helicopters is examined. The design, which uses spiral lay-up of resin-preimpregnated unidirectional glass-fiber tapes, is oriented at automated blade manufacturing using numerically controlled machines for tape lay-up. The design and fabrication of the blade-to-hub attachment fitting is described. The blades are fitted with an electrothermal deicing system, which is also made of nonmetal composites. V.L.

A92-56328
STRUCTURAL DESIGN AND TESTING RESULTS OF COMPOSITE LANDING GEAR COMPONENTS
B. MONTESARCHIO (Magnaghi Napoli S.p.A., Naples, Italy) and I. CRIVELLI VISCONTI (Naples, University, Italy) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 20 p.

The advantages of constructing some landing gear parts from carbon fiber composite materials are evaluated. The items selected as a basis for this study were the transverse tube of the A129 helicopter and the upper and lower arms of the AMX nose landing gear drag brace. It is found that landing gear components normally employed in design solutions may be constructed from composite material, which results in weight savings and is structurally satisfactory. Transverse tube weight was reduced by about 30 percent with a cost increment ratio of 1.5 to 1 as compared to conventional materials. The advantages in terms of weight reduction and costs can be better than those obtained if the composite components are introduced from the beginning in the landing gear project. C.A.B.

A92-56329
A SMALL LIGHT-WEIGHT ROTOR PLATFORM FOR GROUND OBSERVATION AND POLLUTION CONTROL
R. H. G. MUELLER (Forschungsinstitut fuer Bildverarbeitung, Umwelttechnik und Stroemungsmechanik, Duesseldorf, Germany)

and R. SCHUETTE (Institut fuer Sicherheitstechnik und Umweltschutz, Dormagen, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 6 p. refs

The applicability of a versatile, flying rotor platform for measurement or observation purposes in inaccessible locations is discussed. Different applications and their boundary conditions are demonstrated, and results of test measurements using a prototype of the platform are presented. An outline of an optimized rotor platform is developed. For that layout, different boundaries like weather conditions, training standard of the pilot, duration of the measuring task, and aviation regulations need to be taken into account. The design is also influenced by requirements of architectural applications like airborne observation and measurement tasks in building control without the need for scaffoldings. C.A.B.

A92-56330
CURRENT EUROPEAN RESEARCH ACTIVITIES IN HELICOPTER INTERACTIONAL AERODYNAMICS

G. PAGNANO and A. SAPORITI (Agusta S.p.A., Cascina Costa di Samarate, Italy) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 20 p. Research supported by EEC. refs

The status of a Study and Computation of Interactional Aerodynamics (SCIA), an European collaborative program for interactional aerodynamics of helicopter configuration which was started in 1990, is discussed. The SCIA project is aimed at improving existing methodologies for helicopter components and developing algorithms for predicting the complex rotor/fuselage interaction. Particular attention is given to the activities in the experimental and computational fields for both the isolated and complete configurations. O.G.

A92-56335
THE IDENTIFICATION OF COUPLED FLAPPING/INFLOW MODELS FOR HOVERING FLIGHT

D. J. LEITH, R. BRADLEY, and D. J. MURRAY-SMITH (Glasgow, University, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 12 p. Research supported by Ministry of Defence Procurement Executive. refs

Flight conditions close to hover are analyzed in order to resolve some of the difficulties encountered in earlier studies. New light is shed on the fundamental problems of identifiability by designing optimal experiments for the parameters of a variety of coupled flapping/inflow models. The models include the Pitt and Peters formulation of the induced flow equations, and both first- and second-order flapping is considered. The question of whether flapping measurements alone are sufficient for the reliable identification of coupled flapping/inflow models and to the suitability of test inputs currently employed is addressed. It is concluded that for the models considered, in the absence of direct measurements of inflow, it is important to retain LF information in the system identification process. It is shown that within the limitations of the flight data available, a simple flapping model with no induced flow dynamics cannot be improved, and it gives a good fit to measured data for all frequencies up to that of the rotor. C.A.B.

A92-56336
DAMAGE TOLERANCE ANALYSIS FOR ROTORCRAFT - WHAT THE ISSUES ARE

CHARLES C. CRAWFORD, JR., ROBERT L. CARLSON, and PRESTON R. BATES (Georgia Institute of Technology, Atlanta) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 28 p. refs

The problem of damage-tolerant design for rotorcraft is examined with emphasis on creating an improved crack growth data base for small cracks, understanding crack growth near threshold and retardation effects, and characterization of composites under delamination. It is shown that cost effective management of rotorcraft using damage tolerance analysis depends on reduced conservatism in the analytical models used. This can be accomplished through better definition of the threshold region, incorporation of retardation effects, full scale component strain surveys, and the use of automated cycle counting of measured flight loads during data reduction. More accurate knowledge of individual aircraft usage is also essential to cost effective cost management. V.L.

A92-56337
DESIGN METHOD OF A HELICOPTER COCKPIT

B. A. GUBAREV (Kamov Helicopter Scientific and Technology Co., Russia) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 14 p. refs

Problems involved in developing a helicopter crew cabin layout are described. These problems are solved within the scope of the task of rendering compatible two essentially different components: the technical details of a cabin and human performance. Heterogeneity and multicriteria aspects relevant to the cockpit layout are investigated, with priority given to behavioral engineering in search of technical solutions. The task of designing a crew cabin layout and selecting its parameters at the early stages of helicopter design is addressed. In this connection, the cabin structure is based on fundamental interfunctional relations as a starting point in designing a crew cabin layout as a complete helicopter component which reflects its application roles and operational features. C.A.B.

A92-56340
DEVELOPMENT OF A CONCEPTUAL DESIGN METHOD FOR ROTARY-WING AIRCRAFT USING DIGITAL COMPUTERS

D. PALASIS and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Neubiberg, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 14 p. refs (Contract BMVG-T/RF41/I0008/I1407)

Presented in this paper is the development of a conceptual design method for rotary-wing aircraft. This method allows to perform conceptual design studies for a helicopter or tiltrotor based on a given mission and with the help of Carpet-Plots. The corresponding computer program, which has a modular structure, contains a number of subroutines, where the most important ones are those to stimulate the engine behavior including fuel consumption, to calculate the weight break-down and to compute aerodynamic forces, performance and trim. The variation of some geometric parameters is presented for a light helicopter and a tiltrotor. The comparisons of the optimized data for the light helicopter and the tiltrotor show good agreement with those for some designed aircraft. Author

A92-56341
THE COMPOUND HELICOPTER - A CONCEPT REVISITED

D. E. H. BALMFORD (Westland Helicopters, Ltd., Yeovil, United Kingdom) and B. S. BENDER (Rolls-Royce, PLC, Leavesden, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 18 p.

Various forms of lift and thrust compounding are described, and the benefits and conclusions that have arisen from early collaborative studies between Westland Helicopters and Rolls Royce are indicated. The principal features of a thrust-only and thrust-and-lift compounded helicopter are presented, and the advantages to be derived, i.e., increased speed, high speed agility, reduced vibration, improved L/D ratio, horizontal fuselage attitude, and reduced maintenance costs, are presented. Some applications of the compound helicopter concept to both new designs and existing helicopters via retrofit are examined. When the concept is combined with emerging technologies such as active control of vibration, as well as active flight control including integration of engine controls, the overall performance of the vehicle in terms of economics, quality of ride, and safety is expected to be substantial. C.A.B.

A92-56342
THE ACHIEVEMENT OF AERODYNAMIC GOALS ON THE EH101 PROJECT THROUGH THE 'SINGLE SITE' CONCEPT

C. MAZZUCCHELLI (Costruzioni Aeronautiche Giovanni Agusta

S.p.A., Milan, Italy) and F. T. WILSON (Westland Helicopters, Ltd., Yeovil, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 10 p. refs

An ET-101 helicopter project based on a single site concept and developed by a collaborative effort of Agusta and Westland companies is described. A systematic approach to key aerodynamic related issues including shuffle, pitch up, and performance is considered, using scale model testing in the wind tunnels of both companies in conjunction with CFD and simulation codes followed by confirmatory flight tests. The aerodynamic development program is aimed at optimizing the aircraft as an integrated machine with the main and tail rotors, air frame, and engines working effectively together throughout the flight envelope. O.G.

A92-56343
AS 332 MKII - DEVELOPMENT AND CERTIFICATION
J. P. DEDIEU and A. FLEISCHMANN (Aerospatiale, Division Helicoptere, Marignane, France) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 12 p.

The development and certification processes of the Super Puma AS MKII helicopter are examined. It is pointed out that, compared with its predecessor, AS 332 MKI, the aircraft definition of the AS 332 MKII is 80 percent new or is modified, especially in the areas of rotors and transmissions, the avionics, and the electrical power system. The modifications introduced were intended to set new standards for this category of helicopters in terms of safety, maintenance, and passenger and crew comfort. Diagrams of new AS 332 MKII structures are presented. I.S.

A92-56346
PATH IDENTIFICATION IN STRUCTURAL ACOUSTICS
K. H. HERON (Defence Research Agency, Aerospace Div., Farnborough, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 12 p. Research sponsored by CEC.

An experimental method for identifying the structure-borne path by which the vibrational energy from a helicopter gearbox is transmitted to the cabin is described. The method involves taking detailed measurements of the gearbox/cabin interface vibration field as well as of the internal noise field. The statistical accuracy of the various predictions is calculated, and the results are displayed as confidence intervals. The method is centered on the way these statistical results are calculated as well as the way statistical confidence tests are used to drive and steer the necessary data-fitting processes. Results are presented from a full-scale laboratory validation trial using a grounded Lynx helicopter. A series of known 'flight' conditions were measured and then the method applied. The known results were reproduced, and the statistics were validated in the sense that a 90-percent confidence interval for a given result was wrong about 10 percent of the time. The method is argued to accurately diagnose and quantitatively identify the different paths. C.A.B.

A92-56347
A HIGH SPEED EDGEWISE ROTOR USING CIRCULATION CONTROL ONLY IN THE REVERSED FLOW AREA
I. C. CHEESEMAN and M. M. E. SOLIMAN (Southampton, University, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 25 p. Research supported by Ministry of Defence of United Kingdom, SERC, and Westland Helicopters, Ltd. refs

A computer model of a helicopter rotor which could employ circulation control on the rotor blades in the reversed flow region was developed. The blade flapping was modeled in detail and a computer efficient technique was developed on the basis of a harmonic method of solution. The calculations yielded a performance of up to mu = 0.4, which agreed closely with real Lynx data. Above that advance ratio auxiliary thrust and circulation control were applied, and the rotor progressively tilted backwards towards autorotative flight. Fuselage tilt was found to be acceptable. The rotor flapping at 340 knots was considered excessive. The circulation control air compression power was found to be small. The rotor power also decreased to about zero at the high speeds. The rotor performance could be most improved at the highest speed by the generation of increased lift on the advancing blade and at the front and rear of the disk. It is inferred that the choice of aerofoil section(s) and blade geometry may produce significant improvements in overall performance relative to the figures quoted. C.A.B.

A92-56348
LOW ENERGY ICE PROTECTION FOR HELICOPTERS
JAMES T. HINDEL and NORBERT A. WEISEND (BFGoodrich De-Icing Systems, Uniontown, OH) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 12 p. refs

Four unique low-energy mechanical deice systems whose performance meets the requirements for rotor blades and inlets are introduced. These systems are designed to remove ice in small particles that would damage engine components or cause fuselage damage resulting from ice particles launched from a rotor blade. The systems are also capable of shedding very thin layers of ice critical to the retention of airfoil shapes on rotor blades, wings, and stabilizers. Two systems are pneumatically powered and two are operated electrically. All four systems can use discharged, stored energy deicing pulses that result in a low power drain from the helicopters' power sources. These systems can all be designed intrinsically into the airfoil to eliminate aerodynamic effects or can be bonded onto existing airfoils in retrofit applications. C.A.B.

A92-56350
CORRELATION OF FLIGHT, TUNNEL AND PREDICTION DATA ON A HELICOPTER MAIN ROTOR
G. PAGNANO, F. NANNONI, M. SIMONI (Agusta S.p.A., Cascina Costa di Samarate, Italy), and H. J. LANGER (DLR, Braunschweig, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 23 p. refs

Results are presented of a detailed analysis performed on the available data of the wind tunnel testing carried out on an isolated articulated four-bladed main rotor model. The correlation with prediction methods and flight text data is discussed in terms of global data, i.e., power level, rotor forces, control angles, and control loads. Different prediction methods ranging from energy methods and a simplified trim algorithm to a blade element code are applied. The codes are described in terms of characteristics, input data and solution procedures, and the level of confidence already gained with flight test data comparison. The effects of a number of simulation parameters, both in calculation methods and wind tunneling modeling, such as the blade dynamics representation and the rotor system configuration, are discussed. The level of confidence achieved in tunnel simulation and model testing, and in the prediction of rotor characteristics is presented. C.A.B.

A92-56353
MISSION ORIENTED INVESTIGATION OF HANDLING QUALITIES THROUGH SIMULATION
D. BRAUN, K. KAMPA, and D. SCHIMKE (MBB GmbH, Munich, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 13 p. refs

An overview of the simulation tool and its application is provided. The simulation facility is briefly described, and the main features of the simulation model are explained. Particular emphasis is placed on engine, landing gear, noise, and vibration modeling. The model is validated via trim values, time histories, derivatives, and frequency responses. A mission analysis is discussed, with an EMS mission used as an example. Some exemplary investigations evaluating mission effectiveness, control response behavior, and system failures are presented. The quality of the computer-generated image proved to be acceptable. A lack of visual cues (field-of-view) is detected only in hovering and low-speed tasks with high precision and aggressiveness demands. The real time simulation demonstrated its importance for handling qualities design in the preliminary phase of the TIGER. C.A.B.

A92-56354* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPROXIMATIONS FOR INCLUSION OF ROTOR LAG DYNAMICS IN HELICOPTER FLIGHT DYNAMICS MODELS
ROBERT MCKILLIP, JR. and HOWARD C. CURTISS, JR. (Princeton University, NJ) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 9 p. refs
(Contract NAG2-561)

Approximate forms are suggested for augmenting linear rotor/body response models to include rotor lag dynamics. Use of an analytically linearized rotor/body model has shown that the primary effect comes from the additional angular rate contributions of the lag inertial response. Addition of lag dynamics may be made assuming these dynamics are represented by an isolated rotor with no shaft motion. Implications of such an approximation are indicated through comparison with flight test data and sensitivity of stability levels with body rate feedback. Author

A92-56809#
COMPARISON OF RECENT RESULTS FROM DIFFERENT WIND TUNNEL FACILITIES ALONG WITH COMPARISONS OF MEASURED FLIGHT RESULTS AND WIND TUNNEL BASED PREDICTIONS
KEITH PALLISTER (Aircraft Research Association, Ltd., Bedford, United Kingdom), JON PARKER (British Aerospace Airbus, Ltd., Filton, United Kingdom), and BRIAN PROBERT (British Aerospace Defence, Ltd., Warton, United Kingdom) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 22 p. Research supported by Ministry of Defence Procurement Executive. refs
(AIAA PAPER 92-3985) Copyright

Data are presented covering three areas associated with wind tunnel facilities and the prediction and verification of flight vehicle characteristics. Initially, wind tunnel data obtained from two different UK facilities are compared. Secondly, the method used by British Aerospace Airbus Ltd to predict aircraft performance from wind tunnel data is outlined along with the presentation of results for the A310 Airbus. Finally, loading data obtained both in the wind tunnel and flight are compared for the EAP fighter configuration. Author

N92-32536*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE MULTIPLE-FUNCTION MULTI-INPUT/MULTI-OUTPUT DIGITAL CONTROLLER SYSTEM FOR THE AFW WIND-TUNNEL MODEL
SHERWOOD T. HOADLEY and SANDRA M. MCGRAW (Lockheed Engineering and Sciences Co., Hampton, VA.) Jul. 1992 11 p Presented at the Active Flexible Wing I Session at the AIAA Dynamic Specialists' Conference, Dallas, TX, 16-17 Apr. 1992 Previously announced in IAA as A92-35655
(Contract RTOP 505-63-50-15)
(NASA-TM-107600; NAS 1.15:107600) Avail: CASI HC A03/MF A01

A real time multiple-function digital controller system was developed for the Active Flexible Wing (AFW) Program. The digital controller system (DCS) allowed simultaneous execution of two control laws: flutter suppression and either roll trim or a rolling maneuver load control. The DCS operated within, but independently of, a slower host operating system environment, at regulated speeds up to 200 Hz. It also coordinated the acquisition, storage, and transfer of data for near real time controller performance evaluation and both open- and closed-loop plant estimation. It synchronized the operation of four different processing units, allowing flexibility in the number, form, functionality, and order of control laws, and variability in the selection of the sensors and actuators employed. Most importantly, the DCS allowed for the successful demonstration of active flutter suppression to conditions approximately 26 percent (in dynamic pressure) above the open-loop boundary in cases when the model was fixed in roll and up to 23 percent when it was free to roll. Aggressive roll maneuvers with load control were achieved above the flutter boundary. The purpose here is to present the development, validation, and wind tunnel testing of this multiple-function digital controller system. Author

N92-32887*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SKI JUMP TAKEOFF PERFORMANCE PREDICTIONS FOR A MIXED-FLOW, REMOTE-LIFT STOVL AIRCRAFT
LOURDES G. BIRCKELBAW Feb. 1992 24 p
(Contract RTOP 505-59-30)
(NASA-TM-103866; A-91156; NAS 1.15:103866) Avail: CASI HC A03/MF A01

A ski jump model was developed to predict ski jump takeoff performance for a short takeoff and vertical landing (STOVL) aircraft. The objective was to verify the model with results from a piloted simulation of a mixed flow, remote lift STOVL aircraft. The prediction model is discussed. The predicted results are compared with the piloted simulation results. The ski jump model can be utilized for basic research of other thrust vectoring STOVL aircraft performing a ski jump takeoff. Author

N92-33149*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
RAPID DEVELOPMENT OF THE X-31 SIMULATION TO SUPPORT FLIGHT-TESTING
DALE MACKALL, KENNETH NORLIN, DOROTHEA COHEN, GARY KELLOGG, LAWRENCE SCHILLING, and JOHN SHEEN (Rockwell International Corp., Downey, CA.) Sep. 1992 20 p Presented at the AIAA/AHS Flight Simulation Technologies Conference, Hilton Head, SC, 24-26 Aug. 1992
(Contract RTOP 505-64-30)
(NASA-TM-104256; H-1857; NAS 1.15:104256; AIAA PAPER 92-4176) Copyright Avail: CASI HC A03/MF A01

The X-31 Enhanced Fighter Maneuverability Program has been recognized to form the International Test Organization, with the NASA Dryden Flight Research Facility (NASA-Dryden) as the responsible test organization. The two X-31 research aircraft and engineering support personnel were colocated at NASA-Dryden, with flight test operations beginning in Apr. 1992. Therefore, rapid development of a hardware-in-the-loop simulation was needed to support the flight test operations at NASA-Dryden, and to perform verification and validation of flight control software. The X-31 simulation system requirements, distributed simulation system architecture, simulation components math models to the visual system, and the advanced capabilities the X-31 simulation provides. In addition, unique software tools and the methods used to rapidly develop this simulation system will be highlighted. Author

N92-33404*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
THE F-18 HIGH ALPHA RESEARCH VEHICLE: A HIGH-ANGLE-OF-ATTACK TESTBED AIRCRAFT
VICTORIA REGENIE, DONALD GATLIN, ROBERT KEMPEL (PRC Kentron, Inc., Edwards, CA.), and NEIL MATHENY Sep. 1992 17 p Presented at the 6th Biennial Flight Test Conference, Hilton Head Island, SC, 24-26 Aug. 1992
(Contract RTOP 533-02-35)
(NASA-TM-104253; H-1846; NAS 1.15:104253; AIAA PAPER 92-4121) Copyright Avail: CASI HC A03/MF A01

The F-18 High Alpha Research Vehicle is the first thrust-vectoring testbed aircraft used to study the aerodynamics and maneuvering available in the poststall flight regime and to provide the data for validating ground prediction techniques. The aircraft includes a flexible research flight control system and full research instrumentation. The capability to control the vehicle at angles of attack up to 70 degrees is also included. This aircraft was modified by adding a pitch and yaw thrust-vectoring system. No significant problems occurred during the envelope expansion phase of the program. This aircraft has demonstrated excellent control in the wing rock region and increased rolling performance at high angles of attack. Initial pilot reports indicate that the increased capability is desirable although some difficulty in judging

the size and timing of control inputs was observed. The aircraft, preflight ground testing and envelope expansion flight tests are described. Author

N92-33414# Naval Air Warfare Center, Warminster, PA. Air Vehicle and Crew Systems Technology Dept.
AN INVESTIGATION OF SWITCHED RELUCTANCE ROTOR POSITION ESTIMATION USING NEURAL NETWORKS Progress Report, Oct. 1991 - Feb. 1992
JENIFER M. SHANNON Feb. 1992 19 p
(AD-A252846; NAWCADWAR-92022-60) Avail: CASI HC A03/MF A01

The Switched Reluctance Machine (SRM) has potential applications in the More-Electric Aircraft program. Such applications include fuel and oil pump, actuators, braking systems, and integral starter/generators. However, one difficulty in the controller design still exists. Knowledge of the relative position of the rotor with the stator is required for timing of the excitation pulses. This position is conventionally measured by an encoder or resolver. However, for many applications of the SRM such a sensor will not operate in the harsh environment of the machine. Developing a means of estimating the rotor position without the need for a rotor-mounted position sensor is the aim of this research. Specifically, this paper investigates the possibility of using neural networks for rotor position estimation. GRA

N92-33502# Naval Postgraduate School, Monterey, CA.
IMPLEMENTATION OF A PERSONAL COMPUTER BASED PARAMETER ESTIMATION PROGRAM M.S. Thesis
ROBERT G. GRAHAM Mar. 1992 147 p
(AD-A252914) Avail: CASI HC A07/MF A02

Aircraft parameter estimation is the process of extracting numerical values for aerodynamic stability and control derivatives from flight test time history data. This process can be used as a verification or validation tool for results obtained from wind-tunnel testing or through computational analysis, and can obtain or improve estimations of dynamic derivatives. This study implements the MATLAB Personal Computer (PC) based maximum likelihood estimation routine for aircraft longitudinal and lateral-directional derivatives. The parameter estimation was first accomplished on generated simulated data, with and without noise. The noise consisted of measurement and state noise which used the Dryden Gust Model. Secondly, two actual longitudinal flight-test maneuvers are analyzed for the F-14A and the T-37 aircraft. Additionally, the simulated portion of this study can be an excellent instructional aid in Flight Dynamics and Flight Test Courses. GRA

N92-33582 Field Aviation Co., Inc., Mississauga (Ontario).
FIRE BOMBING AND FIRE BOMBERS Patent
JOHN K. HAWKSHAW, inventor (to CISTI) 24 Apr. 1990 21 p
(CA-PATENT-1-268-164; INT-PATENT-CLASS-B64D-1/16; CTN-91-60132) Copyright Avail: Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC/MF

This invention concerns the design of a drop tank and liquid discharge system for a fire bomber. An elongated discharge chute is designed such that the discharge end is located substantially below the tank. When released from the tank, the falling stream will accelerate to a substantial velocity within the chute before discharging. The through passage is progressively reduced in cross sectional area so that the discharged stream has a width transverse to the direction of travel which is less than its thickness in the direction of forward motion of the aircraft, that is, the emerging liquid has a reduced cross section and a streamlined shape. By these means, air entrapment in the free falling liquid is reduced, the time of travel to the target area is reduced, and the uniformity of coverage is improved. In addition, the fuselage of the firebomber is equipped with a tubular shield designed to prevent direct impingement of the airstream on the chute. A plurality of drop tanks may be located on a single aircraft. The ground wetness level may be varied by altering the chute width or by dumping more than one tank at a time. The dropping sequence may be computer controlled. CISTI

N92-33585 Pneumo Corp., Boston, MA.
LANDING GEAR MECHANISM INCLUDING RUNWAY-ROUGHNESS RESTRICTOR ASSEMBLY Patent
LOUIS C. HRUSCH, inventor (to CISTI) 18 Jul. 1989 19 p
(CA-PATENT-1-257-618; INT-PATENT-CLASS-B64C-25/60; CTN-91-60166) Copyright Avail: Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC/MF

This invention relates to a landing gear restrictor assembly mechanism for substantially reducing or eliminating high damping loads as the landing gear negotiates bumps to permit high performance aircraft to operate on relatively rough runways. High performance may be achieved by a landing gear which is provided with different low spring rate load ranges. It can differentiate between shock strut extension during normal ground roll and extension as the strut tire follows a sudden recess during forward travel; prevent cavitation in the lower piston chamber of the gear as the gear extends; and provide for piston rebound damping as the piston approaches the end of its stroke during full extension. High damping loads on the landing gear can be reduced or eliminated. The invention is generally of the type described above but includes a simplified mechanism for substantially reducing or eliminating high damping loads as the gear negotiates bumps during taxiing. The mechanism can readily be packed into a small space within the envelope of the landing gear; it is incorporated within a restrictor assembly which also controls the rate of instroke of the gear during landing. The gear is also provided with restrictor means to restrict the return flow through a bypass passage surrounding the primary orifice during the outstroke movement of the gear but not during taxiing after landing has taken place. CISTI

N92-33750# Rolls-Royce Ltd., Derby (England).
THE ROLLS-ROYCE TRENT
GILES HARVEY 1 May 1991 15 p Presented at the Royal Aeronautical Society, Hong Kong, China, May 1991
(PNR-90875; ETN-92-92185) Copyright Avail: CASI HC A03/MF A01

The design philosophy of the wide bodied Trent aircraft is discussed and principal design features are described. The Trent is a derivative of the RB211 family. The consistent design approach through three generations is outlined. The unique wide-chord fan blade manufacturing sequence, involving superplastic forming and diffusion bonding, is described. A computer model of the engine structure of the Trent 800, and performance retention features, are shown. Structural analysis and design, including finite element analysis, is described. ESA

N92-33874*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HIGH-SPEED RESEARCH: SONIC BOOM, VOLUME 1
CHRISTINE M. DARDEN, comp. Washington Oct. 1992 195 p Workshop held in Hampton, VA, 25-27 Feb. 1992
(Contract RTOP 537-03-21-01)
(NASA-CP-3172; L-17145-VOL-1; NAS 1.55:3172) Avail: CASI HC A09/MF A03

A High-Speed Sonic Boom Workshop was held at LaRC of Feb. 25-27, 1992. The purpose was to make presentations on current research activities and accomplishments and to assess progress in the area of sonic boom since the program was initiated in FY-90. Twenty-nine papers were presented during the 2-1/2 day workshop. Attendees included representatives from academia, industry, and government who are actively involved in sonic-boom research. Volume 1 contains papers related to atmospheric effects on the sonic-boom signature during propagation and on acceptability studies.

N92-33952 Minnesota Univ., Minneapolis.
DESIGN OF HELICOPTER FLIGHT CONTROL SYSTEMS FOR HOVER AND LOW SPEED USING EIGENSTRUCTURE ASSIGNMENT Ph.D. Thesis
EICHER LOW 1991 232 p
Avail: Univ. Microfilms Order No. DA9205453

An eigenstructure-based design methodology for helicopter

flight control systems is developed and evaluated. The technique allows the designer to synthesize control laws which result in desirable response types such as attitude command attitude hold, rate command, and translational rate command position hold. Eigenstructure assignment is used to design inner loop control laws which provide decoupled first-order rate command response in roll pitch and yaw rates and vertical velocity with appropriate bandwidths, and stabilize low frequency open loop instabilities. Outer loop control laws achieve desired response types through classical frequency response design techniques. The control laws were designed for a generic high performance helicopter operating at hover. These control laws were evaluated with the mathematical models used in the design process and were found to yield excellent dynamic response characteristics in both the time and frequency domains. The control laws yielded good tracking of pilot command and attenuation of atmospheric disturbances. They also provided Level 1 handling qualities when evaluated using the design model. The stability robustness of the control laws in the presence of modeling uncertainties was evaluated using unstructured singular values. A simple time delay model of the errors due to neglected high frequency dynamics was used in this analysis and the stability robustness of the system was shown to be acceptable. More detailed robustness analyses were accomplished using structured singular value techniques and computer simulations of dynamic response using an off-nominal flight condition as well as higher order models. Actuator dynamics, rotor dynamics, time delays due to digital implementation of flight control laws, and errors in aerodynamic stability and control derivatives were included in these robustness analyses. The stability and performance robustness of the feedback control laws were shown to be acceptable and in no case were handling qualities less than Level 2 obtained. Eigenstructure assignment provides a straightforward method for design of helicopter flight control systems that will improve handling qualities. The control laws are relatively simple to implement and do not require high order dynamic compensators in the feedback loops. Furthermore, the eigenstructure control laws provide good robustness properties. Dissert. Abstr.

N92-33953 Minnesota Univ., Minneapolis.
NONLINEAR DYNAMIC-INVERSION FLIGHT CONTROL OF SUPERMANEUVERABLE AIRCRAFT Ph.D. Thesis
SIDNEY ANTONY SNELL 1991 287 p
Avail: Univ. Microfilms Order No. DA9207806

The objective of this research was to design flight control laws for supermaneuverable aircraft. Such aircraft routinely operate with high angle-of-attack and high angular rates where nonlinearities are significant. The research showed that a nonlinear dynamic-inversion control law could be readily designed and implemented. The control law exploited the two-time scale nature of the controlled dynamics. This allowed the design to consist of two first-order inversions in sequence. One inversion used three high-bandwidth inner loops to control the fast states corresponding to the three body-axis, angular rates. The second inversion was approximate and employed outer loops to control the angle-of-attack, sideslip angle, and the rate of the bank angle about the velocity vector. Simulations of aggressive maneuvers showed that the control law provides accurate control of these variables, even in the presence of static perturbations to the mathematical model. For comparison, a more conventional, gain-scheduled linear controller was designed. The gain-scheduled controller produced less accurate control of the angle-of-attack and higher levels of sideslip and lateral acceleration than the dynamic-inversion system. Dynamic inversion offers a natural method of incorporating thrust vectoring control into the control law. This produced smaller control deflections during simulations than the gain-scheduled system. An enhancement to the dynamic-inversion control law was developed to allow the aircraft to reach very high roll rates, causing the ailerons to saturate, while retaining accurate control of sideslip. A secondary objective in the research was to design a maneuver generator, to provide the pilot commands during the simulations. The basic maneuver generator, which uses dynamic inversion of the point-mass equations, provides adequate performance. Various configurations of maneuver generator are examined, and possible enhancements are suggested. Dissert. Abstr.

N92-34039*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
EXPERIENCE WITH ADA ON THE F-18 HIGH ALPHA RESEARCH VEHICLE FLIGHT TEST PROGRAM
VICTORIA A. REGENIE, MICHAEL EARLS, JEANETTE LE, and MICHAEL THOMSON (PRC Kentron, Inc., Edwards, CA.) Oct. 1992 17 p Proposed for presentation at the IEEE/AIAA Digital Avionics Systems Conference, Seattle, WA, 5-8 Oct. 1992
(Contract RTOP 533-02-35)
(NASA-TM-104259; H-1860; NAS 1.15:104259) Avail: CASI HC A03/MF A01

Considerable experience was acquired with Ada at the NASA Dryden Flight Research Facility during the on-going High Alpha Technology Program. In this program, an F-18 aircraft was highly modified by the addition of thrust-vectoring vanes to the airframe. In addition, substantial alteration was made in the original quadruplex flight control system. The result is the High Alpha Research Vehicle. An additional research flight control computer was incorporated in each of the four channels. Software for the research flight control computer was written in Ada. To date, six releases of this software have been flown. This paper provides a detailed description of the modifications to the research flight control system. Efficient ground-testing of the software was accomplished by using simulations that used the Ada for portions of their software. These simulations are also described. Modifying and transferring the Ada for flight software to the software simulation configuration has allowed evaluation of this language. This paper also discusses such significant issues in using Ada as portability, modifiability, and testability as well as documentation requirements. Author

N92-34182# RAND Corp., Santa Monica, CA.
ADVANCED AIRFRAME STRUCTURAL MATERIALS: A PRIMER AND COST ESTIMATING METHODOLOGY
SUSAN A. RESETAR, J. C. ROGERS, and RONALD W. HESS 1991 117 p
(Contract F49620-91-C-0003)
(AD-A253371; RAND/R-4016-AF) Avail: CASI HC A06/MF A02

This report identifies, describes, and quantifies the cost effects of structural materials that are likely to be incorporated into aircraft becoming operational in the 1990s (aluminum, aluminum-lithium, steel, titanium, graphite/epoxy, graphite/bismaleimide, and graphite/ thermoplastic). The first half of this report is a primer for advanced aircraft structural materials emphasizing polymer matrix composites. The second half of the report contains both cost data and a cost estimating methodology sensitive to material mix. For each material type separate cost factors are presented for two time frames, the late 1980s and the mid-1990s, and for the following cost elements: nonrecurring engineering, nonrecurring tooling, recurring engineering, recurring tooling, manufacturing labor, manufacturing material, and quality assurance. These factors are based on data obtained from Boeing Airplane Company, General Dynamics Corporation, Grumman Aerospace Corporation, Lockheed Aerospace Systems Corporation-California Division and Georgia Division, LTV Aerospace and Defense Aircraft Group, McDonnell Douglas Corporation, Northrop Aircraft Division, and Rockwell International Group. GRA

N92-34202*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
THERMAL-STRUCTURAL TEST FACILITIES AT NASA DRYDEN
V. MICHAEL DEANGELIS and KARL F. ANDERSON Aug. 1992 15 p Presented at the 23rd Annual Society for Flight Test Engineers Symposium, Hauppauge, NY, 3-6 Aug. 1992
(Contract RTOP 505-62-40)
(NASA-TM-104249; H-1818; NAS 1.15:104249) Avail: CASI HC A03/MF A01

The National Aero-Space Plane (NASP) has renewed interest

in hypersonic flight and hot-structures technology development for both the airframe and engine. The NASA Dryden Thermostructures Research Facility is a unique national facility that was designed to conduct thermal-mechanical tests on aircraft and aircraft components by simulating the flight thermal environment in the laboratory. The layout of the facility is presented, which includes descriptions of the high-bay test area, the instrumentation laboratories, the mechanical loading systems, and the state-of-the-art closed-loop thermal control system. The hot-structures test capability of the facility is emphasized by the Mach-3 thermal simulation conducted on the YF-12 airplane. The Liquid-Hydrogen Structural Test Facility, which is presently in the design phase, will provide the capability of thermally testing structures containing hydrogen. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A92-54324
SOME IMPORTANT FACTORS IN TURBULENCE IN FLIGHT MEASUREMENT
QING CHEN (Braunschweig, Technische Universitaet, Germany) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 206-213. refs
Copyright

A systematic analysis of each part of a data acquisition system and of each sensor that is involved in the measurement of air data and inertial data is presented. Because a data consistency check can handle the linear items fairly well, such as bias and scaling factor in the error model, the emphasis is on the time delay effect caused not only by the sensors and the data acquisition system but also by some other special factors. Based on these results a method is developed to correct the measured air data that are the combination of gust and inertial components with the relative time shift between them. The final influence of the time delay on the system identification is demonstrated by flight test data in a research aircraft. Some suggestions are given to improve turbulence measurement in flight. I.E.

A92-55212*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
INTEGRATION OF RADAR ALTIMETER, PRECISION NAVIGATION, AND DIGITAL TERRAIN DATA FOR LOW-ALTITUDE FLIGHT
RICHARD E. ZELENKA (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 605-615. refs
(AIAA PAPER 92-4420) Copyright

A Kalman filter for the integration of a radar altimeter into a terrain database-dependent guidance system was developed. Results obtained from a low-altitude helicopter flight test data acquired over moderately rugged terrain showed that the proposed Kalman filter removes large disparities in predicted above-ground-level (AGL) altitude in the presence of measurement anomalies and dropouts. Integration of a radar altimeter makes it possible to operate a near-terrain guidance system at or below 50 ft (subject to obstacle-avoidance limitations), whereas without radar altimeter integration, a minimum clearance altitude of 220 AGL is needed, as is suggested by previous work. I.S.

A92-55328*# National Aeronautics and Space Administration, Washington, DC.
A DATA FUSION ALGORITHM FOR MULTI-SENSOR MICROBURST HAZARD ASSESSMENT
CRAIG R. WANKE and JOHN HANSMAN (MIT, Cambridge, MA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 9-20. Research supported by MIT and FAA. refs
(Contract F19628-90-C-0002; NGL-22-009-640)
(AIAA PAPER 92-4339) Copyright

A recursive model-based data fusion algorithm for multi-sensor microburst hazard assessment is described. An analytical microburst model is used to approximate the actual windfield, and a set of 'best' model parameters are estimated from measured winds. The winds corresponding to the best parameter set can then be used to compute alerting factors such as microburst position, extent, and intensity. The estimation algorithm is based on an iterated extended Kalman filter which uses the microburst model parameters as state variables. Microburst state dynamic and process noise parameters are chosen based on measured microburst statistics. The estimation method is applied to data from a time-varying computational simulation of a historical microburst event to demonstrate its capabilities and limitations. Selection of filter parameters and initial conditions is discussed. Computational requirements and datalink bandwidth considerations are also addressed. Author

A92-55907
THE C-17 MULTIFUNCTION DISPLAY - A BUILDING BLOCK FOR AVIONIC SYSTEMS
PAUL WEINDORF (Honeywell, Inc., Defense Avionics Systems Div., Albuquerque, NM) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 7, no. 7, July 1992, p. 32-39. Research sponsored by USAF. refs
Copyright

The C-17 Multifunction Display (MFD) is described for use as the primary cockpit display system on the U.S. Air Force C-17A military air transport. The 6-in. by 6-in. color cathode ray tube (CRT) display features a self-contained 1750 processor and vector generator capable of processing MIL-STD-1553B aircraft data and raster video into any of 10 formats as selected by the pilot or copilot. The MFD can display stroke, raster, or hybrid formats in 16 colors. Raster images are driven by sensor inputs, and the CRT uses a taut-mask delta gun design and provides good brightness and line-width performance. Its small size, low weight, low power, standard interface, and adaptable software make the C-17 MFD an attractive choice for avionic upgrades. Author

A92-55908
TALONS 95 GHZ RADAR SENSOR FOR AUTONOMOUS LANDING GUIDANCE
KENNETH L. KOESTER and WALTER VAILLANCOURT (Norden Systems, Inc., Norwalk, CT) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 7, no. 7, July 1992, p. 40-44. Research supported by USAF.
Copyright

The performance of the Talons 95 GHz radar sensor is studied experimentally for applications to runway/taxiway systems in varying weather conditions. The effects of fog and/or precipitation on radar backscatter data are assessed for typical depression angles, and radar imagery is developed with the data. The measurements are automated with a digital data-acquisition system, and the radar antenna is step-scanned pausing at each step to record 16 sequential returns from 570 range bins. Each image shows the runways and taxiways, but better resolution is noted in the cross-polarized imagery. No image degradation is associated with any of the limited visibility conditions demonstrating the effectiveness of the high-average-power 95-GHz radar with parallel circular polarization for landing and rollout. C.C.S.

A92-56059
FLIGHT TEST OF A FLIGHT REFERENCE DISPLAY FOR POWERED-LIFT STOL AIRCRAFT
KEIJI TANAKA, HIROYASU KAWAHARA, MASARU NAKAMURA, YUSHI TERUI, TOSHIHARU INAGAKI, KOHEI FUNABIKI, YUKICHI TSUKANO, and TAKATSUGU ONO (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 262-265. In Japanese. refs

A flight reference display which indicates the safety margin of powered-lift STOL aircraft was evaluated in flight tests by using the in-flight simulator, the Variable Stability and Response Airplane (VSRA). This paper outlines the flight tests. Objectives of these flight tests were to determine the best combination of pitch attitude and angle of attack in the flight reference equation and to evaluate general availability of a flight reference display system. For these flight tests, the flight reference display system, which consists of flat-panel liquid-crystal display panel and the interface computer, was developed and installed in VSRA. The flight test results to date reveal that the larger contribution of the angle of attack was acceptable, and that employing the limitation due to horizontal gust margin in the display algorithm effected better handling qualities as well as other information for further improvements of the flight reference display. Author

A92-56082
ENGINE CONDITION MONITORING SYSTEM FOR B747-400
TOSHIHIKO NOGUCHI (All Nippon Airways, Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 366-369. In Japanese.

A new engine condition monitoring system in introduced, which has the automatic data acquisition system using the Aircraft Condition Monitoring System and Aircraft Communication Addressing and Reporting System. A ground-based engine-monitoring system is also introduced as the main part of the system. In the flight data monitoring, it was shown that the deviation from the predicted value of the standard engine model is not the best parameter for detecting the sudden shift of the gas-path parameter due to internal engine damage, using the data acquired from a flight. Author

A92-56172* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
HIGH ANGLE-OF-ATTACK FLUSH AIRDATA SENSING SYSTEM
STEPHEN A. WHITMORE, TIMOTHY R. MOES (NASA, Flight Research Center, Edwards, CA), and TERRY J. LARSON (PRC Systems, Inc., Edwards, CA) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 915-919. Previously cited in issue 06, p. 764, Accession no. A90-19746. refs
Copyright

A92-56292
TEST AND INTEGRATION CONCEPT FOR COMPLEX HELICOPTER AVIONIC SYSTEMS
HORST GOELZENLEUCHTER and LOTHAR DIETL (MBB GmbH, Munich, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 6 p.

Experiences with integration rigs and test systems used on complex helicopter avionic systems are described. Advantages of the concept in use at the Messerschmitt-Boelkow-Blohm GmbH Helicopter Division are discussed, and general requirements for test systems for related applications (e.g., integration of civil helicopters, etc.) are outlined. The test means for the TIGER basic avionic system offer the required flexibility for the integration of the various national versions of this helicopter at the same test rig. The use of an off-the-shelf test system avoids any development risks of a 'self-made' solution. C.A.B.

A92-56295
LASER-RADAR BASED OBSTACLE AVOIDANCE SYSTEM FOR HELICOPTERS
MAX EIBERT, CHRISTOPH H. SCHAEFER, and HUBERT STICH (Dornier Luftfahrt GmbH, Friedrichshafen, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 9 p. refs

The technological basis, operating concept, and system-integration techniques are described for a laser-radar sensor presented in this paper with test results. IR laser radar sensors are shown to be more effective than other technologies for small-wavelength applications to low-flying helicopters that must avoid wires. The Obstacle Warning IR Laser Radar system is defined according to helicopter flight requirements for such parameters as field of view, range image, frame rate, and range resolution. Detection ranges of 240-300 m are reported for extended objects, and wires against a sky background can be detected at 100-120 m. A full-scale prototype is developed with electronic line scan, mechanical column scan, a laser-diode laser source, and a photodiode line array as the detector/receiver. The device is of use for low-flying helicopters that need to avoid obstacles such as wires that are hard to detect. C.C.S.

N92-32447# Zeiss (Carl), Oberkochen (Germany).
AIRBORNE EXPERIMENTAL FLIR PROGRAM
KLAUS F. BOECKING *In* AGARD, Integrated Target Acquisition and Fire Control Systems 12 p Feb. 1992
Copyright Avail: CASI HC A03/MF A02; 1 functional color page

The German Air Force has decided to build a forward looking infrared (FLIR) system in order to derive and to consolidate the different technical requirements for their different technical tasks. This FLIR design was designed and built on the basis of available and proven technologies. The equipment is pod-mounted in order to avoid modification of existing Tornado aircraft. Two different modes of operation are comprised in one hardware. These are the navigation mode, used as a pilot aid for flying at night and in adverse weather, and the fire control mode, used for passive targeting and navigation-update. The mechanical and optical designs are presented as well as the electronics architecture. The performance of the sensor system is described. Author

N92-32850# National Aeronautical Establishment, Ottawa (Ontario).
THE USE OF KALMAN FILTERING TECHNIQUES TO IMPROVE THE ACCURACY OF FLIGHT TEST DATA
B. W. LEACH and J. I. MACPHERSON 1990 16 p Presented at the CASI Flight Test Symposium, Toronto, Ontario, 6-7 Mar. 1990
(NRC-32139; CTN-92-60371) Avail: CASI HC A03/MF A01

Flight test programs for which high accuracy aircraft inertial data and air data are required can benefit from the advantages of a Kalman filter integrated systems approach. This paper describes one such approach that is being developed at the Flight Research Laboratory of the National Aeronautical Establishment (NAE) for improving the accuracy of inertial data from a medium accuracy inertial reference system (IRS). This particular IRS was integrated with a variety of other standard airborne navaids in order to improve the accuracy of the complete set of inertial parameters available from the IRS digital data bus (i.e., body accelerations, body rates, attitude components, inertial velocity components, and geographical position components). Using the computer algorithms that were developed, accurate calibration of the IRS can be accomplished either in real-time or off-line. Furthermore, the accurate determination of aircraft inertial velocity components results in a much more accurate calculation of the computed wind components, and can lead to improved calibration of the onboard air data system. Actual flight test data from the NAE Twin Otter Atmospheric Research Aircraft are used to demonstrate how the performance of a baro-damped Litton LTN-90-100 IRS can be improved when it is integrated with an airborne Loran-C receiver and a Doppler radar velocity sensor. Author (CISTI)

N92-32866*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
THE DEVELOPMENT OF AN AIRBORNE INFORMATION MANAGEMENT SYSTEM FOR FLIGHT TEST
GLENN A. BEVER Sep. 1992 13 p Presented at the 6th Biennial Flight Test Conference, Hilton Head, SC, 24-26 Aug. 1992; sponsored by AIAA
(Contract RTOP 505-68-50)
(NASA-TM-104251; H-1839; NAS 1.15:104251; AIAA PAPER 92-4113) Copyright Avail: CASI HC A03/MF A01

An airborne information management system is being developed at the NASA Dryden Flight Research Facility. This system will improve the state of the art in management data acquisition on-board research aircraft. The design centers around highly distributable, high-speed microprocessors that allow data compression, digital filtering, and real-time analysis. This paper describes the areas of applicability, approach to developing the system, potential for trouble areas, and reasons for this development activity. System architecture (including the salient points of what makes it unique), design philosophy, and tradeoff issues are also discussed. Author

N92-33277# Krug Life Sciences, Inc., San Antonio, TX.
THE UTILITY OF ANALOG VERTICAL VELOCITY INFORMATION DURING INSTRUMENT FLIGHT WITH A HEAD-UP DISPLAY (HUD) Final Technical Report, Jan. 1991 - Jan. 1992
LISA F. WEINSTEIN, WILLIAM R. ERCOLINE, and RICHARD H. EVANS Jun. 1992 23 p
(Contract F33615-89-C-0603)
(AD-A252863; AL-TP-1992-0021) Avail: CASI HC A03/MF A01

The United States Air Force (USAF) is attempting to create a standard symbol set for use with the HUD as a primary flight reference. As part of that effort, eight HUD-experienced pilots and twelve non-HUD-experienced pilots participated in a study that examined the effects of variations in vertical velocity indicators (VVI) for use under instrument flight conditions in a simulator. Five configurations were assessed: digital readout, boxed digits with tape, dial, altimeter arc, and altimeter arc with digital readout. The results clearly indicated that the altimeter arc with digital readout, and the altimeter arc alone, resulted in significantly more accurate maintenance of flight parameters (i.e., vertical velocity and altitude) than did the digital readout alone, the boxed digits with tape, or the dial. Subjective data supported the objective findings, in that pilots preferred either configuration that included the altimeter arc. These findings suggest that analog vertical velocity information is useful on the HUD, particularly when it is located in close proximity to the altimeter. GRA

N92-33340*# Honeywell, Inc., Minneapolis, MN. Systems and Research Center.
STUDY OBJECTIVES: WILL COMMERCIAL AVIONICS DO THE JOB? IMPROVEMENTS NEEDED?
HATEM NASR *In* NASA. Lyndon B. Johnson Space Center, Third SEI Technical Interchange: Proceedings p 489-497 1992 Avail: CASI HC A02/MF A05

Improvements in commercial avionics are covered in a viewgraph format. Topics include the following: computer architecture, user requirements, Boeing 777 aircraft, cost effectiveness, and implemention. H.A.

N92-34109*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL ALGORITHMS FOR INCREASED CONTROL OF DEPTH-VIEWING VOLUME FOR STEREO THREE-DIMENSIONAL GRAPHIC DISPLAYS
STEVEN P. WILLIAMS and RUSSELL V. PARRISH Aug. 1992 26 p
(Contract RTOP 505-67-01-04)
(NASA-TM-4379; L-16829; NAS 1.15:4379; AVSCOM-TR-92-E-002) Avail: CASI HC A03/MF A01

Three-dimensional pictorial displays incorporating depth cues by means of stereopsis offer a potential means of presenting information in a natural way to enhance situational awareness and improve operator performance. Conventional computational techniques rely on asymptotic projection transformations and symmetric clipping to produce the stereo display. Implementation of two new computational techniques, as asymmetric clipping algorithm and piecewise linear projection transformation, provides the display designer with more control and better utilization of the effective depth-viewing volume to allow full exploitation of stereopsis cuing. Asymmetric clipping increases the perceived field of view (FOV) for the stereopsis region. The total horizontal FOV provided by the asymmetric clipping algorithm is greater throughout the scene viewing envelope than that of the symmetric algorithm. The new piecewise linear projection transformation allows the designer to creatively partition the depth-viewing volume, with freedom to place depth cuing at the various scene distances at which emphasis is desired. Author

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A92-53486
SOME THERMODYNAMICAL ASPECTS IN THE OPTIMIZATION OF SUPERSONIC COMBUSTORS
DEMETRIO BASTOS-NETTO (INPE, Sao Jose dos Campos, Brazil), LEON R. SINAY (California, University, San Diego), and CARLOS F. ESTRADA ALVES (Centro Tecnico Aeroespacial, Instituto de Atividades Espaciais, Sao Jose dos Campos, Brazil) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, AGNE Publishing, Inc., 1990, p. 255-260. refs
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The possible use of the supersonic combustion ramjet ('scramjet') as an efficient mean of propulsion in hypersonic flight regime is known for more than two decades and the scramjet is nowadays a strong candidate for the main power plant of the U.S. NASP (National Aerospace Plane). A recent survey on the state-of-the-art shows that there are several points in the development of scramjets which need an extra research effort. This work reviews and discusses some thermodynamical aspects in the optimization of supersonic combustors and presents a numerical scheme, taken from an Operations Research Technique, to solve the balance equations for a given flight regime and several equivalence ratios. Author

A92-53487
DEVELOPMENT STUDY ON AIR TURBO-RAMJET ENGINE FOR SPACE PLANE
NOBUHIRO TANATSUGU, YOSHIHIRO NARUO (Institute of Space and Astronautical Science, Sagamihara, Japan), and TAKEKAZU HONDA (Ishikawajima-Harima Heavy Industries Cc., Ltd., Tokyo, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, AGNE Publishing, Inc., 1990, p. 261-266. refs
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The expanded cycle air turbo-ramjet engine named Atrex, which is suitable for a space plane, is discussed. The design configurations and performance characteristics of the Atrex engine are described. The development study, which is to be implemented by a three-step verification test, is examined. These tests include a sea level static test, a hypersonic simulation test in a wind tunnel, and an actual flight test with a flying test bed. C.D.

A92-53490
CONCEPTUAL DESIGN OF SCRAMJET ENGINE
NOBUO CHINZEI, GORO MASUYA, MASAYUKI NIINO, YOSHIO

WAKAMATSU (National Aerospace Laboratory, Kakuda, Japan), TEIICHI TAMAKI, TAMOTSU SAITOH, and YASUNORI OHMORI (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, AGNE Publishing, Inc., 1990, p. 281-287. refs
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The scramjet engine is considered as an appropriate propulsion system for hypersonic transport and space plane flying over Mach 4. The fundamental requirement of this engine is an integrated design with airframe which is to be utilized as a part of the engine to achieve minimum drag and better specific impulse. Here, the airframe-integrated scramjet is taken as an example and the conceptual design of the engine is performed with emphasis on the performance and thermal structural analysis. Author

A92-53491
KEY DESIGN CONSIDERATIONS FOR SCRAMJET POWERED SPACE PLANE
KUNIHISA EGUCHI, TSUTOMU FUJIWARA, TATSUO YAMANAKA (National Aerospace Laboratory, Tokyo, Japan), MASAAKI MATSUHAMA, MORITO TOGAWA, YOUICHIRO MIKI, and TATSURU TOKUNAGA (Mitsubishi Heavy Industries, Ltd., Nagoya Guidance and Propulsion Systems Works, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, AGNE Publishing, Inc., 1990, p. 289-296. refs
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A parametric performance analysis of a scramjet-powered hypersonic vehicle is reported. Fuel kinetic energy and mass addition is found to make a significant contribution to overcoming a large energy loss during the scramjet-boosted flight beyond Mach 20. Improving the propulsive performance by hot hydrogen injection results in preferable reduction of fuel consumption, providing a margin of payload and structure weight. It is concluded that fuel-rich scramjet operation should be chosen for high-speed flight because of the reduced cooling requirements and augmented thrust power. C.D.

A92-53492
SCRAMJET ENGINE AND ITS FLYING TEST BED
MASAYUKI NINO, YOSHIO WAKAMATSU, NOBUO CHINZEI, GORO MASUYA (National Aerospace Laboratory, Kakuda, Japan), KOICHI YONEMOTO, and KENJI FUJIWARA (Kawasaki Heavy Industries, Ltd., Kakamigahara, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, AGNE Publishing, Inc., 1990, p. 297-302. refs
Copyright

The concept of a subscale scramjet engine is introduced. The engine dimensions and fuel system are summarized, and a flight test feasibility study is discussed. A conceptual design for a winged flying test bed is briefly presented. C.D.

A92-53493
PERFORMANCE ANALYSIS OF IDEALIZED SCRAMJET
YOSHIO WAKAMATSU, GORO MASUYA, TAKESHI KANDA, NOBUO CHINZEI, and AKIO KANMURI (National Aerospace Laboratory, Kakuda, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, AGNE Publishing, Inc., 1990, p. 303-308. refs
Copyright

An idealized scramjet is proposed and its behavior is theoretically examined. The performance of the scramjet for the air heating and combustion cycles agree closely. The effects of combustion and nozzle efficiency are great while those of stagnation pressure recovery efficiency is very small. At an equivalence ratio greater than unity, the thrust coefficient increases moderately but the specific impulse decreases rapidly. C.D.

A92-54009*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
EFFECTS OF BLEED AIR EXTRACTION OF THRUST LEVELS ON THE F404-GE-400 TURBOFAN ENGINE
ANDREW J. YUHAS (PRC, Inc., Edwards, CA) and RONALD J. RAY (NASA, Flight Research Center, Edwards, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 13 p. Previously announced in STAR as N92-29425. refs
(AIAA PAPER 92-3092) Copyright

A ground test was performed to determine the effects of compressor bleed flow extraction on the performance of F404-GE-400 afterburning turbofan engines. The two engines were installed in the F/A-18 High Alpha Research Vehicle at the NASA Dryden Flight Research Facility. A specialized bleed ducting system was installed onto the aircraft to control and measure engine bleed airflow while the aircraft was tied down to a thrust measuring stand. The test was conducted on each engine and at various power settings. The bleed air extraction levels analyzed included flow rates above the manufacturer's maximum specification limit. The measured relationship between thrust and bleed flow extraction was shown to be essentially linear at all power settings with an increase in bleed flow causing a corresponding decrease in thrust. A comparison with the F404-GE-400 steady-state engine simulation showed the estimation to be within +/- 1 percent of measured thrust losses for large increases is bleed flow rate. Author

A92-54011*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DETONATION DUCT GAS GENERATOR DEMONSTRATION PROGRAM
A. WORTMAN (ISTAR, Inc., Santa Monica, CA), P. OTHMER (California State University, Fullerton), and W. ROSTAFINSKI (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 12 p. refs
(Contract NAS3-25453)
(AIAA PAPER 92-3174) Copyright

An experimental demonstration is presented for the generation of detonation waves that move periodically across high speed channel flow; these waves can compress the outflow from a low pressure compressor, and thereby both reduce the compressor requirements associated with conventional gas turbines and enhance thermodynamic efficiency through isochoric energy addition. By generating transient transverse waves, rather than standing waves, shock-wave losses are reduced by an order of magnitude; the result is a Humphrey cycle augmenting the basic Brayton-cycle gas turbine. Attention is presently given to results from an experimental detonation duct. O.C.

A92-54020*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PRELIMINARY DYNAMIC TESTS OF A FLIGHT-TYPE EJECTOR
COLIN K. DRUMMOND (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 21 p. Previously announced in STAR as N92-30998. refs
(AIAA PAPER 92-3261)

A thrust augmenting ejector was tested to provide experimental data to assist in the assessment of theoretical models to predict duct and ejector fluid-dynamic characteristics. Eleven full-scale thrust augmenting ejector tests were conducted in which a rapid increase in the ejector nozzle pressure ratio was effected through a unique bypass/burst-disk subsystem. The present work examines two cases representative of the test performance window. In the first case, the primary nozzle pressure ration (NPR) increased 36 percent from one unchoked (NPR = 1.29) primary flow condition to another (NPR = 1.75) over a 0.15 second interval. The second case involves choked primary flow conditions, where a 17 percent increase in primary nozzle flowrate (from NPR = 2.35 to NPR = 2.77) occurred over approximately 0.1 seconds. Transient signal

treatment of the present dataset is discussed and initial interpretations of the results are compared with theoretical predictions for a similar STOVL ejector model. Author

A92-54025*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
APPLIED ANALYTICAL COMBUSTION/EMISSIONS RESEARCH AT THE NASA LEWIS RESEARCH CENTER - A PROGRESS REPORT
J. M. DEUR (Sverdrup Technology, Inc., Brook Park, OH), K. P. KUNDU, and H. L. NGUYEN (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 13 p. Previously announced in STAR as N92-29343. refs
(AIAA PAPER 92-3338) Copyright

Emissions of pollutants from future commercial transports are a significant concern. As a result, the Lewis Research Center (LeRC) is investigating various low emission combustor technologies. As part of this effort, a combustor analysis code development program was pursued to guide the combustor design process, to identify concepts having the greatest promise, and to optimize them at the lowest cost in the minimum time. Author

A92-54035*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE VRT GAS TURBINE COMBUSTOR - PHASE II
JERRY O. MELCONIAN (SOL-3 Resources, Inc., Reading, MA), HUKAM C. MONGIA (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN), and HUNG L. NGUYEN (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 14 p. refs
(AIAA PAPER 92-3471) Copyright

An innovative annular combustor configuration is being developed for aircraft and other gas turbine engines. This design has the potential of permitting higher turbine inlet temperatures by reducing the pattern factor and providing a major reduction in NO(x) emission. The design concept is based on a Variable Residence Time (VRT) technique which allows large fuel particles adequate time to completely burn in the circumferentially mixed primary zone. High durability of the combustor is achieved by dual-function use of the incoming air. In Phase I, the feasibility of the concept was demonstrated by water analogue tests and 3D computer modeling. The flow pattern within the combustor was as predicted. The VRT combustor uses only half the number of fuel nozzles of the conventional configuration. In Phase II, hardware was designed, procured, and tested under conditions simulating typical supersonic civil aircraft cruise conditions to the limits of the rig. The test results confirmed many of the superior performance predictions of the VRT concept. The Hastelloy X liner showed no signs of distress after nearly six hours of tests using JP5 fuel. Author

A92-54059*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FULL NAVIER-STOKES ANALYSIS OF A TWO-DIMENSIONAL MIXER/EJECTOR NOZZLE FOR NOISE SUPPRESSION
JAMES R. DEBONIS (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 16 p. Previously announced in STAR as N92-28419. refs
(AIAA PAPER 92-3570) Copyright

A three-dimensional full Navier-Stokes (FNS) analysis was performed on a mixer/ejector nozzle designed to reduce the jet noise created at takeoff by a future supersonic transport. The PARC3D computational fluid dynamics (CFD) code was used to study the flow field of the nozzle. The grid that was used in the analysis consisted of approximately 900,000 node points contained in eight grid blocks. Two nozzle configurations were studied: a constant area mixing section and a diverging mixing section. Data are presented for predictions of pressure, velocity, and total temperature distributions and for evaluations of internal performance and mixing effectiveness. The analysis provided good insight into the behavior of the flow. Author

A92-54060*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FLOW INDUCTION BY PRESSURE FORCES
C. A. GARRIS, K. H. TOH, and S. AMIN (George Washington University, Washington) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 7 p. refs
(Contract NAG3-860)
(AIAA PAPER 92-3571) Copyright

A dual experimental/computational approach to the fluid mechanics of complex interactions that take place in a rotary-jet ejector is presented. The long-range goal is to perform both detailed flow mapping and finite element computational analysis. The described work represents an initial finding on the experimental mapping program. Test results on the hubless rotary-jet are discussed. O.G.

A92-54104#
ACOUSTIC CONTROL OF COMBUSTOR PRIMARY ZONE AIR-JET MIXING
P. J. VERMEULEN, V. RAMESH, B. SANDERS (Calgary, University, Canada), and J. ODGERS (Universite Laval, Quebec, Canada) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 12 p. refs
(Contract NSERC-A-7801)
(AIAA PAPER 92-3651) Copyright

A small tubular combustor of normal design and behavior employing acoustically controlled primary zone air-jet mixing processes was successfully tested at scaled 1/4-load operating conditions, and some dataa was obtained at 1/2- and 3/4-load conditions. The acoustic drive produced a more uniform exit-plane temperature pattern, resulting in up to 35 percent improvement in mixing relative to 'no-drive' and in up to 20 percent relative improvement in the temperature pattern quality. The effects depended on air/fuel ratio and in general improved relative to 'no-drive' with richening. At 3/4-load, 150W single driver power, the acoustic driving effectiveness was reduced by about 80 percent with correspondingly reduced improvements in mixing and quality. The effects of acoustic drive were favorably controllable by means of the driving power, and increased flow blockage caused by increased jet penetration by the acoustic drive appears to be the control mechanism. Author

A92-54134#
AN ADVANCED SCRAMJET PROPULSION CONCEPT FOR A 350 MG SSTO SPACE PLANE - EXTERNAL NOZZLE PERFORMANCE
KUNIHISA EGUCHI, TSUTOMU FUJIWARA, TATSUO YAMANAKA (National Aerospace Laboratory, Tokyo, Japan), YOICHIRO MIKI, TATSURU TOKUNAGA, and MORITO TOGAWA (Mitsubishi Heavy Industries, Ltd., Aichi, Japan) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 8 p. refs
(AIAA PAPER 92-3719) Copyright

Analytical results of the thrust and lifting forces, and pitching moments on a 350 MG space vehicle over the required flight region are described. Calculations of large expansion flows are performed, in which the assumed nozzle inlet conditions are derived from a 1D thermodynamic analysis based on an optimum compression Brayton cycle theory with isobaric combustion. The thrust and lift forces generated by nozzle flow expansion may be greatly influenced by the combustor exit pressures, depending on the forebody compression, vehicle attack angles and flight altitudes. R.E.P.

A92-54135#
THE STUDY OF EXPERIMENTAL TURBORAMJETS
V. A. SOSOUNOV, M. M. TSKHOVREBOV, V. I. SOLONIN, and V. A. PALKIN (Central Institute of Aviation Motors, Moscow, Russia) AIAA, SAE, ASME, and ASEE, Joint Propulsion

Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 9 p. refs
(AIAA PAPER 92-3720) Copyright

A survey and development status evaluation is presented or experimental turboramjet systems that are under study at Moscow's Central Institute for Aviation Motors. Both turbojet- and turbofan-based systems have been tested and analyzed with a view to their optimal behavior during transition from turbine-powered to ramjet-sustained operational modes, as well as the conditions for stable operation, and the windmilling mode of the core engine's operation. These studies are being conducted for possible application to hypersonic atmospheric vehicle and transatmospheric aerospace plane applications. O.C.

A92-54146#
IN-FLIGHT OPTIMIZATION OF THE TOTAL PROPULSION SYSTEM
JOHN D. CHISHOLM (McDonnell Aircraft Co., Saint Louis, MO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 11 p. refs
(AIAA PAPER 92-3744) Copyright

An algorithm to optimize total propulsion system (inlet, engine, and nozzle) performance has recently completed subsonic flight evaluation on an F-15 test aircraft at the NASA Ames/Dryden Research Facility. The algorithm, called Performance-Seeking Control (PSC), optimizes on-board models of the inlet, engine, and nozzle using Linear Pogramming to compute a set of adjustments to the baseline control settings. The on-board engine model is continually updated, using a Kalman filter, to match measured engine cycle parameters. This approach adjusrs the engine model for off-nominal effects such as engine deterioration and engine-to-engine variations. Thrust increases of up to 15 percent at military power, turbine temperature decreases of up to 120 F at military power, and specific fuel consumption improvements of up to 2.0 percent at cruise were demonstrated. This paper describes the PSC evaluation procedure and examines the optimization process by which PSC achieves its performance benefits. Comparisons are made between the flight test results and digital simulation predictions. Author

A92-54147#
IN-FLIGHT PERFORMANCE DIAGNOSTIC CAPABILITY OF AN ADAPTIVE ENGINE MODEL
M. A. BUSHMAN and G. W. GALLOPS (Pratt & Whitney Group, West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 8 p. refs
(AIAA PAPER 92-3746) Copyright

The progress in microprocessor capability in modern engine controls now allows adaptive models to be incorporated into advanced control algorithms such as in-flight propulsion system optimization, condition management and damage accommodation. These models determine actual engine condition in-flight by estimating component performance deviations from a reference model. This paper describes an evaluation of the performance diagnostics capability of an adaptive model using flight test data. The adaptive model capability is evaluated with truth model test cases and with actual data recorded in-flight from the engine control data bus. The model estimates are compared with the expected condition of the test engine components. Author

A92-54148#
DEVELOPMENT OF THE FULL-ENVELOPE PERFORMANCE SEEKING CONTROL ALGORITHM
S. G. NOBBS, S. W. JACOBS, and D. J. DONAHUE (McDonnell Aircraft Co., Saint Louis, MO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 10 p. refs
(AIAA PAPER 92-3748) Copyright

The Performance-Seeking Control (PSC) adaptive integrated propulsion/flight control system algorithm has been developed to optimize a test aircraft's propulsion system over the entirety of the flight performance envelope. This 'full envelope' PSC both sends trim commands to the engine controller and integrates the inlet and engine flight controllers at supersonic conditions, thereby decreasing specific fuel consumption, increasing excess thrust, and decreasing fan-driving turbine inlet temperatures. The PSC is intended for application to a PW1128-equipped F-15 test aircraft. O.C.

A92-54149#
PERFORMANCE BENEFITS OF ADAPTIVE IN-FLIGHT PROPULSION SYSTEM OPTIMIZATION
W. G. TEMPELMAN and G. W. GALLOPS (Pratt & Whitney Group, West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 10 p. refs
(AIAA PAPER 92-3749) Copyright

The communication throughput and data-processing capacities of integrated flight/propulsion control systems allow engine operating schedules to be adjusted in-flight, on the basis of adaptive optimization algorithms which identify engine component performance variations due to manufacturing, wear, and damage. A quantification is presently made of the performance benefits accruing to adaptive in-flight optimization, via comparisons of fuel consumption and turbine temperature data for variable geometry and component match optimized cases with conventional cases. A low-bypass mixed-flow turbofan and a high-bypass nonmixed turbofan are thus treated. O.C.

A92-54151#
MIXED FLOW COMPRESSOR SURGE MARGIN GAIN USING A MANIFOLDED DIFFUSER SYSTEM
J. T. EXLEY (Teledyne CAE, Toledo, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 6 p. refs
(AIAA PAPER 92-3753) Copyright

It is presently demonstrated that a pneumatic manifold system connecting all locations of a centrifugal or mixed-flow compressor's diffuser throat locations with a secondary flowpath will retard full-stage surge by equalizing the flowfield in the diffuser passages and thereby establishing higher stability margins. A moderate pressure ratio mixed-flow compressor stage has been configured with a vaned diffuser system, and the performance effects of the design have been measured in a rig test program with and without the aforementioned pneumatic manifold system; a significant extension of the stability range is obtained with the manifold. O.C.

A92-54159*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
WIND TUNNEL PERFORMANCE RESULTS OF SWIRL RECOVERY VANES AS TESTED WITH AN ADVANCED HIGH SPEED PROPELLER
JOHN A. GAZZANIGA (Sverdrup Technology Inc., Brook Park, OH) and GAYLE E. ROSE (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 42 p. refs
(AIAA PAPER 92-3770)

Tests of swirl recovery vanes designed for use in conjunction with advanced high speed propellers were carried out at the NASA Lewis Research Center. The eight bladed 62.23 cm vanes were tested with a 62.23 cm SR = 7A high speed propeller in the NASA Lewis 2.44 x 1.83 m Supersonic Wind Tunnel for a Mach number range of 0.60 to 0.80. At the design operating condition for cruise of Mach 0.80 at an advance ratio of 3.26, the vane contribution to the total efficiency approached 2 percent. At lower off-design Mach numbers, the vane efficiency is even higher, approaching 4.5 percent for the Mach 0.60 condition. Use of the swirl recovery vanes essentially shifts the peak of the high speed propeller efficiency to a higher operating speed. This allows a greater degree of freedom in the selection of rpm over a wider operating range. Another unique result of the swirl recovery vane configuration is their essentially constant torque split between the

propeller and the swirl vanes over a wide range of operating conditions for the design vane angle. Author

A92-54168*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL PERFORMANCE OF THREE DESIGN FACTORS FOR VENTRAL NOZZLES FOR SSTOVL AIRCRAFT
BARBARA S. ESKER and GAIL P. PERUSEK (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 15 p. Previously announced in STAR as N92-27669. refs
(AIAA PAPER 92-3789) Copyright

An experimental study of three variations of a ventral nozzle system for supersonic short-takeoff and vertical-landing (SSTOVL) aircraft was performed at the NASA LeRC Powered Lift Facility. These test results include the effects of an annular duct flow into the ventral duct, a blocked tailpipe, and a short ventral duct length. An analytical study was also performed on the short ventral duct configuration using the PARC3D computational dynamics code. Data presented include pressure losses, thrust and flow performance, internal flow visualization, and pressure distributions at the exit plane of the ventral nozzle. Author

A92-54169*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INTERNAL REVERSING FLOW IN A TAILPIPE OFFTAKE CONFIGURATION FOR SSTOVL AIRCRAFT
JACK G. MCARDLE, BARBARA S. ESKER (NASA, Lewis Research Center, Cleveland, OH), and JAMES A. RHODES (McDonnell Aircraft Co., Saint Louis, MO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 22 p. Previously announced in STAR as N92-28418. refs
(AIAA PAPER 92-3790) Copyright

A generic one-third scale model of a tailpipe offtake system for a supersonic short takeoff vertical landing (SSTOVL) aircraft was tested at LeRC Powered Lift Facility. The model consisted of a tailpipe with twin elbows, offtake ducts, and flow control nozzles, plus a small ventral nozzle and a blind flange to simulate a blocked cruise nozzle. The offtake flow turned through a total angle of 177 degrees relative to the tailpipe inlet axis. The flow split was 45 percent to each offtake and 10 percent to the ventral nozzle. The main test objective was to collect data for comparison to the performance of the same configuration predicted by a computational fluid dynamics (CFD) analysis. Only the experimental results are given - the analytical results are published in a separate paper. Performance tests were made with unheated air at tailpipe-to-ambient pressure ratios up to 5. The total pressure loss through the offtakes was as high as 15.5 percent. All test results are shown as graphs, contour plots, and wall pressure distributions. The complex flow patterns in the tailpipe and elbows at the offtake openings are described with traversing flow angle probe and paint streak flow visualization data. Author

A92-54171*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
USE OF AN APPROXIMATE SIMILARITY PRINCIPLE FOR THE THERMAL SCALING OF A FULL-SCALE THRUST AUGMENTING EJECTOR
WENDY BARANKIEWICZ, GAIL P. PERUSEK (NASA, Lewis Research Center, Cleveland, OH), and MOUNIR IBRAHIM (Cleveland State University, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 12 p. Previously announced in STAR as N92-26613. refs
(AIAA PAPER 92-3792) Copyright

Full temperature ejector model simulations are expensive, and difficult to implement experimentally. If an approximate similarity principle could be established, properly chosen performance parameters should be similar for both hot and cold flow tests if the initial Mach number and total pressures of the flow field are held constant. Existing ejector data is used to explore the utility of one particular similarity principle; the Munk and Prim similarity principle for isentropic flows. Static performance test data for a full-scale thrust augmenting ejector are analyzed for primary flow temperatures up to 1560 R. At different primary temperatures, exit pressure contours are compared for similarity. A nondimensional flow paramenter is then used to eliminate primary nozzle temperature dependence and verify similarity between the hot and cold flow experiments. Author

A92-54177#
FURTHER STUDIES OF KINETIC ENERGY METHODS IN HIGH SPEED RAMJET CYCLE ANALYSIS
EDWARD T. CURRAN, JOHN L. LEINGANG, LOUIS R. CARREIRO, and DEAN P. PETTERS (USAF, Wright Laboratory, Wright-Patterson AFB, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 16 p. refs
(AIAA PAPER 92-3805)

A revision and extension is presented of the kinetic energy efficiency treatments of both component (inlet, combustor, nozzle) and overall ramjet engine performance set out in Curran et al. (1991). Overall ramjet performance trends are reviewed, and the application of such concepts to scramjet engines is discussed. Sustained component-development efforts are needed to establish a reliable basis for projecting high-speed engine performance. O.C.

A92-54178#
FLOWPATH AND SENSITIVITY ANALYSES OF HIGH SPEED PROPULSION SYSTEMS
S. N. B. MURTHY (Purdue University, West Lafayette, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 12 p. refs
(AIAA PAPER 92-3806) Copyright

Atmospheric gas breathing engines are of interest for high speed vehicle propulsion on earth and other planets, for example Mars. Other than purely chemical means, the optimization of an engine for obtaining the desired thrust output at the desired levels of propulsive efficiency and energy utilization effectiveness requires a balance of flow speed, heat addition, and internal mass addition. This balance is discussed from the viewpoint of scramjet engines for use in the atmospheres of the earth and the Mars to elucidate the influence of various engine parameters. Finally, considering atmospheric gas collection systems, a limiting case is discussed in which the prime advantage of collection is shown to be the reduction in the gross take-off weight. Author

A92-54546
CIS ENGINES - THE RANGE REVEALED. II
KEN FULTON Air International (ISSN 0306-5634), vol. 43, no. 2, Aug. 1992, p. 91-96.
Copyright

A review is presented of aircraft engines currently in an operational status or under development in the former USSR. Attention is given to the new Soyuz RDK-300-10 single-shaft turbofan design intended for UAVs or as a pylon-mounted takeoff booster for aircraft. A listing is provided of Russian and Ukrainian gas turbine and piston engines that includes basic takeoff thrust and aircraft installations for each of the powerplants. R.E.P.

A92-55281*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PROPULSION SYSTEM PERFORMANCE RESULTING FROM AN INTEGRATED FLIGHT/PROPULSION CONTROL DESIGN
DUANE MATTERN (Sverdrup Technology, Inc., Brook Park, OH) and SANJAY GARG (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1314-1323. refs
(AIAA PAPER 92-4602) Copyright

Propulsion system specific results are presented from the application of the Integrated Methodology for Propulsion and

Airframe Control (IMPAC) design approach to Integrated Flight/Propulsion Control design for a STOVL aircraft in transition flight. The IMPAC method is briefly discussed and the propulsion system specifications for the integrated control design are examined. The structure of a linear engine controller that results from partitioning a linear centralized controller is discussed. The details of a nonlinear propulsion control system are presented, including a scheme to protect the engine operational limits: the fan surge margin and the acceleration/deceleration schedule which limits the fuel flow. Also, a simple but effective multivariable integrator windup protection scheme is investigated. Nonlinear closed-loop simulation results are presented for two typical pilot commands for transition flight: acceleration while maintaining flight path angle and a change in flight path angle while maintaining airspeed. The simulation nonlinearities include the airframe/engine coupling, the actuator and sensor dynamics and limits, the protection scheme for the engine operational limits, and the integrator windup protection. Satisfactory performance of the total airframe plus engine system for transition flight, as defined by the specifications, is maintained during the limit operation of the closed-loop engine subsystem. Author

A92-55500
DEVELOPMENT OF ITS90 SMALL GAS TURBINE ENGINE
MITSUHARA OHMOMO and YOSHIYUKI YUMITE Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 32, no. 3, May 1992, p. 197-201. In Japanese. refs

Attention is given to the ITS90 small gas turbine engine, which was developed as a demonstrator model for the engineering evaluation of a new type of small gas turbine widely applicable to aircraft, land, and marine use. The engine exhibits excellent performance as an aircraft engine gas turbine. Test results showed satisfactory performance and operation of fuel and oil systems and structure. Development specifics, engine features, special applied technology, and details of test results are presented. C.A.B.

A92-55902
DESIGN OF THE BOEING 777 ELECTRIC SYSTEM
LUIZ ANDRADE (Sundstrand Aerospace Electric Power Systems, Rockford, IL) and CARL TENNING (Boeing Commercial Airplane Group, Seattle, WA) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 7, no. 7, July 1992, p. 4-11. Copyright

The electric power system for the 777 twin-engine transport jet is presented detailing the automation inherent in the main and backup systems. The main electric system is based on two engine-driven integrated drive generators, an auxiliary generator, generator control units, and bus power control. Microprocessor-based control units are employed for system automation based on control, protection, and built-in testing. The backup system comprises two engine-driven generators and an integrated converter/control unit. Specific attention is given to the redundant two-way communication bus developed for the microprocessor-based system control units which provide communication between the control units. The number of interface circuits is thereby reduced, and the integrated converter-control unit yields the redundancy of electrical sources needed for a three-engine airplane. The system is therefore efficient, highly automated, and lighter than existing equivalent electric systems. C.C.S.

A92-56122
STATE-OF-THE-ART MATERIALS FOR FUTURE GAS TURBINE ENGINES
O. CHEN (Pratt & Whitney Group, East Hartford, CT; Tokyo, University, Japan) Japan Society for Aeronautical and Space Sciences and Japan Aeronautical Engineers Association, Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Paper. 15 p. In Japanese. refs

The current status and future prospects of gas turbine engine materials are presented. The advanced materials and processing technology for the PW4000 engine are addressed. Advances in turbine blade materials and thermal barrier coating (TBC) are discussed. Silicon carbide fiber reinforced glass-ceramic matrix composites and functional gradient materials are considered. Y.P.Q.

A92-56281
'A NEW PROPOSAL FOR AN OLD PROBLEM' - THE RIGHT ENGINE FOR THE RIGHT HELICOPTER
A. SPIRKL (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Germany), W. MUGGLI (MBB GmbH, Munich, Germany), and L. HOLLY (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 18 p.

An overview is presented of the various factors involved in the engine selection process for helicopter development, using the MTR390 turboshaft engine as an example of the procedure. The design is an iterative process between the helicopter and engine manufacturers to derive an optimum overall system. Attention is given to the calculation of operating costs, the influence of the engine on the payload integral, and a summary of evaluation criteria. R.E.P.

A92-56300
V-22 PROPULSION SYSTEM DESIGN
W. G. SONNEBORN, E. O. KAISER, C. E. COVINGTON, and K. WILSON (Bell Helicopter Textron, Inc., Fort Worth, TX) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 17 p.

The propulsion system of the V-22 Osprey is comprised of the drive system, the power plant installation, and the proprotor. The drive system of V-22 includes five gearboxes, shafting, and special nonlubricated flexible coupling. The paper describes the lubrication of gearboxes for tiltrotor operations, testing facilities, special development problems, the power plant and its installation, the engine mount and controls, the fuel system, and other components of the propulsion system. It is shown that failsafe structure of V-22 is achieved by using composite structural elements and elastomeric bearings, combined with the constant-speed drive and the automatic blade folding system. I.S.

A92-56338
THE ADVANTAGES OF DIGITAL ENGINE CONTROL AS COMPARED WITH TRADITIONAL SYSTEMS (HYDRAULIC OR PNEUMATIC)
M. BARRAL and J. P. RAMOND (Turbomeca, Bordes, France) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 9 p.

The use of digital engine control is examined and compared to hydromechanical control techniques in terms of the pilot, operator, and manufacturer workloads. The digital electronic control unit (DECU) is shown to be useful to the pilot during high-workload operations such as nap-of-the-earth flying, platform takeoff, and approach. The DECU has applications during failure cases and restarting an engine in flight, and digital control can enhance pilot training. The operator's tasks are reduced because a DECU provides a health-monitoring system and a check on the engine power. Digital control is also argued to help the manufacturer by insuring more precise responses and preventing torsional instability. Other manufacturing issues and technological developments for DECUs make the devices effective additions to helicopter engines. C.C.S.

A92-56759#
SMOOTHING CFM56 ENGINE REMOVAL RATE AT USAIR
ROBERT A. HALSMER and ROBERT E. MATSON (USAir, Inc., Pittsburgh, PA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 7 p.
(AIAA PAPER 92-3928) Copyright

An overview is presented of the airborne developed engine performance trending (ADEPT) engine condition monitoring system, employed to smooth out engine removal variance, incurred over annual seasonal ambient temperature variations. The cyclic nature of engine removals and the problems it creates are discussed,

and the specific steps that can be taken to minimize the highs and lows are outlined. A summary of the benefits attained by using the ADEPT system is given. R.E.P.

A92-56803#
TURBINE ENGINE PERFORMANCE TEST AND EVALUATION TECHNIQUES
S. A. SAVELLE and M. B. PRUFERT (Sverdrup Technology, Inc., Arnold AFB, TN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 14 p. refs
(AIAA PAPER 92-3977)

An overview of turbine engine performance test and evaluation practices employed in altitude test facilities (ATF) is given. Methods for the measurement of key performance parameters and for the evaluation of specific engine requirements are reviewed. Typical results of recent turbine engine performance assessments are presented to illustrate the types of tests and evaluations currently performed. Upcoming challenges in performance test and evaluation and their effect on current methods are discussed. Author

A92-56805#
A MODEL STUDY ON DIFFUSER PRESSURE RECOVERY IN NAL SCRAMJET TEST FACILITY WITH SIMULATED HYDROGEN COMBUSTION
T. KUROSAKA, T. YAMAMURA, S. IWAGAMI (Kobe Steel, Ltd., Hyogo, Japan), J. L. GRUNNET, K. HAYAKAWA (FluiDyne Engineering Corp., Minneapolis, MN), and H. MIYAJIMA (National Aerospace Laboratory, Miyagi, Japan) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 11 p. refs
(AIAA PAPER 92-3979) Copyright

An experimental test program was conducted to study the characteristics of supersonic diffuser pressure recovery for a semifreejet scramjet engine test facility. The effect of hydrogen combustion was also evaluated by injecting a supersonic air stream into the engine module model. The optimized test chamber configuration was obtained with nozzle and diffuser extensions which permitted optical measurements of the model. Test results with simulated hydrogen combustion indicate that the test chamber pressure can be maintained below the nozzle exit pressure with hydrogen injection. The diffuser thermal choke, however, will restrict the operational equivalence ratio to below 0.8 at a simulated Mach number of 4 and more than 1.5 at Mach 6. V.L.

A92-57098
TESTS RESULTS ON AIR TURBO RAMJET FOR A FUTURE SPACE PLANE
NOBUHIRO TANATSUGU, YOSHIHIRO NARUO (Institute of Space and Astronautical Science, Sagamihara, Japan), and ITARU ROKUTANDA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) IAF, International Astronautical Congress, 43rd, Washington, Aug. 28-Sept. 5, 1992. 9 p. refs
(IAF PAPER 92-0657) Copyright

The current status of the Air Turbo Ramjet (ATR) development program initiated in Japan in 1986 is reviewed. The ATR engine being developed is a combined cycle air-breathing propulsion system consisting of a turbojet and a fan boosted ramjet using liquid hydrogen as a fuel. With the introduction of an expander cycle, the engine system has been named ATREX. The ATREX is energized by thermal energy extracted regeneratively in both the precooler installed in the air intake and the heat exchanger in the combustion chamber. Results of the testing of the ATREX-500 engine in the sea level static condition are presented. V.L.

A92-57099
AIRBREATHING ENGINE SELECTION CRITERIA FOR SSTO PROPULSION SYSTEM
Y. OHKAMI (Tokyo Institute of Technology, Japan), T. YAMANAKA, and M. MAITA (National Aerospace Laboratory, Chofu, Japan) IAF, International Astronautical Congress, 43rd, Washington, Aug. 28-Sept. 5, 1992. 6 p. refs
(IAF PAPER 92-0658) Copyright

This paper presents airbreathing-engine selection criteria to be applied to the propulsion system of a single-stage-to-orbit vehicle. To establish the criteria, a relation among three major parameters, i.e., delta-V capability, weight penalty, and effective specific impulse of the engine subsystem, is derived as compared to these parameters of the LH2/LOX rocket engine. The delta-V capability is defined by the velocity region starting from the minimum operating velocity up to the maximum velocity. The system parameters are computed by iteration based on the Newton-Raphson method. It is concluded that performance in the higher velocity region is important. A SCRAM engine system is promising if it operates up to 5000 km/sec or more. Author

N92-32452*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATIONS OF UNSTEADY MULTISTAGE COMPRESSOR FLOWS IN A WORKSTATION ENVIRONMENT
KAREN L. GUNDY-BURLET Jun. 1992 14 p Previously announced in IAA as A92-15701
(Contract RTOP 505-60-00)
(NASA-TM-103839; A-91074; NAS 1.15:103839) Avail: CASI HC A03/MF A01

High-end graphics workstations are becoming a necessary tool in the computational fluid dynamics environment. In addition to their graphic capabilities, workstations of the latest generation have powerful floating-point-operation capabilities. As workstations become common, they could provide valuable computing time for such applications as turbomachinery flow calculations. This report discusses the issues involved in implementing an unsteady, viscous multistage-turbomachinery code (STAGE-2) on workstations. It then describes work in which the workstation version of STAGE-2 was used to study the effects of axial-gap spacing on the time-averaged and unsteady flow within a 2 1/2-stage compressor. The results included time-averaged surface pressures, time-averaged pressure contours, standard deviation of pressure contours, pressure amplitudes, and force polar plots. Author

N92-33102# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
IDEAL EFFICIENCY OF PROPELLERS BASED ON THEODORSEN'S THEORY: A REVIEW AND COMPUTER STUDY, WITH EXTENDED PLUS SIMPLIFIED CHARTS
STEPHEN P. FOSTER and H. S. RIBNER Feb. 1991 145 p Sponsored by Natural Sciences and Engineering Research Council
(ISSN 0082-5263)
(UTIAS-TN-271; CTN-92-60378) Copyright Avail: CASI HC A07/MF A02

Ideal propeller performance is explored in an examination of Theodorsen's theory of propellers. This work presents an overview of the theory with analysis and interpretation. Computational methods are used in place of Theodorsen's analog technique to calculate key parameters for most cases. In addition, relations between the fundamental quantities (thrust, power, advance, and efficiency) are presented in this format plus a more convenient one that avoids iteration. Theodorsen's methodology is further applied to calculate slipstream contraction. A slightly more general approach is taken with the removal of several light loading assumptions. A review of how the updated results may be applied to the design of single rotation propellers is also provided. Author (CISTI)

N92-33105# Naval Air Propulsion Test Center, Trenton, NJ.
STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN US COMMERCIAL AVIATION DURING 1988 Final Report
R. A. DELUCIA, E. R. CHAPDELAINE (Federal Aviation Administration, Atlantic City, NJ.), and B. C. FENTON (Federal Aviation Administration, Atlantic City, NJ.) Mar. 1992 27 p
(Contract DOD/FA7INA-AP)
(DOT/FAA/CT-91/28) Avail: CASI HC A03/MF A01

Statistical information relating to gas turbine engine rotor failures, which occurred during 1988 in U.S. commercial aviation

service, is presented. Four hundred and thirteen failures occurred in 1988. Rotor fragments were generated in 175 of the failures, and of these 14 were uncontained. The predominant failure involved blade fragments, 95 percent of which were contained. Five disk failures occurred and all were uncontained. Forty-two percent of the 413 failures occurred during the takeoff and climb stages of flight. This service data analysis is prepared on a calendar year basis and published yearly. The data are useful in support of flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses. Author

N92-33479*# Pratt and Whitney Aircraft Group, East Hartford, CT.

LIFE PREDICTION AND CONSTITUTIVE MODELS FOR ENGINE HOT SECTION ANISOTROPIC MATERIALS PROGRAM Final Report

D. M. NISSLEY, T. G. MEYER, and K. P. WALKER (Engineering Science Software, Inc., Smithfield, RI.) Sep. 1992 312 p
(Contract NAS3-23939; RTOP 590-21-11)
(NASA-CR-189223; NAS 1.26:189223; PWA-5968-102) Avail: CASI HC A14/MF A03

This report presents a summary of results from a 7 year program designed to develop generic constitutive and life prediction approaches and models for nickel-based single crystal gas turbine airfoils. The program was composed of a base program and an optional program. The base program addressed the high temperature coated single crystal regime above the airfoil root platform. The optional program investigated the low temperature uncoated single crystal regime below the airfoil root platform including the notched conditions of the airfoil attachment. Both base and option programs involved experimental and analytical efforts. Results from uniaxial constitutive and fatigue life experiments of coated and uncoated PWA 1480 single crystal material formed the basis for the analytical modeling effort. Four single crystal primary orientations were used in the experiments: group of zone axes (001), group of zone axes (011), group of zone axes (111), and group of zone axes (213). Specific secondary orientations were also selected for the notched experiments in the optional program. Constitutive models for an overlay coating and PWA 1480 single crystal materials were developed based on isothermal hysteresis loop data and verified using thermomechanical (TMF) hysteresis loop data. A fatigue life approach and life models were developed for TMF crack initiation of coated PWA 1480. A life model was developed for smooth and notched fatigue in the option program. Finally, computer software incorporating the overlay coating and PWA 1480 constitutive and life models was developed. Author

N92-33645# Technische Univ., Brunswick (Germany). Fakultaet fuer Maschinenbau und Elektrotechnik.

A MULTIVARIABLE CONTROL CONCEPT FOR A GAS TURBINE ENGINE Ph.D. Thesis [MEHRGROESSEN-REGELUNGSKONZEPT FUER EIN GASTURBINENTRIBWERK]

HARALD SOELTER 1991 169 p In GERMAN
(ETN-92-92104) Avail: CASI HC A08/MF A02

An alternative control concept is presented for LARZAC 04 type gas turbine. It is shown that a possible way to systematize the design process is to use concepts of methodical projects from adjacent fields. The gas turbine engine process and the detailed control requirements are examined. The engine control system, theoretical linear engine control concepts, and examples for control systems for similar complex processes are analyzed. The obtained results lead to the formulation of a control structure, which is based on an adaptive anticipated control in connection with a multivariable control, which is used to maintain the state of the process in the allowed operating range, even in the case of disturbances or parameter divergences. ESA

N92-33746*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

NAVIER-STOKES ANALYSIS AND EXPERIMENTAL DATA COMPARISON OF COMPRESSIBLE FLOW IN A DIFFUSING S-DUCT

GARY J. HARLOFF (Sverdrup Technology, Inc., Brook Park, OH.), BRUCE A. REICHERT, and STEVEN R. WELLBORN (Iowa State Univ. of Science and Technology, Ames.) Jul. 1992 11 p Presented at the 10th Applied Aerodynamics Conference Exhibit, Palo Alto, CA, 22-24 Jun. 1992; sponsored by AIAA Previously announced in IAA as A92-45541
(Contract NAS3-25266; RTOP 505-62-52)
(NASA-TM-105683; E-7062; NAS 1.15:105683; AIAA PAPER 92-2699) Avail: CASI HC A03/MF A01

Full three-dimensional Navier-Stokes computational results are compared with new experimental measurements for the flowfield within a round diffusing S-duct. The present study extends previous computational and experimental results for a similar smaller scale S-duct. Predicted results are compared with the experimental static and total pressure fields, and velocity vectors. Additionally, wall pressures, velocity profiles in wall coordinates, and skin friction values are presented. The CFD results employ algebraic and k-epsilon turbulence models. The CFD computed and experimentally determined separated flowfield is carefully examined. Author

N92-33748# Rolls-Royce Ltd., Derby (England).

RE-ENGINING FOR REAL STAGE 3 COMPLIANCE Progress Report

K. GODDARD and M. R. SELLAR 4 May 1992 15 p Presented at the Aircraft Noise Attenuation and Regulatory Update, Miami, FL, 3-5 Apr. 1991
(PNR-90872; ETN-92-92183) Copyright Avail: CASI HC A03/MF A01

Noise legislation developments relevant to noisy stage 2 aircraft are described, and reengining for noise reduction to stage 3 compliance is discussed. The Rolls Royce Tay engine is addressed, and Tay 650 design features and noise reductions are described. The status of current programs for the BAC1-11-2400, B727-1000, and Tay 670, is outlined. The current business scene, aircraft resale values, and lease rates, are discussed. ESA

N92-33749# Rolls-Royce Ltd., Derby (England).

AN IMPROVED COMPRESSOR PERFORMANCE PREDICTION MODEL

P. I. WRIGHT and D. C. MILLER 4 Apr. 1992 13 p
(PNR-90873; ETN-92-92184) Copyright Avail: CASI HC A03/MF A01

The improvement of a mean line compressor performance prediction model is reported. The overall characteristic is generated by the mean line stacking of blade row characteristics generated from mid-radius blading data. New correlations for freestream and end wall losses, together with an improved shock loss model, were included. The effect of Reynolds number on loss was incorporated. An improved correlation for deviation based both on empirical data and on a blade to blade time marching analysis was derived. The correlation for throat area was improved, and this is used together with inlet Mach number as the basis for a correlation of minimum loss incidence. A correlation for blockage factor is included. The methods for predicting the effect of off-design incidence on loss and deviation and the definition of the surge line are unchanged from those previously reported. The empirical coefficients included in the compressor performance prediction model were calibated using single stage test data at design and part speed. ESA

N92-33815# Rolls-Royce Ltd., Bristol (England). Experimental Vibration Dept.

JOINT STUDY ON THE COMPUTERISATION OF IN-FIELD AERO ENGINES VIBRATION DIAGNOSIS

H. R. CARR 1 Nov. 1990 11 p Sponsored by Ministry of Defence

(PNR-90799; ETN-92-92177) Copyright Avail: CASI HC A03/MF A01

A program to develop software based diagnostics for rotor dynamic symptoms in fixed wing engines is addressed. When installed, the system must be flexible and suitable for inexperienced operators. The initial development of data acquisition and interpretive methods and the provision of a 'signature' data base for Adour and RB199 engines are described. Important aspects are the combination of engineering understanding, operator experience, and where necessary detailed strip and inspection of problem engines. Although orientated towards military aeroengine practices, the experience and methodology apply to any diagnostic situation. ESA

N92-34236*# General Motors Corp., Indianapolis, IN. Gas Turbine Div.

COOLED HIGH-TEMPERATURE RADIAL TURBINE PROGRAM 2 Final Report

PHILIP H. SNYDER May 1991 95 p

(Contract NAS3-24230; RTOP 505-62-OK; RTOP 505-68-10)

(NASA-CR-189122; NAS 1.26:189122; EDR-15982; USAAVSCOM-TR-92-C-010) Avail: CASI HC A05/MF A01

The objective of this program was the design and fabrication of a air-cooled high-temperature radial turbine (HTRT) intended for experimental evaluation in a warm turbine test facility at the LeRC. The rotor and vane were designed to be tested as a scaled version (rotor diameter of 14.4 inches diameter) of a 8.021 inch diameter rotor designed to be capable of operating with a rotor inlet temperature (RIT) of 2300 F, a nominal mass flow of 4.56 lbm/sec, a work level of equal or greater than 187 Btu/lbm, and efficiency of 86 percent or greater. The rotor was also evaluated to determine it's feasibility to operate at 2500 F RIT. The rotor design conformed to the rotor blade flow path specified by NASA for compatibility with their test equipment. Fabrication was accomplished on three rotors, a bladeless rotor, a solid rotor, and an air-cooled rotor. Author

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A92-53546

PARAMETER ESTIMATION OF AN AUGMENTED AIRPLANE WITH UNSTEADY AERODYNAMICS MODELLING

S. C. RAISINGHANI (Indian Institute of Technology, Kanpur, India) and AJOY K. GHOSH (Armament Research and Development Establishment, Poona, India) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, AGNE Publishing, Inc., 1990, p. 699-706. refs

Copyright

An augmented aircraft with coupled stabilator and trailing edge flap is studied using a modeling which includes unsteady effects in downwash. The maximum likelihood method is used in the frequency domain to extract parameters from simulated flight data. Control input forms are suggested to separate the control derivatives of the stabilator and flap. C.D.

A92-55170*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DYNAMICS AND CONTROL OF HYPERSONIC AEROPROPULSIVE/AEROELASTIC VEHICLES

DAVID K. SCHMIDT (Arizona State University, Tempe) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 161-171. refs

(Contract NAG1-1341)

(AIAA PAPER 92-4326) Copyright

The guidance and control of hypersonic vehicles is examined by studying the airframe/engine/structural-dynamic interactions of a generic vehicle with scramjet propulsion. The pitch-attitude dynamics are described for the vehicle configuration that can sustain hypersonic flight at near-orbital altitudes. These aerospacecraft have strong airframe/engine/elastic coupling in attitude dynamics and engine responses with static instability with respect to pitch. An integrated airframe-engine control system is presented for the control of the system's strong aeropropulsive/aeroelastic coupling. The control methodology utilizes feedback of measured/synthesized values of angle of attack, blended pitch rate, thrust, and combustor-inlet pressure. The multiinput/multioutput engine controller requires high-bandwidth actuation of the fuel-flow control and the effective diffuser ratio. The proposed control laws do not provide optimized performance in terms of pitch response suggesting that additional control crossfeeds and filtering is needed. C.C.S.

A92-55171#

CONTINUOUS FLYING QUALITY IMPROVEMENT - THE MEASURE AND THE PAYOFF

J. HODGKINSON, M. PAGE, J. PRESTON, and D. GILLETTE (Douglas Aircraft Co., Long Beach, CA) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 172-180. refs

(AIAA PAPER 92-4327) Copyright

A measure that aids the integration of flying qualities into the design of transport aircraft is suggested. The measure is based on a statistical interpretation of the Cooper-Harper pilot rating scale, and is a first step in a more structured and formalized process for incorporating flying qualities requirements into the design process. Author

A92-55172#

A SIMULATOR EVALUATION OF VARIOUS MANUAL CONTROL CONCEPTS FOR FLY-BY-WIRE TRANSPORT AIRCRAFT

P. J. VAN DER GEEST, A. M. H. NIEUWPOORT, and J. BORGER (Fokker Aircraft, Schiphol, Netherlands) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 181-191. refs

(AIAA PAPER 92-4328) Copyright

Results are presented of an evaluation, on a fixed base simulator, of three control concepts based on different design philosophies, applied to a FBW-controlled Fokker 100 aircraft: a rate command system, a flight path vector command system, and a C* command system. The control laws of the three concepts were designed to provide Level 1 short-term responses in both pitch and roll. Results of tests indicate that, in general, the performance (in terms of flight path accuracy) could not be significantly improved in comparison to the conventional Fokker 100, especially when Flight Director System is available. Advantages of FBW-control concepts primarily show up in terms of reduced workload and enhanced safety during manual flight. It is suggested that a flight path vector command concept may provide significant operational, and associated economic, benefits for short-haul aircraft. I.S.

A92-55173*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ROBUST DYNAMIC INVERSION CONTROL LAWS FOR AIRCRAFT CONTROL

GARY J. BALAS, WILLIAM L. GARRARD, and JAKOB REINER (Minnesota, University, Minneapolis) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 192-205. refs

(Contract NAG1-821; NAG1-1380)
(AIAA PAPER 92-4329) Copyright

Dynamic inversion is a technique for control law design in which feedback is used to simultaneously cancel system dynamics and achieve desired dynamic response characteristics. However, dynamic inversion control laws lack robustness to modeling errors if improperly designed. This paper examines a simple linear example, control of roll rate about the body axis of high performance aircraft, to illustrate some robustness problems which may occur with a simple dynamic inversion control law. The paper demonstrates how structured singular value synthesis techniques can be used to enhance the robustness properties of the dynamic inversion controller. Author

A92-55174*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PRELIMINARY ASSESSMENT OF THE ROBUSTNESS OF DYNAMIC INVERSION BASED FLIGHT CONTROL LAWS
S. A. SNELL (California, University, Davis) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 206-216. refs
(Contract NAG1-821)
(AIAA PAPER 92-4330) Copyright

Dynamic-inversion-based flight control laws present an attractive alternative to conventional gain-scheduled designs for high angle-of-attack maneuvering, where nonlinearities dominate the dynamics. Dynamic inversion is easily applied to the aircraft dynamics requiring a knowledge of the nonlinear equations of motion alone, rather than an extensive set of linearizations. However, the robustness properties of the dynamic inversion are questionable especially when considering the uncertainties involved with the aerodynamic database during post-stall flight. This paper presents a simple analysis and some preliminary results of simulations with a perturbed database. It is shown that incorporating integrators into the control loops helps to improve the performance in the presence of these perturbations. Author

A92-55191#
FLIGHT CONTROL LAW SYNTHESIS USING NEURAL NETWORK THEORY
R. DIGIROLAMO (U.S. Navy, Naval Air Warfare Center, Warminster, PA) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 385-394. refs
(AIAA PAPER 92-4390)

This paper discusses the use of multiple layer feedforward neural networks as a method for selecting optimal gain schedules for the control of a high performance fighter aircraft. This method has been applied to the pitch rate tracking problem of a nonlinear longitudinal F/A-18 model. In the application, a standard three layer backpropagation neural network is trained to schedule gains for a fixed structure pitch control augmentation system (PCAS) over an envelope of flight conditions. The objective of the controller is to accurately track the pitch rate response of a linear, scheduled 'performance' model through given test maneuvers. Simulation results demonstrate that the neural network is capable of generating a continuous mapping between scheduling variables and controller gains which minimizes an arbitrary cost function based on the system tracking error. Author

A92-55192#
NEURAL NETWORKS FOR FEEDBACK LINEARIZATION IN AIRCRAFT CONTROL
ANTHONY J. CALISE, BYOUNG S. KIM (Georgia Institute of Technology, Atlanta), MOSHE KAM, and MISBAHUL AZAM (Drexel University, Philadelphia, PA) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 395-406. refs
(AIAA PAPER 92-4391) Copyright

Several neural network architectures and learning procedures for neurocontrol of aircraft are examined. Among the issues investigated are: (1) the use of sigma-pi multiperceptrons and radial-basis-function-based architectures as feedback linearizers; (2) dynamic range limitations of neural approximators; and (3) on-line training for compensation of modeling errors and parameter drifts. Demonstration of architecture and learning-algorithm applicability are based on simulations of subsystems in the F/A-18 model. Author

A92-55193#
A FUZZY LOGIC BASED F/A-18 AUTOMATIC CARRIER LANDING SYSTEM
MARC STEINBERG (U.S. Navy, Naval Warfare Center, Warminster, PA) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 407-417. refs
(AIAA PAPER 92-4392)

A demonstration of fuzzy logic for aircraft outer loop control is described. The F/A-18 fuzzy logic automated carrier landing system (FACLS) is designed so that an aircraft has the proper position, sink rate, angular attitudes, and speed at touchdown on a carrier under varying conditions and with limited control authority. The FACLS has eleven sensor inputs, three effector outputs and several hundred fuzzy rules which are embedded in a classical control structure. This use of fuzzy logic models a set of human rules and also combines the best features of human and automatic control approaches. The system acceptability was improved by making it sensitive to pilot concerns which are difficult to accomodate in conventional control systems. The FACLS was tested in simulation and compared with the conventional F/A-18 automated carrier landing system. The simulation test bed is described and test results are discussed. Results indicated that fuzzy logic could yield significant benefits for aircraft outer loop control. A.O.

A92-55194#
IDENTIFICATION AND CONTROL OF AIRCRAFT DYNAMICS USING RADIAL BASIS FUNCTION NEURAL NETWORKS
F. AHMED-ZAID, P. A. IOANNOU, M. M. POLYCARPOU (Southern California, University, Los Angeles, CA), and H. M. YOUSSEF (Lockheed Aeronautical Systems Co., Marietta, GA) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 418-427. refs
(AIAA PAPER 92-4393) Copyright

Recently, the emergence of neural networks as a promising tool for approximating complex system input-output mappings has generated a great deal of interest in the area of modeling, identification and control of nonlinear dynamic systems. One specific research area that would tremendously benefit from this approach is the area of identification and control of high performance aircraft, especially at high angles of attack. At those flight conditions, the control task becomes extremely difficult due to added design complexity and hard nonlinearities characterizing the system. One type of neural networks, namely the Radial Basis Function (RBF) networks is investigated, and apply them to the identification and control problems of an aircraft system. The RBF network is used as an on-line approximator of the aircraft pitch dynamics, combined with a nonlinear control law to improve the closed-loop system performance. The results are illustrated through simulations using a nonlinear model of the F-16 aircraft pitch dynamics. Author

A92-55196*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT-DETERMINED STABILITY ANALYSIS OF MULTIPLE-INPUT-MULTIPLE-OUTPUT CONTROL SYSTEMS
JOHN J. BURKEN (NASA, Flight Research Center, Edwards, CA) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1.

Washington, American Institute of Aeronautics and Astronautics, 1992, p. 439-453. refs
(AIAA PAPER 92-4396) Copyright

Singular value analysis can give conservative stability margin results. Applying structure to the uncertainty can reduce this conservatism. This paper presents flight-determined stability margins for the X-29A lateral-directional, multiloop control system. These margins are compared with the predicted unscaled singular values and scaled structured singular values. The algorithm was further evaluated with flight data by changing the roll-rate-to-aileron-command-feedback gain by +/- 20 percent. Also presented are the minimum eigenvalues of the return difference matrix which bound the singular values. Extracting multiloop singular values from flight data and analyzing the feedback gain variations validates this technique as a measure of robustness. This analysis can be used for near-real-time flight monitoring and safety testing. Author

A92-55199*# National Aeronautics and Space Administration. *Langley Research Center, Hampton, VA.*
AIRCRAFT RIDE QUALITY CONTROLLER DESIGN USING NEW ROBUST ROOT CLUSTERING THEORY FOR LINEAR UNCERTAIN SYSTEMS
R. K. YEDAVALLI (Ohio State University, Columbus) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 477-485. refs
(Contract NAG1-1164)
(AIAA PAPER 92-4399) Copyright

The aspect of controller design for improving the ride quality of aircraft in terms of damping ratio and natural frequency specifications on the short period dynamics is addressed. The controller is designed to be robust with respect to uncertainties in the real parameters of the control design model such as uncertainties in the dimensional stability derivatives, imperfections in actuator/sensor locations and possibly variations in flight conditions, etc. The design is based on a new robust root clustering theory developed by the author by extending the nominal root clustering theory of Gutman and Jury to perturbed matrices. The proposed methodology allows to get an explicit relationship between the parameters of the root clustering region and the uncertainty radius of the parameter space. The current literature available for robust stability becomes a special case of this unified theory. The bounds derived on the parameter perturbation for robust root clustering are then used in selecting the robust controller.
Author

A92-55200#
ROBUST SAMPLED DATA EIGENSTRUCTURE ASSIGNMENT USING THE DELTA OPERATOR
JEAN E. PIOU and KENNETH M. SOBEL (City College, New York) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 486-496. refs
(Contract F49620-88-C-0053)
(AIAA PAPER 92-4400) Copyright

Eigenstructure assignment is considered for a linear time invariant plant. The plant is represented by the unified delta model which is valid for continuous time and sampled data plant operation. For the unified delta model as sampling time approaches zero discrete time eigenvalues approach continuous time eigenvalues. It is shown that delta model eigenvectors are identical to continuous time plant eigenvectors and an expression is derived for the eigenstructure assignment feedback gain matrix of the delta model. A sufficient condition for the robust stability of a linear time invariant unified delta plant subject to linear time invariant structured state space uncertainity is proposed. A robust sampled data design is computed for the extended medium range air to air missile by minimizing the actuator deflection rates, the integral of the roll rate with constraints on selected eigenvalues, and the sufficient condition for robust stability. This robust design is compared with an orthogonal projection eigenstructure assignment design. A.O.

A92-55203#
DESIGN OF ROBUST QUANTITATIVE FEEDBACK THEORY CONTROLLERS FOR PITCH ATTITUDE HOLD SYSTEMS
DAVID E. BOSSERT (U.S. Air Force Academy, Colorado Springs, CO) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 517-524. refs
(AIAA PAPER 92-4409)

This paper develops a robust Quantitative Feedback Theory (QFT) design for two case studies to show the effectiveness of QFT controllers for a pitch attitude hold system over a wide range of flight conditions. Short period approximations for flight conditions ranging from a power approach to supersonic cruise provide the plant variations for study. Two case studies using transfer functions for a business jet and the F-4 fighter jet display the versatility of the technique. The military specification MIL-F-8785B defines the constraints, and each aircraft is evaluated at three flight conditions. Finally, the design is detailed and validated. This application shows the potential for use of QFT controllers in flight applications as a robust control technique which is not dependent upon gain scheduling. Author

A92-55204#
INVERTIBILITY AND TRAJECTORY CONTROL FOR NONLINEAR MANEUVERS OF AIRCRAFT
MISBAHUL AZAM and SAHJENDRA N. SINGH (Nevada, University, Las Vegas) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 525-535. refs
(AIAA PAPER 92-4410) Copyright

A new control system design approach for simultaneous nonlinear lateral and longitudinal maneuvers of aircraft based on nonlinear inversion theory is presented. First, a control law for the inner loop is derived for the independent control of the angular velocity components of the aircraft along roll, pitch, and yaw axes using aileron, elevator, and rudder to follow given angular velocity command trajectories. Then it is shown that by a judicious choice of angular velocity command signals, independent trajectory control of the sets of output variables (angle of attack, roll and sideslip angles), (roll rate, angle of attack and yaw angle), or (pitch, roll, and way angles) can be accomplished. These angular velocity command signals are generated in the outer-loops around the inner decoupled loop using state feedback and the reference angle of attack, pitch, yaw, and roll angle trajectories which are to be tracked to accomplish desired maneuvers. Simulation results are presented to show that in the closed-loop system, various simultaneous lateral and longitudinal maneuvers can be performed in spite of the presence of uncertainty in the stability derivatives by switching appropriate angular velocity command generators.
Author

A92-55205*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NEW LITERAL APPROXIMATIONS FOR THE LONGITUDINAL DYNAMIC CHARACTERISTICS OF FLEXIBLE FLIGHT VEHICLES
RAFAEL LIVNEH and DAVID K. SCHMIDT (Arizona State University, Tempe) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 536-545. refs
(Contract NAG1-1341)
(AIAA PAPER 92-4411) Copyright

The goal of the literal approximation method is to obtain simple literal (analytical) approximations for key dynamic characteristics of flexible flight vehicles. A basic question regarding the method is its usefulness as an additional design tool for existing design and simulation procedures. Two aspects of this question are: (1)

ease of derivation and use of the literal approximations, and (2) the suitability of one set of literal approximations to describe the dynamics of a large set of significantly different vehicles. These issues are addressed by incorporating symbolic manipulation software into the literal approximation method for the analysis of a fifth order model of the longitudinal dynamics of a flexible flight vehicle. The automated literal approximation generated in this fashion reduces the manual derivation time by an approximate factor of four. A single set of literal approximations is shown to provide adequate approximations for the dynamics of significantly different flight vehicles configurations, such as an aircraft, a missile, and a hypersonic vehicle. Author

A92-55206#
AN EFFICIENT ALGORITHM FOR OPTIMAL AIRCRAFT TRAJECTORIES
B. RASHIDIAN (Cessna Airplane Co., Wichita, KS) and M. G. NAGATI (Wichita State University, KS) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, *Technical Papers*. Pt. 1. *Washington, American* Institute of Aeronautics and Astronautics, 1992, p. 546-554. refs
(AIAA PAPER 92-4412) Copyright

An efficient dynamic programming technique for computing aircraft trajectories is presented. The objective is to develop an optimal control time history for aircraft flying such that obstructions in the flight path are avoided. Such is the case of collision avoidance, or avoidance of restricted airspaces which are dynamic in nature. The advantages of this method include the reduction of problem size by discretizing the time range of interest and using a spline function to interpolate in these discrete time steps, and by using two time scales for the fast and slow variables, and introducing a correction for altitude. The method provided a versatile tool for computing optimal three dimensional trajectories for a variety of maneuvers. Test cases are included which demonstrate the effectiveness of the present algorithm. Author

A92-55229#
ROBUSTNESS OF A HELICOPTER FLIGHT CONTROL SYSTEM DESIGNED USING EIGENSTRUCTURE ASSIGNMENT
EICHER LOW (Nanyang Technological University, Singapore) and WILLIAM L. GARRARD (Minnesota, University, Minneapolis) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 786-803. refs
(Contract DAAL03-86-K-0056)
(AIAA PAPER 92-4469) Copyright

The paper analyzes the robustness properties of the Low et al. (1992) flight control system for the enhancement of the helicopter handling qualities. Robustness of the system is evaluated by structured singular values and by simulations of the dynamic response, using models whch include variations of aerodynamic coefficients. The results of tests showed that, in spite of the fact that certain combinations of parameter variations could destabilize the helicopter, the handling qualities were still no worse than Level 2. I.S.

A92-55230*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CONTROL DESIGN OF A UH-60 ROTORCRAFT VIA CLTR AND DIRECT OPTIMIZATION
BRETT VANSTEENWYK and UY-LOI LY (*Washington, University,* Seattle) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 804-817. refs
(Contract NAG2-691)
(AIAA PAPER 92-4470) Copyright

High-performance rotorcraft controller design is characterized by the need to compensate for both the longitudinal and lateral dynamics simultaneously. Rather than leaving these modes largely decoupled, one often needs for performance consideration to incorporate direct mode decoupling as a part of the controller design, especially when the system model includes high-frequency dynamics from the rotor and lag states. In addition to the usual design considerations of stability augmentation, a high-performance rotorcraft such as the UH-60 would also require a good command bandwidth and decoupling in the heave, yaw, pitch and roll command responses. In this paper, the method of closed-loop transfer recovery (CLTR) and direct optimization are applied to the control design of a UH-60 rotorcraft. Author

A92-55231#
OPTIMAL CONTROL OF HELICOPTERS FOLLOWING POWER FAILURE
YOSHINORI OKUNO (National Aerospace Laboratory, Tokyo, Japan) and KEIJI KAWACHI (Tokyo, University, Japan) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 818-825. refs
(AIAA PAPER 92-4471) Copyright

Helicopters' control procedure in the event of power failure is theoretically investigated by applying nonlinear optimal control theory. Comparison between the optimal solutions and flight test results shows that the pilots used nonoptimal controls during the *recovering procedure, especially in the timing and amplitude of* the collective flare before touchdown, or in the pull-up manueuver when continuing flight. It is also pointed out that parameters such as wind speed, initial flight-path angle, collective pitch range, emergency landing site location, and its available field length have significant effects on safe landing and successful continued flight following power failure, although some of these effects are not taken into account during current certification flight tests. Author

A92-55232*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CONCEPTS FOR PILOT INTERACTION WITH AN AUTOMATED NOE OBSTACLE-AVOIDANCE SYSTEM
R. A. COPPENBARGER and V. H. L. CHENG (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 826-837. refs
(AIAA PAPER 92-4472) Copyright

The problem of providing an appropriate method by which a human pilot interacts with an automated nap-of-the-earth rotorcraft guidance and control system is addressed. This problem is closely related to the broader question of what level and degree of automation is effective at reducing pilot workload during low-altitude flight missions requiring obstacle avoidance. A systematic approach for establishing the possible combinations of manual vs automatic authority over relevant guidance and control functions is first presented. From these possibilities, three candidate concepts are selected based upon their potential for practical implementation and reduction in pilot workload. This paper describes the selection of these three pilot-interaction concepts and the mathematical models for their implementation. Author

A92-55233#
AUTOMATIC FORMATION FLIGHT CONTROL
J. L. DARGAN, M. PACHTER, and J. J. D'AZZO (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, *Technical Papers*. Pt. 2. *Washington, American* Institute of Aeronautics and Astronautics, 1992, p. 838-857. refs
(AIAA PAPER 92-4473) Copyright

The problem of automatic formation flight control is addressed. An aircraft formation consisting of a Leader and a Wingman is considered and this novel dynamical system is carefully modeled and analyzed. The subsequent synthesis of a Proportional plus Integral formation-hold autopilot is greatly facilitated by the observation that the formation flight control system is amenable to decomposition. Extensive simulations of the nonlinear formation flight control system were performed to validate the proposed formation-hold autopilot design. Author

A92-55246#
THE APPLICATION OF DIRECT TRANSCRIPTION TO COMMERCIAL AIRCRAFT TRAJECTORY OPTIMIZATION
JOHN T. BETTS and EVIN J. CRAMER (Boeing Computer Services, Seattle, WA) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 986-997. refs
(AIAA PAPER 92-4528) Copyright

The application of the direct transcription method to the optimal design of a commercial aircraft trajectory, subject to reasonable constraints on the aircraft flight path, is presented. The applications are characterized by a relatively great number of trajectory phases involving nonlinear path constraints. The path constraints when adjoined to the state equations form systems of differential algebraic equations that are resolved in a natural, straightforward manner utilizing the transcription technique. R.E.P.

A92-55280#
E-6 FLUTTER INVESTIGATION AND EXPERIENCE
ROBERT G. BORST and ROBERT W. STROME (Boeing Defense & Space Group, Seattle, WA) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1301-1313. refs
(AIAA PAPER 92-4601) Copyright

During E-6 airplane flutter testing, two separate incidents occurred which resulted in the partial loss of aircraft vertical tails. In both cases, the aircraft landed without further incident. Linear aero-servo-elastic analyses provided no indication of a flutter instability. Nonlinear aero-servo-elastic behavior had to be included to define the instability. Resolution involved gain stabilizing the rudder control system and phase stabilizing the vertical fin structure. Analytical and test results leading to resolution of E-6 aero-servo-elastic flutter are presented. Attention is focused on the multidisciplinary interaction of aerodynamics, flight controls, and structures. Author

A92-55283*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN INTEGRATED DEVELOPMENT OF THE EQUATIONS OF MOTION FOR ELASTIC HYPERSONIC FLIGHT VEHICLES
KARL D. BILIMORIA and DAVID K. SCHMIDT (Arizona State University, Tempe) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1334-1346. refs
(Contract NAG1-1341)
(AIAA PAPER 92-4605) Copyright

An integrated, consistent analytical framework is developed for modeling the dynamics of elastic hypersonic flight vehicles. A Lagrangian approach is used in order to capture the dynamics of rigid-body motion, elastic deformation, fluid flow, rotating machinery, wind, and a spherical rotating earth model, and to account for their interactions with each other. A vector form of the force, moment and elastic-deformation equations is developed from Lagrange's equation; a useable scalar form of these equations is also presented. The appropriate kinematic equations are developed, and are presented in a useable form. A preliminary study of the significance of selected terms in the equations of motion is conducted. Using generic data for a single-stage-to-orbit vehicle, it was found that the Coriolis force can reach values of up to 6 percent of the vehicle weight, and that the forces and moments attributable to fluid-flow terms can be significant. Author

A92-55284#
AUTOMATED PROCEDURES FOR AIRCRAFT AEROSERVOELASTIC COMPENSATION
PETER Y. CHENG and TIMOTHY J. HIRNER (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1347-1351. refs
(AIAA PAPER 92-4606) Copyright

An automated procedure is presented for designing aeroservoelastic (ASE) compensation without dependence on trial and error. Instead, an analytical approach is used to design filters that minimize phase lag introduced to the control system, while still meeting the stability margin and quality requirements. It is shown that the procedure can automatically select the best filter architecture, as well as the coefficients of the filters, resulting in a more effective ASE design with savings in time and manpower costs. I.S.

A92-55296#
ROBUST CONTROL DESIGN OF AN AUTOMATIC CARRIER LANDING SYSTEM
JOHN L. CRASSIDIS and D. J. MOOK (New York, State University, Buffalo) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1471-1481.
(AIAA PAPER 92-4619) Copyright

A robust controller, utilizing H-infinity control design techniques, is developed for an automatic carrier landing system. First, a detailed nonlinear aircraft simulation, which includes the aircraft dynamics, pitch atitude autopilot, and automatic thrust compensator, is summarized. Then, impulse response data are used to form a time-invariant linear model approximation. This linear model is the plant used in the H-infinity control design process. However, this plant has a pure integrator. Consequently, the H-infinity control design formulation does not form a proper rational transfer function. A solution to this difficulty is developed by incorporating a simple feedback loop. With this modification, the robust control design is obtained. A comparison study between the robust control design and the proportional-integral-derivative-double derivative control law of the current carrier landing system is shown. The design study indicates that the robust H-infinity controller dramatically improves response characteristics and system performance. Author

A92-55302#
NONLINEAR MODEL-FOLLOWING CONTROL APPLICATION TO AIRPLANE CONTROL (1992 AIAA CONTROLS DESIGN CHALLENGE)
WAYNE C. DURHAM, FREDERICK H. LUTZE, M. R. BARLAS, and BRUCE C. MUNRO (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1527-1536. refs
(AIAA PAPER 92-4625) Copyright

Results presented in this paper constitute a proof-of-concept for the use of nonlinear feedback gains for the all-altitude control of the six degrees of freedom of an aircraft. The control law exhibits excellent control of aircraft velocity, Euler angles, body-axis angular rates, angle of attack, and sideslip angle. There is no requirement for gain scheduling with respect to airplane attitude, and the control law is equally valid during a high-g maneuver and in steady level flight. V.L.

A92-55303#
QUANTITATIVE FEEDBACK THEORY APPROACH TO AIAA CONTROLS DESIGN CHALLENGE
YUTAKA IKEDA, PETER CHENG, JEFF SHULTZ (McDonnell Aircraft Co., Saint Louis, MO), CHU-YIN CHANG, SHIH H. WANG, TSU-SHUAN CHANG, and CHENG W. CHEN (California, University, Davis) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1537-1547. refs
(AIAA PAPER 92-4626) Copyright

Quantitative Feedback Theory (QFT) is applied to design flight control laws for the AIAA Controls Design Challenge nonlinear aircraft model. The control laws are designed in two steps. First,

the aircraft model is linearized and baseline control laws are designed with the LQG/LTR technique. Then the QFT control design concept is applied to enhance robustness of baseline control laws in order to account for nonlinearities of the aircraft dynamics. The QFT technique loop shapes baseline control laws so that the resulting closed loop responses satisfy the inner loop design specifications. The outer loop control laws are designed using the LQG technique to provide hands-off autopilot for specified maneuvers. Author

A92-55304#
GAIN SCHEDULED LINEAR PID AUTOPILOT FOR THE AIAA CONTROLS DESIGN CHALLENGE AIRCRAFT
RICHARD J. ADAMS, JAMES M. BUFFINGTON, and SIVA S. BANDA (USAF, Wright Laboratory, Wright-Patterson AFB, OH) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1548-1558. refs
(AIAA PAPER 92-4629)

The application of linear quadratic synthesis to an autopilot design for the AIAA Controls Design Challenge vehicle is described. Design objectives are incorporated into the quadratic cost function using the asymptotic properties of linear quadratic regulators (LQRs). A simple linear transformation is used to convert the state feedback LQR result into an implementable output feedback form that retains the desired closed-loop properties. The control gains are scheduled primarily with dynamic pressure but are also dependent on Mach number, attitude, bank angle, and power level angle. A composite maneuver demonstrates that the implemented control laws provide continuous regulation and tracking across the flight envelope. V.L.

A92-55305#
MULTIPLE DELAY MODEL APPROACH APPLIED TO THE AIAA 1922 CONTROLS DESIGN CHALLENGE
YOSHIKAZU MIYAZAWA (National Aerospace Laboratory, Tokyo, Japan) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1559-1568. refs
(AIAA PAPER 92-4630) Copyright

The Multiple Delay Model and Multiple Design Point (MDM/MDP) approach is applied to the AIAA 1992 Controls Design Challenge, and a structured constant feedback is derived using this approach. The approach is compared with more complex control laws at each design point to assess its feasibility and verified against time histories of two flight simulations. The performance is evaluated at four specified points. The performance index is easily defined, and uncertainty and change of dynamics are easily represented with multiple models, and the design can be carried out with a small number of trials and errors. V.L.

A92-55326
AIAA ATMOSPHERIC FLIGHT MECHANICS CONFERENCE, HILTON HEAD ISLAND, SC, AUG. 10-12, 1992, TECHNICAL PAPERS. PTS. 1-2
Washington, American Institute of Aeronautics and Astronautics, 1992, p. Pt. 1, 416 p.; pt. 2, 462 p. For individual items see A92-55327 to A92-55401.
Copyright

Consideration is given to aircraft dynamics and aerodynamics in atmospheric disturbances, vehicle trajectory optimization, projectile and missile flight dynamics, high alpha prediction codes for flow phenomenon, aircraft handling qualities, high alpha CFD and control, aircraft agility, unsteady flow phenomenon, parameter estimation, hypersonic technology, CFD for store separation, aeroassist technology, and unsteady and high alpha numerical studies. Particular attention is given to optimal recovery from microburst wind shear, optimal trajectories for an unmanned air-vehicle in the horizontal plane, numerical simulation of missile flow fields, pulsating spanwise blowing on a fighter aircraft, pilot control identification using minimum model error estimation, Navier-Stokes computations for oscillating control surfaces, aircraft agility maneuvers, fin motion after projectile exit from gun tube, the vortical structure in the wake during dynamic stall, nonlinear aerodynamic parameter estimation, missile and spacecraft coning instabilities, 3D Euler solutions on wing-pylon-store configuration with unstructured tetrahedral meshes, and a simulation model for tail rotor failure. O.G.

A92-55327*# National Aeronautics and Space Administration, Washington, DC.
OPTIMAL RECOVERY FROM MICROBURST WIND SHEAR
SANDEEP S. MULGUND and ROBERT F. STENGEL (Princeton University, NJ) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1-8. Research sponsored by FAA. refs
(Contract NGL-31-001-252)
(AIAA PAPER 92-4338) Copyright

The flight path of a twin-jet transport aircraft is optimized in a microburst encounter during approach to landing. The objective is to execute an escape maneuver that maintains safe ground clearance and an adequate stall margin during the climb-out portion of the trajectory. A cost function penalizing rate of climb deviations from a nominal value and rate of elevator deflection produces qualitatively good results in a variety of microburst encounters. The optimal maneuver is a gradual pitch-up that ceases near the core of the microburst, followed by a slight reduction in pitch attitude in the tailwind area of the microburst. A minimum airspeed constraint in the optimization prevents excessive airspeed loss in very severe microbursts. The aircraft equations of motion include short-period dynamics, so that the optimization solves directly for the control surface deflections required to achieve the optimal flight paths. Author

A92-55329#
EFFECT OF ATMOSPHERIC DISTURBANCES ON AIRPLANE RESPONSE
MUHAMMAD A. GHAZI and ALI M. AL-BAHI (King Abdulaziz University, Jeddah, Saudi Arabia) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 21-30. refs
(AIAA PAPER 92-4340) Copyright

A general solution for the airplane response under nonuniform atmosphere is presented. General gust terms are introduced to the coupled equations of motion and the general nondimensional small disturbance equations are obtained as a system of first order linearized differential equations. the latter are solved using the Z-transform notation, where the output paramters are integrated by trapezoidal integration while the excitations are processed by rectangular integration. The computer output displays the response including the overshoots, short period oscillations, and long-period oscillation modes in both the gust and gust-free zones. O.G.

A92-55330*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SEVERE TURBULENCE AND MANEUVERING FROM AIRLINE FLIGHT RECORDS
R. C. WINGROVE and R. E. BASCH, JR. (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 31-45. refs
(AIAA PAPER 92-4341) Copyright

Digital flight records from reported clear-air turbulence incidents are used to determine winds, to determine maneuver G loads, and to analyze control problems. Severe turbulence is found downwind of mountains and thunderstorms associated with vortices in atmospheric waves. It is also found in strong updrafts above thunderstorm buildups that are not detected by onboard weather radar. An important finding is that there are large maneuvering loads in over half of the reported clear-air turbulence incidents. Maneuvering loads are determined through an analysis of the

short-term variations in elevator deflection and aircraft pitch angle. For altitude control in mountain waves the results indicate that small pitch angle changes with proper timing are sufficient to counter the vertical winds. For airspeed control in strong mountain waves, however, there is neither the available thrust nor the quickness in engine response necessary to counter the large and rapid variations in horizontal wind. Author

A92-55331#
STABILITY, CONTROL AND GUST RESPONSE CHARACTERISTICS OF AN ULTRALIGHT FREEWING AIRPLANE
WEIPING CHEN and JEWEL B. BARLOW (Maryland, University, College Park) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 46-57. refs
(AIAA PAPER 92-4342)

The freewing is a design in which the wing is attached by a lateral hinge to the fuselage thereby allowing the wing to assume a pitch attitude independently of the attitude of the fuselage. The outstanding characteristic of this class of aircraft is its potential for decreased sensitivity to atmospheric gusts as compared to traditional designs of similar wing loading. Ultralights, having very light wing loading, are most sensitive to gusts. This paper presents results of mathematical simulations and other analysis of the stability, control and gust sensitivity of the ultralight aircraft including time domain and frequency domain results. Important parameters were obtained from a wind tunnel program. Some of these parameters cannot be reliably predicted by analysis. It is shown that the freewing design has strong gust alleviation effects without using any additional devices compared to conventional aircraft of the same class. The freewing design analysis here shows no specific unwanted characteristics. Author

A92-55332#
ATTAS FLIGHT TEST AND SIMULATION RESULTS OF THE ADVANCED GUST MANAGEMENT SYSTEM LARS
K.-U. HAHN and R. KOENIG (DLR, Institut fuer Flugmechanik, Braunschweig, Germany) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 58-70. refs
(AIAA PAPER 92-4343)

Design and development of a new load alleviation and ride smoothing (LARS) system is reviewed with particular attention given to simulation results and flight test analyses. The system is capable of effective gust alleviation related to rigid body and elastic mode responses. The system was tested using the DLR Advanced Technologies Testing Aircraft System (ATTAS). It is concluded that lift control leads to substantial suppressions of wind induced normal accelerations, more precise flight path control, and reduced pilot workload. Aircraft response in the longitudinal direction can be improved by a combination of lift and drag control devices. Flight control systems with small overall time delays should be used to perform the control of structural modes. O.G.

A92-55333#
OPTIMAL TRAJECTORIES FOR AN UNMANNED AIR-VEHICLE IN THE HORIZONTAL PLANE
JOSEPH Z. BEN-ASHER (Israel Military Industries, Advanced Systems Div., Ramat-Hasharon) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 71-77. refs
(AIAA PAPER 92-4344)

Time-optimal trajectories in the horizontal plane are studied using a point-mass model for the dynamics and control of the vehicles bank angle. The minimum principle is applied to point-to-point maneuvering problem. The optimality of the solutions was verified using the Jacobi condition. Constant-speed approximations are also considered which contain singular sub-arcs. O.G.

A92-55334#
A LIE BRACKET SOLUTION OF THE OPTIMAL THRUST MAGNITUDE ON A SINGULAR ARC IN ATMOSPHERIC FLIGHT
SUDHAKAR MEDEPALLI and N. X. VINH (Michigan, University, Ann Arbor) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 78-86. refs
(AIAA PAPER 92-4345)

Singular arcs form possible sub-arcs in various flight path optimization problems whenever a constant ejection velocity type propulsion system is assumed, the thrust magnitude being the singular control. However, the actual evaluation of the thrust magnitude on these arcs is very cumbersome, especially for problems with an atmospheric flight segment. This is done using a recent extension of the Lie Bracket solution of singular controls on partially singular arcs. The lift and the bank controls are assumed to be interior while the thrust direction is assumed to be along the velocity vector. The Lie Bracket solution is shown to be much easier to compute and to pressure any symmetry properties in the problem. The solution is presented in vectorial form which allows for a compact and coordinate independent solution. An example canonical transformation illustrates how the results can be transformed to any set of state variables. Some interesting subcases such as flight in a vertical plane and flight in a circular orbit with no lift are studied. Author

A92-55340#
DEVELOPMENT OF A HIGH-ANGLE-OF-ATTACK STABILITY AND CONTROL PREDICTION CODE
WILLIAM B. BLAKE (USAF, Wright Laboratory, Wright-Patterson AFB, OH), CHARLES J. DIXON, and CHARLES O. ADLER (Lockheed Aeronautical Systems Co., Marietta, GA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 142-152. refs
(AIAA PAPER 92-4354)

A computer program for estimating high-angle-of-attack stability and control parameters, HASC, is discussed. The program is a combination of three previously existing analysis modules which include a vortex lattice method, a forebody vortex method, and a semiempirical method for strake/wing leading edge vortices which empirically predicts vortex transition and burst. A comparison with wind tunnel and flight data for the F16A configuration gives favorable results. It is noted that the major weakness of the current version of the program is the lack of direct interaction between the forebody vortices with strake/wing, and tail leading edge vortices. O.G.

A92-55341#
DYNAMIC DERIVATIVE DATA FOR HIGH ANGLE OF ATTACK SIMULATION
JAMES M. SIMON (USAF, Wright Laboratory, Wright-Patterson AFB, OH) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 153-162. refs
(AIAA PAPER 92-4355)

Analytical methods were used to obtain a complete set of dynamic stability derivatives. These derivatives were compared with forced oscillation test data and were used to estimate the rotary derivatives. A method is presented to combine the analytical predictions with rotary balance test data to yield a complete set of body axis dynamic stability derivatives. This procedure makes it possible to improve both roll and yaw damping predictions in the mid-high angle of attack regions. O.G.

A92-55342#
EFFECTS OF THE ROLL ANGLE ON CRUCIFORM WING-BODY CONFIGURATIONS AT HIGH INCIDENCES
J. MEYER (Technion - Israel Institute of Technology, Haifa) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head

Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 163-173. refs
(AIAA PAPER 92-4356) Copyright

Three cruciform wings were tested on a body at five roll angles and up to three longitudinal positions in a low-speed wind tunnel, up to an angle of attack of alpha = 90 deg. The roll angle affects significantly the fin normal force coefficient. The vortex breakdown on the lower fins induces separated flow on the upper fins, the normal force of which decreases to zero, at alpha greater than 40 deg. As a consequence, a strong rolling moment is induced at these incidences at asymmetric roll angles. This rolling moment is independent of the wing position, but proportional to the wing planform area, as the fin normal force coefficients is. An empirical relation for the maximum rolling moment is consequently proposed. This rolling moment is much larger than the rolling moment induced on symmetrical configurations by the asymmetric body vortices. The wing contribution to the side force is small compared to the body contribution, at asymmetric roll angles. As a result, the maximum side force is not higher than that obtained at symmetric + and x attitudes. Author

A92-55343*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AERODYNAMIC PARAMETERS OF THE X-31 DROP MODEL ESTIMATED FROM FLIGHT-DATA AT HIGH ANGLES OF ATTACK
VLADISLAV KLEIN and KEITH D. NODERER (Joint Institute for Advancement of Flight Sciences, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 174-181. refs
(Contract NCC1-29)
(AIAA PAPER 92-4357) Copyright

Lateral aerodynamic parameters of the X-31 drop model were estimated from flight data at angles of attack between 25 deg and 45 deg. Partitioned data from an ensemble of 12 maneuvers and data from 13 single maneuvers were analyzed by a stepwise regression technique to obtain an aerodynamic model structure and least squares parameter estimates. Because of data collinearity in several maneuvers, these maneuvers were reanalyzed by two biased estimation techniques, mixed estimation and fractional rank regression. The final parameter estimates in the form of stability and control derivatives were plotted against the angle of attack and compared with wind tunnel results and a limited number of estimates from full-scale aircraft data. There was no significant disagreement between parameters from the two sets of drop model data and the full-scale aircraft data. Some differences, however, existed between the dihedral, damping-in-roll, and aileron-effectiveness parameters from flight and wind tunnel data. Author

A92-55346#
ANALYTICAL DEVELOPMENT OF AN EQUIVALENT SYSTEM MISMATCH FUNCTION
MARK R. ANDERSON (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 199-205. refs
(AIAA PAPER 92-4422) Copyright

A mismatch function is used to check the validity of a low order equivalent system model which has been derived from a high-order system representation. If the difference between the low and high-order models is greater than allowed by the mismatch function, the flying qualities predictions obtained from parameters of the low-order equivalent system may not be representative of the ratings a pilot would give the actual aircraft. A methodology is developed in this paper to derive equivalent system mismatch functions analytically. The methodology is used to analytically determine a mismatch function for the longitudinal-axis of a Class IV fighter aircraft in the Category A, non-terminal flight phase. Author

A92-55347#
COMPUTER AIDED EVALUATION OF AIRCRAFT HANDLING QUALITIES AND FLIGHT CONTROL SYSTEM ROBUSTNESS
SHYAM CHETTY and J. R. RAOL (National Aeronautical Laboratory, Bangalore, India) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 206-216. refs
(AIAA PAPER 92-4423) Copyright

An interactive software package is described which has been developed for the analytical evaluation of the handling qualities, generation of lower-order equivalent system models, estimation of robustness margins, and generation of ideal handling quality models for each phase of the flight. The software is based on MATLAB/FORTRAN-77 and runs on IBM-compatible personal computers. The discussion also covers some techniques used for model order reduction, evaluation of closed-loop handling quality criteria, and control system robustness. V.L.

A92-55349#
FLIGHT TEST RESULTS USING A LOW ORDER EQUIVALENT SYSTEMS TECHNIQUE TO ESTIMATE FLYING QUALITIES
CLARKE O. MANNING (USAF, Wright-Patterson AFB, OH) and DANIEL GLEASON (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 231-243. refs
(AIAA PAPER 92-4425) Copyright

A new technique is developed for matching the time response of high-order aircraft systems with lower-order equivalent systems. The lower-order equivalent systems are extracted in the form of the short-period pitch rate transfer function to take advantage of the aircraft data base in MIL-STD-1797. The advantages of the least-squares low-order equivalent systems (LOES) program are its simplicity and adaptability to flight test parameter identification requirements. Results of a flight test program to evaluate the LOES time response technique are reported. V.L.

A92-55351#
HIGH ANGLE-OF-ATTACK CONTROL ENHANCEMENT ON A FORWARD SWEPT WING AIRCRAFT
LAWRENCE A. WALCHLI, ROBERT W. GUYTON, FRANK LURIA, and WILLIAM J. GILLARD (USAF, Wright Laboratory, Wright-Patterson AFB, OH) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 254-264. refs
(AIAA PAPER 92-4427)

Results of a proof-of-concept pneumatic discrete port blowing experiments conducted on the slender-nosed X-29 as a testbed aircraft are reported. Extensive wind tunnel testing led to the development of an optimal blowing configuration. The results demonstrate that very large yawing moments can be generated through nose vortex manipulation and that these moments can be used to compensate for the loss of directional control caused by fuselage blanking of the vertical tail at high angle of attack. V.L.

A92-55352*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NAVIER-STOKES PREDICTION OF LARGE-AMPLITUDE DELTA-WING ROLL OSCILLATIONS CHARACTERIZING WING ROCK
NEAL M. CHADERJIAN (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 265-279. refs
(AIAA PAPER 92-4428) Copyright

High-incidence vortical flow about a 65-deg sweep delta wing undergoing static roll and large-amplitude, high-rate-of-roll oscillations is simulated numerically using the time-dependent,

three-dimensional, Reynolds-averaged, Navier-Stokes equations. Turbulent computations are presented for static roll angles up through 42 degrees. The effects of roll angle on the vortex aerodynamics are discussed, and the solution accuracy is evaluated by comparison with experimental data. The effects of grid refinement and zonal boundary condition treatment on solution accuracy are assessed at zero roll angle. Numerical simulation of a forced periodic roll motion is also presented. Author

A92-55354*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VORTICAL FLOW CONTROL ON A WING-BODY COMBINATION USING TANGENTIAL BLOWING
ZEKI Z. CELIK and LEONARD ROBERTS (Stanford University, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 293-303. refs
(Contract NCC2-55)
(AIAA PAPER 92-4430) Copyright

The objective of the experimental program reported here was to evaluate the possibility of using tangential blowing to create roll and yaw control on a delta wing-forebody combination at high angles of attack. It is found that the vortical flow over the model can be manipulated more efficiently by blowing on the nose section rather than fuselage. Large rolling moments and side forces are generated by blowing from forebody compared to wing blowing. For a wing-body combination, a model with a blunt nose is found to be less sensitive to flow asymmetry than a sharp-nosed configuration. Rolling moment changes sign from prestall to stall for all the configurations tested. V.L.

A92-55363*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ASSESSMENT OF PASSIVE POROSITY WITH FREE AND FIXED SEPARATION ON A TANGENT OGIVE FOREBODY
RICHARD M. WOOD, DANIEL W. BANKS, and STEVEN X. S. BAUER (NASA, Langley Research Center, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 375-390. refs
(AIAA PAPER 92-4494) Copyright

Subsonic wind tunnel tests were performed on solid and porous (22 percent) 5.0-caliber forebody models to assess the effect of free and fixed cross-flow separation on the effectiveness of passive porosity. The effectiveness of passive porosity to control the local pressure loading for forced cross-flow separation is found to be similar to that observed for the free cross-flow separation condition. It is also found that the effectiveness of passive porosity is significantly enhanced in the presence of large positive pressures on the porous surface. V.L.

A92-55366#
STOCHASTIC SELF-INDUCED ROLL OSCILLATIONS OF SLENDER DELTA WING AT HIGH ANGLES OF ATTACK
M. GOMAN, A. KHRABROV, and A. STUDNEV (Central Aerohydrodynamics Institute, Zhukovski, Russia) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 407-415. refs
(AIAA PAPER 92-4498) Copyright

This paper summarizes some new experimental study of wing rock mechanisms. The wind tunnel tests data, demonstrating new type of wing rock-stochastic oscillations are presented. To simulate this phenomena, a mathematical model of unsteady nonlinear aerodynamics was proposed. Two unsteady phenomena, vortex core dynamics and vortex breakdown dynamics, were investigated separately in the framework of the mathematical model. Analytical analysis of damping effect during wing rock was conducted using proposed mathematical model. Nondimensional mathematical model of wing rock mechanism was analyzed. Different types of oscillations were revealed. The dependence of oscillations type on the initial disturbances, observed in experiments, was simulated. Phase portraits and moment dependencies of different types of wing rock are presented. Author

A92-55370#
ROBUST IDENTIFICATION OF NONLINEAR AERODYNAMIC MODEL STRUCTURE
THOMAS J. MEYER and D. J. MOOK (New York, State University, Buffalo) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 458-467. refs
(AIAA PAPER 92-4503) Copyright

A robust nonlinear identification technique based on minimum model error (MME) optimal estimation, is used to identify nonlinear aerodynamic model structure. Data was obtained from digital simulations of longitudinal flight of a McDonnell Douglas F4C type aircraft with a standard linear model plus a nonlinear pitching moment derivative. The base model used in the algorithm knew the linear portion of the truth perfectly, but knew nothing of the nonlinear portion (e.g., where the nonlinearities were buried, what forms they took, let alone the values of any coefficients and exponents involved). The algorithm detected that some nonlinearity was present, determined where it was, determined the functional form, and very accurately parameterized the functional form. The test was performed twice, once with clean data and once with nominally white Gaussian noise added to both input and output measurements. In both cases, the identification was excellent. The main objective was to identify the nonlinear pitching moment aerodynamic coefficient. Pertinent identification results for the records analyzed, including time history comparisons between the simulated flight data and computer-generated responses using the resulting model estimates, are presented. Author

A92-55371#
APPLICATION OF RECURSIVE PARTIALLY UNKNOWN SYSTEM IDENTIFICATION TO AERODYNAMIC COEFFICIENTS ESTIMATION
WON-JONG KIM, JANG G. LEE, and DAL H. LEE (Seoul National University, Republic of Korea) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 468-473. refs
(AIAA PAPER 92-4504) Copyright

Presented in this paper is an application to aerodynamic coefficients estimation of new recursive parameter identification algorithm which utilizes the recursive least squares method and the constrained quadratic programming, useful for partially unknown systems described in state space. It is possible to combine the two independent techniques because they both minimize cost functions in least square sense. Also discussed is the convergence properties of the algorithm, showing that it converges well and fast. In order to demonstrate its practical use, the technique is applied to a set of discretized and linearized equations of the motion of an aircraft, to show a satisfactory result in identifying aerodynamic coefficients in the equations. Author

A92-55380#
A SIMULATION MODEL FOR TAIL ROTOR FAILURE
MATTHEW J. O'ROURKE (Lockheed Engineering & Sciences Co., Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 599-617. refs
(AIAA PAPER 92-4633) Copyright

Tail rotor failure in a helicopter can be a very dangerous and unstable condition. For this reason a helicopter simulation model, DYN, has been formulated to analyze helicopter flight response to tail rotor failure and steady flight recovery. This model uses classical rotor theory and integrates the nonlinear Euler equations of motion. DYN has been validated against flight tests in several flight regimes in response to all three main rotor controls. The helicopter used for the validation is the AH-64A Apache. The

validation also compares dynamic response to FLYRT, the McDonnell Douglas AH-64A flight simulation model. The results of the validation show fairly good agreement with flight test, and even better agreement with FLYRT. Analysis of aircraft response following a tail rotor failure shows the potentially catastrophic nature of this kind of failure. With the use of some basic feedback control, however, the helicopter may be recovered with some descent rate and forward airspeed. The relationship between forward airspeed and descent rate needed for trimmed flight without a tail rotor is established. Author

A92-55393*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FORCE PRODUCTION MECHANISMS OF A TANGENTIAL JET ON BODIES AT HIGH ALPHA
G. I. FONT (Stanford University, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 735-744. refs
(Contract NCC2-55)
(AIAA PAPER 92-4648) Copyright

This work explores the mechanisms by which tangential slot blowing creates forces on a body at a high angle of attack. The study is conducted numerically by solving the three-dimensional, compressible-flow Navier-Stokes equations. A tangent-ogive cylinder configuration is used with the blowing slot located both on the nose and on the cylindrical part of the body. The angle of attack used is 30 deg., the Mach no. is 0.2 and the Reynolds no., based on diameter, is 52,000. Several conclusions were made concerning the physical mechanisms by which the jet interacts with the ambient flowfield to produce a side force: (1) A centrifugal force component is created at the wall due to the momentum of the jet being forced to follow the curvature of the surface. (2) A large amount of vorticity is added to the flowfield by the jet. In the region of the slot, the vorticity has the effect of inducing circulation around the body. Downstream of the slot, the vorticity alters the strength of the nose vortices. (3) The position of the nose vortices can be altered to the jet changing the location of separation. And (4), the jet has the ability to excite unstable behavior producing a global change in the character of the flow. Author

A92-55396#
NUMERICAL SIMULATIONS OF FLUTTER AND ITS SUPPRESSION BY ACTIVE CONTROL
J. A. LUTON and DEAN T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 767-775. refs
(Contract AF-AFOSR-90-0032)
(AIAA PAPER 92-4652) Copyright

A general formulation for aeroservoelastic behavior of high-aspect-ratio wings in the subsonic regime is presented. A numerical solution scheme is proposed which is based on a predictor-corrector method and is capable of incorporating almost any structural model or aerodynamic model whose solution is found in the time domain. To model the aerodynamics a vortex-lattice method is used which takes into account nonlinear effects asssociated with high angles of attack, unsteady behavior, and deformations of the wing. A linear model and a nonlinear model which account for finite curvature consider the flexural-torsional motion of an inextensional wing. The flutter behavior and the response of the wing to random wind gusts are illustrated by several examples. Data obtained indicate that the suppression of flutter is possible at velocities well beyond the flutter speed, but the gust alleviation is more difficult. O.G.

A92-55906
C-17 FLIGHT CONTROL SYSTEM OVERVIEW
BRIAN F. KOWAL (USAF, Wright-Patterson AFB, OH), CARL J. SCHERZ (Douglas Aircraft Co., Long Beach, CA), and RICHARD QUINLIVAN (General Electric Co., Binghamton, NY) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 7, no. 7, July 1992, p. 24-31.
Copyright

The design of the flight-control system (FCS) for the C-17 airlifter is presented with test results demonstrating the inherent redundancy and robustness of the system. The C-17 FCS is based on a combination of elements from fly-by-wire and conventional mechanical systems, and the electronics include four flight-control computers, two spoiler-control electronic-flap computers, a control panel, actuators, and a ground-proximity warning system. The stability- and control-augmentation system (SCAS) incorporates several modes for pitch, roll, and yaw control at takeoff, approach, and other modes. The data bus architecture is illustrated for the electronics with diagrams provided for actuator interfaces. Preliminary flight-test results are given which demonstrate the ability of the system to cope with such failure modes as jammed control sticks, two-on-two failures, and software errors. C.C.S.

A92-55910
FLIGHT MANAGEMENT SYSTEM OF THE F-117A
S. R. COMBS, R. C. LOSCHKE, and G. J. TAUKE (Lockheed Advanced Development Co., Burbank, CA) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 7, no. 7, July 1992, p. 49-55. Research supported by USAF. refs
Copyright

The flight-management system (FMS) for the F-117A night attack aircraft is described in terms of its functional computing systems and automated flight options. The FMS comprises an integrated package of: (1) a two-channel navigation interface and autopilot computer; (2) an autopilot/autothrottle; (3) a quad redundant flight-control computer; and (4) a navigation weapons-system computer. Control modes are described for pitch attitude, pitch outer-loop modes, altitude control, and for automatic throttle control. The autopilot safety features permit autothrottle/autopilot speed limiting, all-altitude automatic recovery, and general override, and several climb and descent modes are possible with the autothrottle engaged. The integrated FMS can significantly reduce pilot workload associated with routine navigation so that work with sensor systems and weapons systems can be accomplished. C.C.S.

A92-55911
ON-LINE IDENTIFICATION AND CONTROL OF LINEARIZED AIRCRAFT DYNAMICS
ILAN RUSNAK, ALLON GUEZ, IZHAK BAR-KANA (Drexel University, Philadelphia, PA), and MARC STEINBERG (U.S. Navy, Naval Air Warfare Center, Warminster, PA) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 7, no. 7, July 1992, p. 56-60. refs
(Contract AF-AFOSR-89-0010)
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This paper examines a new approach for on-line identification and control that requires weaker excitation than the existing approaches based on Least Square schemes and works in closed loop systems. This approach also uses Multiple Objective Optimization Theory to resolve the conflict between identification and controller performance as they compete for the only available resource, the inputs to the aircraft. The approach is applied to a longitudinal model of a representative linearized high performance aircraft model. Simulation results compare the final controller with a conventional gain scheduled Pitch Command Augmentation System. It is demonstrated that by allowing some control input to be given to the identification process, the controller's overall performance is improved. Author

A92-56021
SYNTHESIS OF GUST LOAD ALLEVIATION WITH FLUTTER MARGIN AUGMENTATION
KENJI FUJII, HIROSHI MATSUSHITA, and YOSHIKAZU MIYAZAWA (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 84-87. In Japanese. refs

A synthesis method to obtain gust load alleviation control laws which also provide flutter margin augmentation is presented. The cost function introduced to synthesize the gust load alleviation control laws is eqivalent to the kinetic energy, and is expected to be not only effective in gust load alleviation, but also flutter suppression. In order to enhance flutter margin augmentation, control laws were synthesized with design velocities being set higher than the estimated flutter speed. The derived control laws were analytically evaluated. Author

A92-56022
OPTIMIZATION OF AEROELASTIC SYSTEM WITH ACTIVE CONTROL
SHINJI SUZUKI (Tokyo, University, Japan) and SATOSHI YONEZAWA (KOBELCO, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 88-91. In Japanese. refs

This paper considers an optimization capability for designing airframe structures with active control system subjected to random gust loads. An aileron surface attached to a cantilevered flexible wing is actively controlled with a feedback signal of a wing acceleration to reduce gust induced stresses. A wing spar is modeled with a set of FEM bar elements to obtain the equation of motion in a first-order time-domain (state-space) form. The thickness distribution of the wing spar and a feedback gain are simultaneously optimized for gust load requirements and stability requirements to minimize the structural weight. A goal programming approah with a concept of priorities is successfully applied for multiple design requirements. Author

A92-56025
OPTIMIZATION APPROACH FOR HELICOPTER MANEUVERABILITY WITH A POINT MASS MODEL
SHIGERU SASAKI, TOSHIFUMI NEKOHASHI, and TOMOARI NAGASHIMA (National Defense Academy, Yokosuka, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 100-103. In Japanese. refs

Using a point mass approximation, maneuverability analyses of a helicopter based on optimal control theory are conducted. The problem is formulated as an optimal control problem involving differential and nondifferential constraints. The effect due to the induced velocity is evaluated by taking a power constraint into account. The optimal solution is determined numerically by the SGRA. Minimum time 180 deg turns in the horizontal plane as well as the space are discussed. The results show importance of the autorotation capability for the minimum time turn performance. Author

A92-56026
AN INVESTIGATION OF THE AUTOMATION OF EMERGENCY LANDINGS FOR HELICOPTERS
HIROSHI SAITO and MASAKI KOMODA (Tokyo Metropolitan Institute of Technology, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 104-107. In Japanese. refs

A control system for helicopter emergency landing is presented. The neighboring optimal control is computed and the backward sweep method is used. Vertical optimal control and neighboring optimal control are compared. Y.P.Q.

A92-56027
MULTIAXIS CONTROL IN LONGITUDINAL MODE OF AIRCRAFT
MASAKI KOMODA (Tokyo Metropolitan Institute of Technology, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 108-113. In Japanese. refs

A pitch-mode decoupling system is proposed where only limited servo bandwidth is called for. The resulting cross-coupling between airspeed and flight path control is discussed from manual control point of view. Author

A92-56028
A320 FLIGHT CONTROL FROM THE PILOT'S POINT OF VIEW
MITSUO MORIMOTO and MASAAKI SUZUKI (All Nippon Airways, Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 114-117. In Japanese.

The A320 fly by wire control system is described. Modifications introduced to facilitate pilot operation and control sense perception are discussed. Y.P.Q.

A92-56029
ROBUST CONTROL SYSTEM DESIGN WITH MULTIPLE MODEL APPROACH
YOSHIKAZU MIYAZAWA (National Aerospace Laboratory, Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 118-122. In Japanese. refs

Robust control system design with a multiple-delay model approach and its application to flight control systems are discussed. The approach is based on concepts of multiple models, LQR (linear quadratic regulator), and proportional output feedback. Multiple-delay models are used to represent uncertain dynamics in the high-frequency range. Previously obtained numerical examples are reviewed, such as active flutter control, longitudinal flightpath control, and model-following flight control. The numerical examples show that the approach can directly give robust and high-performance control laws with only a few design parameters including delay times for each control input. Author

A92-56030
FLIGHT CONTROL SYSTEM DESIGN USING H(INFINITY) OPTIMAL CONTROL
MORLO TAKAHAMA, TAKASI KIMURA, EI TOKUDA, and MASAHIRO OHNO (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 122-125. In Japanese. refs

We applied the mixed sensitivity problem, which is one method of H(infinity) optimal control, to design a control-augmentation system for the longitudinal flight control system of a typical small aircraft. But this method cannot achieve model matching. Thus, we propose a design method for a robust flight-control system that has a disturbance estimator using H(infinity) optimal control to realize model matching. Author

A92-56032
AN AUTOROTATION-ENTRY CONTROL FOR A HELICOPTER WITH A FUZZY CONTROLLER
NAKOTO UEMURA, MUNENORI ISHIKAWA, NAOKI SUDO, and YOSHIHARU KUBO (Kawasaki Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 130-133. In Japanese.

The design of a fuzzy control system for a helicopter is presented. Helicopter rate control and positional control are addressed. Simulation results are given, and the 'if-then' rule for the autorotation entry control system is discussed. Y.P.Q.

A92-56033
APPLICATION OF FUZZY CONTROL TO AIRCRAFT GUIDANCE
TAKASHI SHINAGAWA, MASAMI MATSUDA, and KATSUYA ISHIMOTO (Fuji Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 134-137. In Japanese.

A ground-control approach (GCA) for aircraft guidance is discussed. The fuzzy control system and the PD control system are compared. GCA simulation is tested and its results are evaluated. Y.P.Q.

A92-56057
ESTIMATION OF AIRCRAFT INERTIAL CHARACTERISTICS USING MAXIMUM LIKELIHOOD ESTIMATION
HIROBUMI OHTA and HIROFUMI NISHIMURA (Nagoya University, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 254-257. *In Japanese.*

The Lagrangian equations of motion are used to estimate aircraft inertial characteristics. The free vibration model test facility is discussed, and the maximum likelihood estimation results are analyzed. Y.P.Q.

A92-56062
SYNTHESIS OF A MLS AUTOMATIC LANDING CONTROL LAW FOR THE NAL EXPERIMENTAL RESEARCH AIRCRAFT DO-228
TADAO UCHIDA, TOSHIHO SAKAI, TOSHIHARU INAGAKI, KOKI NOZUMI, and KAZUTOSHI ISHIKAWA (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 274-277. In Japanese. refs

This paper presents a preliminary design synthesis of an automatic landing control law using the MLS for the NAL experimental research aircraft Do-228. The control law consisting of altitude hold, glide path tracking, and flare, has been evaluated by a digital flight simulation with turbulence. Author

A92-56066
MIMO STATE-FEEDBACK CONTROL SYSTEM CONSIDERING PHASE STABILITY BY -90 DEG PHASE-LOCUS METHOD
RYOJI KATAYANAGI (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) IN: *Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991*, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 290-293. In Japanese. refs

A lateral-directional flight control system was investigated using the -90-deg phase-locus method. This method gives a state-feedback control system with highly stability robustness. The -90-deg phase-locus is that the root locus whose phase lag is 90 deg. First, pole-zeros of the system are determined to get a desired response for the closed system. Then, phase lag of each open loop transfer function is checked so as not to exceed 90 deg using -90 deg phase-locus method. Author

A92-56068
APPLICATION OF RESTRUCTURABLE FLIGHT CONTROL SYSTEM USING NONLINEAR CONTROL TO AN AIRLINER
YOSHIMASA OCHI (National Defense Academy, Yokosuka, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 298-301. In Japanese. refs

The feedback linearization method is applied to the accommodation of aircraft failures occurring at control effectors or the airframe. The failures are identified as parameter changes in the six-degree-of-freedom nonlinear equations of motion by the recursive least square method. The control parameters are updated using the latest estimated parameters. The control system is discretized considering implementation using digital computer. It was applied to an airliner and the performance was evaluated by computer simulation. Author

A92-56070
SELECTION OF SAMPLING RATE FOR NONLINEAR FLIGHT TRAJECTORY CONTROLLER OF AIRCRAFT
Y. BABA, K. SATONAKA, and K. TAKAO (National Defense Academy, Yokosuka, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 306-309. In Japanese.

In a previous paper, the nonlinear flight trajectory controller was designed using a singular perturbation theory. Since a digital computer is used to realize this control system, it reduces to a digital control system. In this paper, we show how to select the sampling rate for the controller. Author

A92-56079
A LOW SPEED WIND TUNNEL INVESTIGATION OF THE DIRECT SIDE FORCE CONTROL OF A JOINED-WING AIRCRAFT WITH OVERHANGING FIN
TOSHIMI FUJITA, AKIHITO IWASAKI, HIROTOSHI FUJIEDA (National Aerospace Laboratory, Chofu, Japan), HISASI SATO (Tokai University, Japan), and NAOTO TAKIZAWA IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 350-353. In Japanese.

The effectiveness of the side force control of a joined-wing aircraft with overhanging fin is presented. The upper fin shape and its model configurations are described. The direct controlled side force coefficient and composite side force coefficient are analyzed. Y.P.Q.

A92-56086
CHANGE AND RELIABILITY OF THE DC-9-81 DIGITAL FLIGHT GUIDANCE SYSTEM
TAKASHI OGATA (Japan Air System, Tokyo) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 386-389. In Japanese.

The digital flight guidance computer (DFGC) system for the DC-9-81 is described. Its functions include autopilot, yaw damper, Mach trim compensation, speed control, autothrottle, and thrust rating. The continuous built-in-test and power-up test of the system are addressed, and the improvement of the DFGC is discussed. Y.P.Q.

A92-56119
AN EXPERIMENTAL STUDY ON VARIABLE PRESSURE HYDRAULIC FLIGHT CONTROL SYSTEM
TORU NAGAO, HIROYUKI KATAOKA (Fuji Heavy Industries, Ltd., Tokyo, Japan), KAZUYA KOGA, and JUN NISIOKA (Tokimec, Inc., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 532-535. In Japanese.

Characteristics and benefits of a variable pressure hydraulic flight control system with respect to energy saving and reduction of heat rejection are described. Design, development, and testing of a variable pressure system have been implemented successfully. This new concept is validated for improving efficiency. Author

A92-56151
ESCAPE STRATEGIES FOR TURBOPROP AIRCRAFT IN MICROBURST WINDSHEAR
RICHARD B. BOBBITT and RICHARD M. HOWARD (U.S. Naval Postgraduate School, Monterey, CA) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 745-752. Previously cited in issue 20, p. 3415, Accession no. A91-47831. refs

A92-56282
RESPONSE OF HELICOPTER BLADES TO A SHARP COLLECTIVE INCREASE
Y. HECHT and O. RAND (Technion - Israel Institute of Technology, Haifa) *European Rotorcraft Forum, 17th, Berlin, Germany, Sept.* 24-26, 1991, Paper. 12 p. refs

A theoretical investigation of the response of helicopter blades to a sharp collective increase in hover is presented. The modeling addresses the spanwise distribution of the unsteady loads and the corresponding structural dynamic response of the elastic blades and the rotor-fuselage system as a whole. The aerodynamic loads distribution is calculated via the determination of the spanwise distribution of the aerodynamic equivalent mass, which is responsible for the time dependent development of the velocity induced by the trailing vortices. The structural modeling is based on the FEM approach, and the equations of motion are derived using Lagrange's equations. The role and sensitivity of a variety of parameters are identified and quantified. It is concluded that

for high command rates, the induced velocity exhibits relatively slow response and, therefore, the dynamic phenomena become predominant. C.A.B.

A92-56283
TRIMMING ROTOR BLADES WITH PERIODICALLY DEFLECTING TRAILING EDGE FLAPS
Y. K. YILLIKCI (Ministry of National Defence, Undersecretariat for Defence Industries, Ankara, Turkey) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 12 p. refs

A simplified trimming process for rotors with periodic trailing edge flap motions is developed. In this process, first collective and cyclic pitch control inputs are calculated by the use of standard helicopter trim equations. At the second stage, pitch motions are replaced with periodic trailing edge flap (TEF) motions represented up to the first harmonics. For the TEF case only rigid collective and pretwist angles are retained. The trailing edge flap motion harmonics are calculated based on the idea that TEF control must achieve identical trust harmonics of the pitch control case. Sample results for a small remotely controlled helicopter configuration with trailing edge flaps controls are presented. Different flap geometries are investigated and ETF concept is evaluated. Author

A92-56284
THE SOLUTION OF THE HELICOPTER FLIGHT DYNAMICS TASKS BY THE METHODS OF OPTIMAL CONTROL THEORY
L. N. NIKIFOROVA (Kamov Helicopter Scientific and Technology Co., Russia) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 20 p.

A package of applied programs is created to solve a number of practical tasks for definition of helicopter maneuver capabilities at the modes of the limiting values of the flight parameters, to examine complex flight modes and to provide for the helicopter flight mode automation. Determination of the effect of the design constraints upon the helicopter turn angle in hover and the Ka-32 helicopter autorotation landing task at different flight weights are examined. It is shown that using the optimal control method for solution of the helicopter flight dynamics task will allow more effective utilization of the existing reserves and will assure that all the existing constraints are observed. R.E.P.

A92-56303
OPTIMAL CONTROL OF TILTROTOR AIRCRAFT FOLLOWING POWER FAILURE
YOSHINORI OKUNO (National Aerospace Laboratory, Tokyo, Japan) and KEIJI KAWACHI (Tokyo, University, Japan) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 10 p. refs

Nonlinear optimal control theory was used to study optimal control of tilt-rotor aircraft following power failure. Optimal control procedures following power failure during hover were studied with emphasis on nacelle angle control effects, by considering (1) continued flight (fly-away) following one engine failure and (2) an autorotative landing following total power failure. The fly-away optimization problem was formulated so as to minimize the initial hovering height using the terminal condition of the transition to level flight with 35 ft minimum clearance above the takeoff surface. The landing optimization problem following total power failure was formulated to minimize the initial hovering height using the terminal condition that the touchdown speed factor is within the landing gear capacity. The analytical methods proposed in this paper are expected to reduce the cost, time, and risks involved in the certification flight tests. I.S.

A92-56308
BLADE INSTABILITY OF HORIZONTALLY STOPPABLE ROTORS
U. ARNOLD (Braunschweig, Technical University, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 16 p. refs

One important source for instability of stopped rotors during the decelerating and accelerating process is investigated. Flapping stability is usually lost at advance ratios above two, due to strong parameter excitation through periodic aerodynamic forces. The differential equation of motion is derived for the common rigid blade approximation, considering the spring restrained hinge with arbitrary hinge offset. Reverse flow, which is shown to be decisive for the stability boundaries, is included analytically in a straightforward way. The effect of the parameter excitation is discussed on the basis of Mathieu- and Hill-type differential equations. Simple stability criteria derived from Strutt's stability diagram are compared with the computed eignevalues using Floquet theory. The effect of the forcing function, i.e., the amplitude amplification of the inhomogeneous equation, is shown to be even more important than stability. The possibility of suppressing divergent flap oscillations by applying high rotor deceleration and acceleration rates is discussed. C.A.B.

A92-56314
SMART STRUCTURES IN THE ACTIVE CONTROL OF BLADE VORTEX INTERACTION
S. HANAGUD, J. V. R. PRASAD, T. BOWLES, and G. L. NAGESH BABU (Georgia Institute of Technology, Atlanta) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 7 p. refs
(Contract DAAL03-88-C-0003)

During the operation of a rotorcraft, rotor blades interact with vortices shed by preceding blades. As a result of the interaction, large pressure pulses are created at the leading edge of the airfoil. In this paper, feasibilities studies have been conducted to investigate if a combination of active camber changes by the use of smart structures concepts and optimum control techniques can be used to reduce the magnitude of the large pressure pulse created by the interaction of the airfoil and vortices shed by the preceding blade. The optimum control techniques used in this paper include a technique based on the use of a quadratic performance index and a technique based on H-infinity control concepts. Author

A92-56315* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COUPLED ROTOR-FUSELAGE VIBRATION REDUCTION WITH MULTIPLE FREQUENCY BLADE PITCH CONTROL
I. PAPAVASSILIOU, P. P. FRIEDMANN, and C. VENKATESAN (California, University, Los Angeles) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 45 p. refs
(Contract NAG2-477)

A nonlinear coupled rotor/flexible fuselage analysis has been developed and used to study the effects of higher harmonic blade pitch control on the vibratory hub loads and fuselage acceleration levels. Previous results, obtained with this model have shown that conventional higher harmonic control (HHC) inputs aimed at hub shear reduction cause an increase in the fuselage accelerations and vice-versa. It was also found that for simultaneous reduction of hub shears and fuselage accelerations, a pitch input representing a combination of two higher harmonic components of different frequencies was needed. Subsequently, it was found that this input could not be implemented through a conventional swashplate. This paper corrects a mistake originally made in the representation of the multiple frequency pitch input and shows that such a pitch input can be only implemented in the rotating reference frame. A rigorous mathematical solution is found, for the pitch input in the rotating reference frame, which produces simultaneous reduction of hub shears and fuselage acceleration. New insight on vibration reduction in coupled rotor/fuselage systems is obtained from the sensitivity of hub shears to the frequency and amplitude of the open loop HHC signal in the rotating reference frame. Finally the role of fuselage flexibility in this class of problems is determined. Author

A92-56317
HELICOPTER NONLINEAR FLIGHT CONTROL SYSTEM DEVELOPMENT
J. V. R. PRASAD and D. P. SCHRAGE (Georgia Institute of Technology, Atlanta) European Rotorcraft Forum, 17th, Berlin,

Germany, Sept. 24-26, 1991, Paper. 15 p. Research supported by U.S. Army. refs

This paper considers synthesis of a helicopter full authority flight controller using approximate inversion of the nonlinear model of the vehicle. Based on the natural time scale separation between position and attitude dynamics of the vehicle, the vehicle attitudes are treated as pseudo-command variables. In order to simplify the controller, approximations to the body axes forces are used in the controller calculations. The first approximation involves neglecting the cyclic and pedal control force terms and the second approximation involves neglecting the body x- and y-axis force components in the controller calculations. The adequacy of these approximations and the performance of the resulting controller in executing an elliptical turn maneuver are evaluated through nonlinear simulation. Author

A92-56318
EXPERIMENTAL INVESTIGATION OF HELICOPTER COUPLED ROTOR/BODY CONTROL

P. R. BRINSON (Bristol, University, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 11 p. Research supported by Defence Research Agency of United Kingdom. refs

A program of research that aims to contribute to a better understanding of the crucial issues associated with the design of full authority control systems for high bandwidth helicopter applications is presented. The status of an experimental program at Bristol University is discussed and the design of an experimental test facility is described. Preliminary test results and rig calibration data are detailed. R.E.P.

A92-56333
A GENERIC HARMONIC ROTOR MODEL FOR HELICOPTER FLIGHT SIMULATION

M. CHAIMOVICH, A. ROSEN, and O. RAND (Technion - Israel Institute of Technology, Haifa) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 14 p. refs

Attention is given to a new rotor model for helicopter flight mechanics simulation. Multiblade coordinates are used to describe the rotor dynamics. The aerodynamic loads include nonlinear effects such as stall and compressibility. These loads are described as harmonic series. The number of harmonics in the series determines the model accuracy. Thus by changing the number of harmonics from one to a large number, it is possible to obtain models that range between a tip path plane approach and an accurate blade-element model. The user of the model can very easily change the model accuracy and consequently its efficiency. The rotor model's application for trim and maneuver calculations is discussed. C.A.B.

A92-56334
A STUDY OF HELICOPTER ROTOR/FUSELAGE RESPONSE IN LOW-SPEED MANOEUVRES - COMPARISON OF THEORY WITH FLIGHT

A. T. MCCALLUM (Defence Research Agency, Aerospace Div., Bedford, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 30 p. refs
Copyright

Comparisons have been made of the behavior of a rigid blade rotor simulation model with data gathered on a Puma helicopter during quick-hop maneuvers as part of a validation study. Two validation techniques are investigated; the first method involves driving a full helicopter simulation model with pilot controls, whilst the second involves driving an isolated rotor model with rotor controls and fuselage motions. Relative merits of each method are discussed and, in the case of the quick-hop maneuver, the advantages of using the latter method, called open loop simulation, are demonstrated. Inflow dynamics and nonlinear section aerodynamics are briefly discussed and preliminary results illustrating the effects of these modelling features presented. It is concluded that the method of driving open loop simulation is ideal for validating and understanding rotor behaviour and will be investigated for a broader range of flight conditions and rotor system types. Author

N92-32435# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
A LEARNING ENHANCED FLIGHT CONTROL SYSTEM FOR HIGH PERFORMANCE AIRCRAFT M.S. Thesis

NOEL F. NISTLER 1992 100 p
(AD-A252520; AFIT/CI/CIA-92-039) Avail: CASI HC A05/MF A01

Numerous approaches to flight control system design have been proposed in an attempt to govern the complex behavior of high performance aircraft. Gain scheduled linear control and adaptive control have traditionally been the most widely used methodologies, but they are not without their limitations. Gain scheduling requires large amounts of a priori design information and costly manual tuning in conjunction with flight tests, while still lacking an ability to accommodate unmodeled dynamics and model uncertainty beyond a limited amount of robustness that can be incorporated into the design. Adaptive control is suitable for nonlinear systems with unmodeled dynamics, but has deficiencies in accounting for quasi-static state dependencies. Moreover, inherent time delays in adaptive control make it difficult to match the performance of a well-designed gain scheduled controller. An alternative approach that is able to compensate for the inadequacies experienced with traditional control techniques and to automate the tuning process is desired. Recent Teaming techniques have demonstrated an ability to synthesize multivariable mappings and are thus able to learn a functional approximation of the initially unknown state dependent dynamic behavior of the vehicle. By combining a learning component with an adaptive controller, a new hybrid control system that is able to adapt to unmodeled dynamics and novel situations, as well as to learn to anticipate quasi-static state dependencies is formed. GRA

N92-32487 ESDU International Ltd., London (England).
CONTRIBUTION OF TAILPLANE-MOUNTED TWIN FINS TO SIDEFORCE, YAWING MOMENT, AND ROLLING MOMENT DERIVATIVES DUE TO SIDESLIP

Mar. 1992 17 p Supersedes ESDU-Aero-C.01.01.02
(ISSN 0141-397X)
(ESDU-92007; ESDU-AERO-C.01.01.02; ISBN-0-85679-812-6)
Avail: ESDU

ESDU 92007 gives a semi-empirical method applying to fins of small sweep (up to 20 deg) for small sideslip angles up to Mach 0.7. From an analysis of limited experimental data extracted from the literature, a fin effective aspect ratio was determined as a function of fin vertical height on the tailplane that allows for the end plate effect of the tailplane. The lift-curve slope for the effective aspect ratio is then corrected for the effect of fuselage sidewash by a factor that depends on fuselage height/width at the tail and the exposed tailplane span. To determine the moment derivatives, the sideforce is assumed to be divided according to the areas above and below the tailplane, and to act at a point 0.424 of the height of each portion from the tailplane (assuming half elliptical loading on each portion). For the rolling derivative an additional correction is made to allow for the asymmetric loading on the tailplane induced by the fins in sideslip. Sketches compare experimental and predicted results and show the sideforce, rolling, and yawing derivatives to be predicted to within 0.03, 0.005, and 0.012 respectively. The ranges of geometry considered are tabulated, and a worked example illustrates the use of the data. ESDU

N92-32778*# Douglas Aircraft Co., Inc., Long Beach, CA.
FLY-BY-LIGHT TECHNOLOGY DEVELOPMENT PLAN Final Report

J. R. TODD, T. WILLIAMS, S. GOLDTHORPE, J. HAY, M. BRENNAN, B. SHERMAN, J. CHEN, LARRY J. YOUNT (Honeywell, Inc., Phoenix, AZ.), RICHARD F. HESS (Honeywell, Inc., Phoenix, AZ.), J. KRAVETZ (Honeywell, Inc., Phoenix, AZ.) et al. Aug. 1990 187 p

(Contract NAS1-18028; RTOP 506-46-21-05)
(NASA-CR-181954; NAS 1.26:181954) Avail: CASI HC A09/MF A02

The driving factors and developments which make a fly-by-light (FBL) viable are discussed. Documentation, analyses, and recommendations are provided on the major issues pertinent to facilitating the U.S. implementation of commercial FBL aircraft before the turn of the century. Areas of particular concern include ultra-reliable computing (hardware/software); electromagnetic environment (EME); verification and validation; optical techniques; life-cycle maintenance; and basis and procedures for certification. Author

N92-32780 ESDU International Ltd., London (England).
A BACKGROUND TO THE HANDLING QUALITIES OF AIRCRAFT
Mar. 1992 28 p
(ISSN 0141-3988)
(ESDU-92006; ISBN-0-85679-811-8) Avail: ESDU

ESDU 92006 examines those factors that affect the ease and safety with which an aircraft may be flown. For consideration of aircraft handling, aircraft are divided by class or role indicating the primary purpose of the operation of the aircraft. Within each class, flight or sorties are subdivided by flight phase which describes the type of tasks to be completed. A discussion of piloting techniques and the development of pilot opinion ratings, including the Cooper-Harper ratings, precedes an examination according to the mode of motion (short period, phugoid, roll, spiral or Dutch roll) of the primary parameters that characterize the handling qualities criteria. Extracts from current UK Design and Airworthiness Requirements for services Aircraft then cover the required flying qualities according to aircraft class and flight phase that define the acceptable characteristics for the control feel in longitudinal maneuvering flight and for the response in the five modes of motion. ESDU

N92-32788*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COLLABORATIVE RESEARCH ON V/STOL CONTROL SYSTEM/COCKPIT DISPLAY TRADEOFFS UNDER THE NASA/MOD JOINT AERONAUTICAL PROGRAM
J. A. FRANKLIN and O. P. NICHOLAS (Royal Aircraft Establishment, Bedford, England) Jan. 1992 32 p
(Contract RTOP 533-02-37)
(NASA-TM-103910; A-92039; NAS 1.15:103910) Avail: CASI HC A03/MF A01

Summarized here are activities that have taken place from 1979 to the present in a collaborative program between NASA Ames Research Center and the Royal Aerospace Establishment (now Defence Research Agency), Bedford on flight control system and cockpit display tradeoffs for low-speed and hover operations of future V/STOL aircraft. This program was created as Task 8A of the Joint Aeronautical Program between NASA in the United States and the Ministry of Defence (Procurement Executive) in the United Kingdom. The program was initiated based on a recognition by both parties of the strengths of the efforts of their counterparts and a desire to participate jointly in future simulation and flight experiments. In the ensuing years, teams of NASA and RAE engineers and pilots have participated in each other's simulation experiments to evaluate control and display concepts and define design requirements for research aircraft. Both organizations possess Harrier airframes that have undergone extensive modification to provide in-flight research capabilities in the subject areas. Both NASA and RAE have profited by exchanges of control/display concepts, design criteria, fabrication techniques, software development and validation, installation details, and ground and flight clearance techniques for their respective aircraft. This collaboration has permitted the two organizations to achieve jointly substantially more during the period than if they had worked independently. The two organizations are now entering the phase of flight research for the collaborative program as currently defined. Author

N92-32864*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT TESTING AND SIMULATION OF AN F-15 AIRPLANE USING THROTTLES FOR FLIGHT CONTROL
FRANK W. BURCHAM, JR., TRINDEL MAINE, and THOMAS WOLF Aug. 1992 21 p Presented at the AIAA Flight Test Conference, Hilton Head, SC, 24 Aug. 1992
(Contract RTOP 533-02-36)
(NASA-TM-104255; H-1826; NAS 1.15:104255; AIAA PAPER 92-4109) Avail: CASI HC A03/MF A01

Flight tests and simulation studies using the throttles of an F-15 airplane for emergency flight control have been conducted at the NASA Dryden Flight Research Facility. The airplane and the simulation are capable of extended up-and-away flight, using only throttles for flight path control. Initial simulation results showed that runway landings using manual throttles-only control were difficult, but possible with practice. Manual approaches flown in the airplane were much more difficult, indicating a significant discrepancy between flight and simulation. Analysis of flight data and development of improved simulation models that resolve the discrepancy are discussed. An augmented throttle-only control system that controls bank angle and flight path with appropriate feedback parameters has also been developed, evaluated in simulations, and is planned for flight in the F-15. Author

N92-32988# Naval Postgraduate School, Monterey, CA.
INVESTIGATION OF THE FLIGHT CONTROL REQUIREMENTS OF A HALF-SCALE DUCTED FAN UNMANNED AERIAL VEHICLE M.S. Thesis
MARK A. BRYNESTAD 26 Mar. 1992 82 p
(AD-A252730) Avail: CASI HC A05/MF A01

The goal of this investigation was to study the requirements to fly a previously constructed, half-scale, ducted-fan Unmanned Aerial Vehicle (UAV) in horizontal and vertical flight as a proof of concept for a full-scale UAV of similar design. The following items were investigated: (1) methods to increase thrust from the ducted-fan propulsion system; (2) the determination of the effectiveness and necessary coupling of the four control vanes in controlling the vehicle in vertical flight (pitch, roll, yaw) and in countering the engine torque; and (3) the design, construction, and effectiveness of stator vanes. The following items were accomplished: (1) thrust was improved over the original vehicle through the design and construction of an effective bellmouth and nine-bladed fan; (2) control-vane effectiveness was determined, and stator vanes were designed and installed; (3) gyro stabilization was incorporated into the roll axis controls and the ducted fan flew in a controlled, tethered hover; and (4) gyroscopic cross-coupling was demonstrated. GRA

N92-33107*# Florida Atlantic Univ., Boca Raton. Dept. of Mechanical Engineering.
COMPUTATIONAL ASPECTS OF HELICOPTER TRIM ANALYSIS AND DAMPING LEVELS FROM FLOQUET THEORY Final Technical Report, 1 Aug. 1991 - 31 Jul. 1992
GOPAL H. GAONKAR and N. S. ACHAR Sep. 1992 50 p
(Contract NAG2-727)
(NASA-CR-190736; NAS 1.26:190736) Avail: CASI HC A03/MF A01

Helicopter trim settings of periodic initial state and control inputs are investigated for convergence of Newton iteration in computing the settings sequentially and in parallel. The trim analysis uses a shooting method and a weak version of two temporal finite element methods with displacement formulation and with mixed formulation of displacements and momenta. These three methods broadly represent two main approaches of trim analysis: adaptation of initial-value and finite element boundary-value codes to periodic boundary conditions, particularly for unstable and marginally stable systems. In each method, both the sequential and in-parallel schemes are used and the resulting nonlinear algebraic equations are solved by damped Newton iteration with an optimally selected damping parameter. The impact of damped Newton iteration, including earlier-observed divergence problems in trim analysis, is demonstrated by the maximum condition number of the Jacobian

matrices of the iterative scheme and by virtual elimination of divergence. The advantages of the in-parallel scheme over the conventional sequential scheme are also demonstrated. Author

N92-33536*# Princeton Univ., NJ.
ON THE CALCULATION OF THE RESPONSE OF HELICOPTERS TO CONTROL INPUTS
H. C. CURTISS, JR. 24 Sep. 1992 21 p Presented at the 18th European Rotorcraft Forum, Avignon, France, 14-17 Sep. 1992
(Contract NAG2-561)
(NASA-CR-190812; NAS 1.26:190812; PAPER-F07) Avail: CASI HC A03/MF A01

In the past few years, a number of studies have provided accurate flight test data for the control response of single rotor helicopters over a wide frequency range. These measured responses have been compared to theory in a number of studies. Various differences between theory and experiment appear in all of these studies. Some of these differences are examined. A quantitative explanation of one prominent difference associated with the contribution of the lag degree of freedom is provided. Areas for further investigation are suggested. The discussion is directed towards articulated rotor helicopters. Flight test data from the UH-60, CH-53, and AH-64 helicopters, much of it taken for the express purpose of evaluating the control response, correlation with theory, and the use of parameter identification methods, is considered. Results for flight conditions near hover are emphasized. Author

N92-33537*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SIMULATION MODEL OF A TWIN-TAIL, HIGH PERFORMANCE AIRPLANE
CAREY S. BUTTRILL, P. DOUGLAS ARBUCKLE, and KEITH D. HOFFLER (Vigyan Research Associates, Inc., Hampton, VA.) Jul. 1992 180 p
(Contract NAS1-18585; RTOP 505-64-30-01)
(NASA-TM-107601; NAS 1.15:107601) Avail: CASI HC A09/MF A02

The mathematical model and associated computer program to simulate a twin-tailed high performance fighter airplane (McDonnell Douglas F/A-18) are described. The simulation program is written in the Advanced Continuous Simulation Language. The simulation math model includes the nonlinear six degree-of-freedom rigid-body equations, an engine model, sensors, and first order actuators with rate and position limiting. A simplified form of the F/A-18 digital control laws (version 8.3.3) are implemented. The simulated control law includes only inner loop augmentation in the up and away flight mode. The aerodynamic forces and moments are calculated from a wind-tunnel-derived database using table look-ups with linear interpolation. The aerodynamic database has an angle-of-attack range of -10 to +90 and a sideslip range of -20 to +20 degrees. The effects of elastic deformation are incorporated in a quasi-static-elastic manner. Elastic degrees of freedom are not actively simulated. In the engine model, the throttle-commanded steady-state thrust level and the dynamic response characteristics of the engine are based on airflow rate as determined from a table look-up. Afterburner dynamics are switched in at a threshold based on the engine airflow and commanded thrust. Author

N92-34107*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PILOTED EVALUATION OF AN INTEGRATED PROPULSION AND FLIGHT CONTROL SIMULATOR
MICHELLE M. BRIGHT and DONALD L. SIMON (Army Aviation Systems Command, Cleveland, OH.) Aug. 1992 13 p Proposed for presentation at the Flight Simulation Technologies Conference and Exhibit, Hilton Head, SC, 24-26 Aug. 1992; sponsored by AIAA
(Contract RTOP 505-62-50)
(NASA-TM-105797; E-7227; NAS 1.15:105797; AVSCOM-TR-92-C-028) Copyright Avail: CASI HC A03/MF A01

A piloted evaluation of the integrated flight and propulsion control simulator for advanced integrated propulsion and airframe control design is described. The evaluation will cover control effector gains and deadbands, control effectiveness and control authority, and heads up display functionality. For this evaluation the flight simulator is configured for transition flight using an advanced Short Take-Off and Vertical Landing fighter aircraft model, a simplified high-bypass turbofan engine model, fighter cockpit displays, and pilot effectors. The piloted tasks used for rating displays and control effector gains are described. Pilot comments and simulation results confirm that the display symbology and control gains are very adequate for the transition flight task. Additionally, it is demonstrated that this small-scale, fixed base flight simulator facility can adequately perform a real time, piloted control evaluation. Author

N92-34131# Department of the Navy, Washington, DC.
IMPROVED ARTICULATED FIN/WING CONTROL SYSTEM STATEMENT OF GOVERNMENT INTERESTS Patent Application
CHARLES H. BEAUCHAMP, inventor (to Navy), MANUAL CINCOTTA, inventor (to Navy), ANTHONY RAFFA, inventor (to Navy), and BENOIT GAUTHIER, inventor (to Navy) 8 Nov. 1991 17 p
(AD-D015268; US-PATENT-APPL-SN-790607; NAVY-CASE-73152) Avail: CASI HC A03/MF A01

An articulated control surface is provided for hydrodynamic control utilizing a moldable control surface. The central surface is shaped by contracting and elongating wire bundles fabricated with shape-memory alloys located in an adjacent cooling chamber. The shape-memory alloys contract when heated via an applied electric current and elongate when cooled, i.e., the electric current is removed. A pair of wire bundles is anchored inside the cooling chamber. Each bundle is routed over several pulleys in such a manner that a lateral movement is produced at the actuator end of the wire. A pair of bundles act in opposition to maintain dynamic tension at the actuator end. Cooling flow to opposing wire bundles is controlled independently to enhance response time and reduce power requirements. The actuator is a post extending from the cooling chamber to the trailing edge structure of the control surface. GRA

N92-34161# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
INTRODUCTION TO FLUTTER OF WINGED AIRCRAFT, VOLUME 2
1992 501 p Lecture series held in Rhode-Saint-Genese, Belgium, 9-13 Dec. 1991
(ISSN 0377-8312)
(VKI-LS-1992-01-VOL-2; ETN-92-92163) Avail: CASI HC A22/MF A04

Papers on the following topics are presented: elementary flutter analysis; flight flutter testing; the design, manufacture, and ground testing of flutter models; aeroelasticity of bluff bodies; unsteady wind tunnel tests; flutter in transonic flight regime; and flutter analyses using high speed computers for large aircraft and aerodynamic procedures. The papers are from the second volume of a two volume set.

ESA

N92-34162# Manchester Univ. (England). Dept. of Engineering.
ELEMENTARY FLUTTER ANALYSIS
JAN R. WRIGHT *In* VKI, Introduction to Flutter of Winged Aircraft, Volume 2 47 p 1992
Avail: CASI HC A03/MF A04

Basic ideas and common misunderstandings of wing flexure-torsion flutter are clarified. The following topics are addressed: an understanding of the physics of wing flexure-torsion flutter through a number of specific examples; an examination of the energy interpretation of the physics of flutter, indicating its limited usefulness; a graphical representation to assess the contribution of various parameters to flutter onset; subcritical

response below the critical flutter speed; and some practical wing flutter considerations. ESA

N92-34163# Manchester Univ. (England). Dept. of Engineering.
FLIGHT FLUTTER TESTING
JAN R. WRIGHT *In* VKI, Introduction to Flutter of Winged Aircraft, Volume 2 185 p 1992
Avail: CASI HC A09/MF A04

Flight flutter testing is explained in regard to the airworthiness requirements, the subcritical clearance philosophy, the excitation device used, the excitation signal types, the instrumentation/recording, the signal processing, and the system identification methods used for analyzing the flight data. Some practical problems and future needs are considered. A bibliography is included but it is not exhaustive, either historically or internationally; some modal identification references are added since there are many parallels between flight and ground vibration testing. ESA

N92-34164# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
FLUTTER MODELS: THEIR DESIGN, MANUFACTURE, AND GROUND TESTING
F. DUPRIEZ *In* VKI, Introduction to Flutter of Winged Aircraft, Volume 2 25 p 1992
Avail: CASI HC A03/MF A04

Dynamically similar models (similar to the aircraft in their geometric, elastics, and mass representations) are used for the general investigation of flutter. However, there are similarity defects and rules, and these are discussed. A system for suspending the model in the wind tunnel is described. The flutter model design and construction technologies used are discussed. Static and dynamic tests are considered. ESA

N92-34165# Johns Hopkins Univ., Baltimore, MD. Dept. of Civil Engineering.
AEROELASTICITY OF BLUFF BODIES
ROBERT H. SCANLAN *In* VKI, Introduction to Flutter of Winged Aircraft, Volume 2 76 p 1992
Avail: CASI HC A05/MF A04

Low speed fluid structure interactive phenomena, principally as brought under observation by practical problems and circumstances in the civil engineering field, are addressed. The following phenomena are examined: bridge flutter, torsional divergence, wake and wind rain galloping, and stall flutter. Some general observations in flow induced observations are made. Vortex shedding is also addressed. ESA

N92-34166# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
UNSTEADY WIND TUNNEL TESTS
P. M. HUTIN *In* VKI, Introduction to Flutter of Winged Aircraft, Volume 2 38 p 1992
Avail: CASI HC A03/MF A04

Various measurements concerning unsteady aerodynamics are discussed. The unsteady pressure measurements in a wing, used as points of comparison for the unsteady aerodynamic computation methods on which flutter computations are based, are mentioned and wind tunnel tests of flutter are analyzed. Various measurements, their use, and the safety systems are discussed to give an overview of what can be done in this area. ESA

N92-34167# Boeing Commercial Airplane Co., Seattle, WA. Structures Research.
FLUTTER IN THE TRANSONIC FLIGHT REGIME
WARREN H. WEATHERILL *In* VKI, Introduction to Flutter of Winged Aircraft, Volume 2 50 p 1992
Avail: CASI HC A03/MF A04

Characteristics of the transonic flutter boundary and the corresponding unsteady aerodynamics are discussed. Three different types of shock motion are discussed together with an interesting characteristic of unsteady pressure distribution, the presence of a 'pulse' or 'blip', which is directly related to the movement of the shock. The characteristics of the transonic flutter boundary and associated unsteady aerodynamics are illustrated through a typical section, two dimensional flutter example. The effects of flutter in attached and separated flow are considered. The calculation of unsteady airload, for use in transonic flutter analyses is discussed, and a procedure which is representative of the current state of the art is described. This procedure is the CAP-TSD (Computational Aeroelastic Program-Transonic Small Disturbance) program which is based on the transonic small disturbance equation for the velocity potential. ESA

N92-34168# Boeing Commercial Airplane Co., Seattle, WA. Structures Research.
FLUTTER ANALYSES USING HIGH SPEED COMPUTERS. PART 1: FLUTTER ANALYSES FOR LARGE AIRCRAFT
WARREN H. WEATHERILL *In* VKI, Introduction to Flutter of Winged Aircraft, Volume 2 35 p 1992
Avail: CASI HC A03/MF A04

Characteristics of flutter analyses pertaining to large aircraft are discussed. A description of the physical system presented by the equations of motion is given. Typically, the equations of motion are written to describe a simplified version of the actual physical system being analyzed. These simplifications result from a combination of limitations in available modeling procedures as well as computer cost limitations. A description of a simplified physical model to be represented by the equations of motion, in the present case a large transport type aircraft, is given. The general nature of the terms of the equations is discussed with respect to the number of unknowns and important characteristics with respect to the flutter problem. Solution procedures are examined and some comments about the nature of flutter boundaries in general are made. ESA

N92-34169# Boeing Commercial Airplane Co., Seattle, WA. Structures Research.
FLUTTER ANALYSES USING HIGH SPEED COMPUTERS. PART 2: AERODYNAMIC PROCEDURES
WARREN H. WEATHERILL *In* VKI, Introduction to Flutter of Winged Aircraft, Volume 2 36 p 1992
Avail: CASI HC A03/MF A04

The doublet lattice procedure is an aerodynamic procedure for use in flutter analyses with high speed computers. The nature of the doublet lattice procedure and how it is used with flutter equations is introduced. Means of correcting the doublet lattice using empirical data to account for physical phenomena that are not modeled in the original formulation are described, and two examples are discussed. ESA

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A92-53564
A PRELIMINARY STUDY OF A SUPERSONIC WIND TUNNEL FOR A RAM JET TEST FACILITY
SHIGERU SATO, TATSUO KUMAGAI, MUNEO IZUMIKAWA, NOBORU SAKURANAKA, and TOHRU MITANI (National Aerospace Laboratory, Kakuda, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 825-830.
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A Mach-4-class supersonic wind tunnel test facility has been constructed and evaluated in order to obtain data necessary for the design of a supersonic wind tunnel for a ramjet test facility. Details of the experiments are discussed with emphasis on a

comparison between a combination of a two-dimensional nozzle and an axisymmetric diffuser and that of an axisymmetric nozzle and a common diffuser. V.L.

A92-54058*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL INVESTIGATION OF AN EJECTOR-POWERED FREE-JET FACILITY
MARY J. LONG (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 13 p. refs
(AIAA PAPER 92-3569) Copyright

The Nozzle Acoustic Test Rig (NATR) is a large free-jet test facility powered by an ejector system. Prior to the operation of the actual facility a 1/5-scale model of the NATR was built and tested to assess the pumping performance of the ejector concept as well as its sensitivity to various design parameters. The 1/5 scale model and full-scale facility are described as well as the design parameters which were investigated. The results of the scale model tests are discussed and compared with the findings of the full-scale tests. A.O.

A92-54180*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLOW CHARACTERIZATION IN THE NASA AMES 16-INCH SHOCK TUNNEL
JOHN A. CAVOLOWSKY (NASA, Ames Research Center, Moffett Field, CA), MARK P. LOOMIS (MCAT Institute, San Jose, CA), DAVID W. BOGDANOFF, HORACIO A. ZAMBRANA (Eloret Institute, Palo Alto, CA), MARK E. NEWFIELD, and TIM C. TAM (NASA, Ames Research Center, Moffett Field, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 14 p. refs
(AIAA PAPER 92-3810)

Flow characteristics of NASA's 16-Inch Shock Tunnel are determined for purposes of providing hypersonic propulsion simulation capability. The key tunnel operating parameters are the incident shock speed and reservoir pressure and enthalpy. Flow characteristics of concern are the nozzle exit pressure, temperature, Mach number, Reynolds number, chemical composition, and flow uniformity. Surface mounted gages (for pressure and heat transfer) and nonintrusive optical flow diagnostics (emission and absorption spectroscopy and holographic interferometry) are used to verify tunnel conditions. Experimental measurements are used to validate computational analysis for predicting facility performance, and CFD is used to interpret the free stream optical diagnostic measurements. Author

A92-54307
A NEW LOOK AT SURFACE FLOW VISUALIZATION TO PROVIDE INSIGHT INTO COMPLEX FLUID DYNAMIC BEHAVIOR
R. G. DIMICCO and P. J. DISIMILE (Cincinnati, University, OH) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 43-48. refs
Copyright

An experimental study focusing on the development of a new surface flow visualization technique and its application to supersonic flows around complex geometric configurations is reported. This technique has been applied to a three-dimensional rectangular cavity installed within the wall of a supersonic wind tunnel. The technique provides high-quality images of the complex steady-state flow behavior. Three vortical structures were observed and were closely intertwined within the cavity. The test was conducted at a Mach number of 2.00 and a Reynold's number of 42.5 million per meter. The cavity width-to-depth ratio was 2:1. I.E.

A92-54311
NONINTRUSIVE MEASUREMENTS IN FLUID DYNAMIC FLOWS FROM MACH .0005 TO 14
G. L. SEIBERT (USAF, Wright Laboratory, Wright-Patterson AFB, OH) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 74-81. refs

A concentrated effort was begun to introduce nonintrusive diagnostics systems into the test facilities wherever possible. The author describes the efforts made, the results obtained, and the plans underway to achieve the goal of providing state-of-the-art diagnostics instrumentation in all the operating facilities. A survey of the work that has been accomplished and the ongoing development is reviewed, including a low-speed large water tunnel and some development concepts being studied. I.E.

A92-54315
NOTES ON THE USE OF FUSIBLE TEMPERATURE INDICATORS TO BOUND THE TEMPERATURE OF HOT GRAPHITE IN THE NAVSWC HYPERVELOCITY WIND TUNNEL FACILITY
MICHAEL A. METZGER (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 113-122. refs

Temperature sensors, which indicate by melting whether or not a particular temperature level has been reached, were used to determine upper and lower bounds on the peak operating temperatures of a clamping fixture that is made of graphite. The clamp secures an electrically powered carbon-carbon heating element to its graphite support base in a pressure vessel that is part of the hypervelocity wind tunnel located at the US Naval Surface Warfare Center in Silver Spring, Maryland. During wind tunnel testing the clamp was exposed to an extremely hostile environment that included: temperatures to 3700 C (6700 F), intense thermal radiation, pressure to 22,500 psi, hot chemically reactive carbon and carbon vapor, electrified parts, stray electromagnetic fields, and an intense aerodynamic loading. I.E.

A92-54319* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PROBLEMS AND SOLUTIONS FOR TRANSITION DETECTION IN CRYOGENIC WIND TUNNELS BY INFRARED IMAGING
EHUD GARTENBERG (Old Dominion University, Norfolk, VA) and ROBERT E. WRIGHT, JR. (NASA, Langley Research Center, Hampton, VA) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 156-168. refs
(Contract NAS1-18584)
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The authors analyzed the problems associated with the detection of boundary-layer transition to turbulence by using the IR imaging techique in cryogenic wind-tunnel testing. It is shown that testing at low temperatures forces this implementation to run against the physical laws of diminishing returns. The most difficult obstacle resulted from the considerable decrease in the overall level of IR radiation and the parallel shift of the bulk of the radiated energy to longer wavelengths, beyond 30 microns at 100 K. Some measures to alleviate the problem are described. The thermal signature of transition can be enhanced by allowing the flow in the wind tunnel to heat incrementally, thus inducing a transient heat transfer to the model. As a result, the model area under the turbulent regime is revealed by its higher heating rate compared to the laminar regime. I.E.

A92-54322
CONCEPTION OF A UHB ENGINE SIMULATOR FOR THE ESSENTIAL CHARACTERISTICS OF A TRUE-SCALE ENGINE
H. T. BOLMS and W. BRAEUNLING (DLR, Goettingen, Germany) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 190-195. refs
Copyright

Turbine powered simulators (TPSs) usually are not able to simulate the whole spectrum of characteristic features of an original engine correctly and simultaneously. The difficulties in scaling down an engine are the reasons for these deficiencies. The order of magnitude of the errors resulting from these problems is shown for a turbine powered simulator set up conventionally. A revised simulator concept that avoids most of the significant deficiencies of conventional simulators is presented. A correct simulation, which permits the full transmission of simulation results to the real engine, requires the correct simulation of the secondary cycle, the primary nozzle flow, and the inlet flow. Contrary to a conventional TPS, the new concept, besides the correct simulation of the specific thrust, also allows the correct simulation of the thrust partition between the secondary and the primary cycle. I.E.

A92-54323
RECENT DEVELOPMENTS IN DATA ACQUISITION AND CONTROL SYSTEMS AT THE AIRCRAFT RESEARCH ASSOCIATION LIMITED

DAVID G. COULTON (Aircraft Research Association, Ltd., Bedford, United Kingdom) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 196-205. refs

The data acquisition systems (DASs) described are all based on the one connected to the 2.74-m x 2.44-m transonic wind tunnel which is the main testing facility at Aircraft Research Association Limited. The systems are based on Radstone single-board computers utilizing Motorola 68020 processors operating on the VME bus. Each DAS interfaces with a PRIME computer that is dedicated to point-by-point computation and presentation of fully corrected wind tunnel results. The additional systems described include an intelligent controller for electronically scanned pressure modules, the transonic wind tunnel automated test system, and the captive trajectory rig. The main features of the various data acquisition systems are highlighted, and the design concepts of several other applications of single-board computers are described. I.E.

A92-54325
A NEW SYSTEM FOR RECORDING UNSTABLE AERODYNAMIC PHENOMENA IN NAVSWC HYPERVELOCITY WIND TUNNEL NO. 9

SCOTT SWINFORD (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 214-222.

Hypervelocity Wind Tunnel No. 9, located at the U.S. Naval Surface Warfare Center in Silver Spring, MD, is a blowdown wind tunnel which operates at Mach numbers 8, 10, and 14. The desire to better quantify transient events has led to the procurement of a 20,000,000-sample/s data acquisition system. The new system, high-speed data acquisition and recording equipment (HSDARE), has been operational since June, 1990, and is available for Tunnel 9 tests requiring high temporal resolution. The HSDARE was purchased to provide transient signal acquisition while maintaining the capability to sample high quantities of standard speed sensors. The HSDARE samples signals one million times per second and resolves signals was bandwidths up to 100 kHz. The HSDARE provides the transient data acquisition function of the Tunnel 9 data acquisition facility. The architectures of HSDARE and earlier DARE versions are described. The earlier DARE versions are used for acquiring steady-state signals. I.E.

A92-54326
PRELIMINARY AIRFOIL TESTING EXPERIENCE IN THE NDA CRYOGENIC WIND TUNNEL

YUTAKA YAMAGUCHI, YASUO NAKAUCHI, MASAHIRO YOROZU, and TERUO SAITO (National Defense Academy, Yokosuka, Japan) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 223-230. refs

A small two-dimensional high-speed cryogenic wind tunnel was constructed at the Japanese National Defense Academy (NDA) in 1985. The authors describe the present status of the NDA cryogenic wind tunnel and give some preliminary airfoil testing results and experience. Two airfoil models, a NACA 0012 and a R4 airfoil model, were constructed. The R4 test results were compared with those of NASA TM-85739. They were in good agreement in the negative angle of attack range. However, the present R4 model has an extremely small aspect ratio of 0.5 and a high section thickness to tunnel height ratio of about 0.1. Therefore, the present results might be more influenced by the tunnel walls than those of NASA. I.E.

A92-54336
APPLICATION OF A WALL PRESSURE METHOD IN A WIND TUNNEL TEST SECTION WITH ADJUSTABLE LONGITUDINAL SLOTS

H. HOLST and A. HEDDERGOTT (DLR, Goettingen, Germany) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 304-313. refs

Green's theorem has been applied to the problem of wind tunnel wall interference. A wall pressure method for test sections of rectangular cross sections has been completed, which can be used for the computation of wall interferences, wall adaptation and, in case of adaptive test sections, for residual wall interferences. For these cases, a single computational step is sufficient. Measurements in the transonic wind tunnel TWG of DLF Goettingen with adjustable longitudinal slots on the top and bottom walls show that for this special application the determination of residual wall interference is also reliable. Test data, e.g., force coefficients, can be corrected to be approximately interference-free, using the residual interference velocities. After correction, the discrepancies between test data from different slot widths were substantially reduced. I.E.

A92-54341
AUTOMATIC CONTROL OF TEST PARAMETERS FOR INTAKE MEASUREMENTS IN A LOW-SPEED WIND TUNNEL

R. FRIEDRICHS and R. SIEBERT (DLR, Braunschweig, Germany) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 348-358. refs

An automatic process control method has been developed for intake measurements in a low-speed wind tunnel. Three computers were used as supervisors for process control and data acquisition. They were connected via a local area network. In the low-speed range the inlet flows into the model were simulated by sucking air through the intakes. To calculate the Mach number in the compressor entrance plane it is necessary to measure the total pressure distribution and the mass flow using for the latter standardized nozzles in the piping system. The mass flows were adjusted by remote-controlled regulating valves. The designed control systems demonstrate that automation increases the efficiency of the wind tunnel measurement technique. I.E.

A92-54342
THE WIND TUNNEL TEST 'SYSTEM' OF 1995 - COST EFFECTIVE EXPERIMENTATION THROUGH A FUSION OF RELATED TECHNOLOGIES

RICHARD D. NEUMANN (Science Applications International Corp., Dayton, OH) and LEE WEBSTER (Tesco, Inc., Tullahoma, TN) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics

Engineers, Inc., 1991, p. 359-371.
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A technology that allows the application of microfabrication techniques to wind tunnel experimentation is an onboard data acquisition system, the modular data acquisition and recording system (MDARS), currently under development by TeSCO, Inc. Both the conceptual developments possible in advanced experimentation and the specific technology which starts with the TeSCO developed MDARS approach are addressed. The MDARS hardware is discussed in detail, and possibilities for further development are suggested. I.E.

A92-54343
HYPERVELOCITY WIND TUNNEL 9 CONTROL SYSTEM
DOUGLAS F. NEWELL and STEPHEN F. RINALDI (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 372-381. refs

The U.S. Naval Surface Warfare Center Hypervelocity Wind Tunnel 9 operates from Mach 8 to Mach 14 with Reynolds numbers ranging from 75,000 per foot to 53,000,000 per foot. The Tunnel 9 facility control system was recently modernized. The architecture of the original and upgraded control system is described. In the upgraded system programmable logic controllers provide safety interlocking and input/output interfacing to the facility valve system. Mini computers (MicroVax II) provide an operator interface to the programmable logic controllers, the sensors, the prerun initialization and online tunnel run command and status monitors, the displays, and tunnel condition data acquisition. I.E.

A92-54347* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A LASER FLUORESCENCE ANEMOMETER SYSTEM FOR THE LANGLEY 16- BY 24-INCH WATER TUNNEL
F. K. OWEN, GARY M. ORNGARD (Complere, Inc., Palo Alto, CA), and DAN H. NEUHART (Lockheed Engineering & Sciences Co., Hampton, VA) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 403-412.
(Contract NAS1-18667)
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A laser fluorescence anemometer which comprises a three-component laser Doppler velocimeter system with a fourth channel to measure fluorescent dye concentration has been installed in the NASA Langley 16- by 24-in water tunnel. The system includes custom designed optics, data acquisition, and traverse control instruments and a custom software package. Feasibility studies demonstrated how water tunnels can be used in conjunction with advanced optical techniques to provide nonintrusive detailed flow field measurements of complex fluid flows with a minimum of expense. The measurements show that the laser fluorescence anemometer can provide new insight into the structure, entrainment, control and of mixing vortical and shear layer flows. I.E.

A92-54351
SKIN FRICTION MEASUREMENTS IN 3-D BOUNDARY LAYERS
G. IUSO, M. ONORATO, and P. G. SPAZZINI (Torino, Politecnico, Turin, Italy) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 442-448. Research supported by CNR and MURST. refs
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To advance the understanding of the reliability of obstacle-type pressure probes for skin friction measurements in three-dimensional (3-D) flow, omnidirectional triangular block probes have been tested. The probes have been calibrated in a channel flow. Details of the calibration tunnel and of the calibration procedure are given. Results obtained by testing different probes having different geometrical characteristics are shown. Finally, an application to a complex 3-D shear flow is presented. I.E.

A92-55100
INSTRUMENTATION KEY TO NASP COMBUSTOR TESTS
MICHAEL A. DORNHEIM Aviation Week & Space Technology (ISSN 0005-2175), vol. 137, no. 11, Sept. 14, 1992, p. 67, 69, 70.
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A review is presented of the National Aerospace Plane program that is applying a battery of optical instrumentation to the difficult problem of measuring the aerodynamics and chemistry of a hypersonic combustor during 0.002-sec shock tunnel tests. Attention is given to several types of optical instrumentation used including planar laser-induced fluorescence, and holography. Consideration is given to high-speed schlieren photography, a high-speed video camera that operates at a 3000 frame/sec speed, and the T5 free-piston reflected-shock tunnel that produces high flow enthalpies (up to 13,000 BTU/lb). R.E.P.

A92-55348*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLIGHT SIMULATOR FIDELITY ASSESSMENT IN A ROTORCRAFT LATERAL TRANSLATION MANEUVER
R. A. HESS, T. MALSBURY (California, University, Davis), and A. ATENCIO, JR. (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 217-230. refs
(Contract NAG2-482)
(AIAA PAPER 92-4424) Copyright

A model-based methodology for assessing flight simulator fidelity in closed-loop fashion is exercised in analyzing a rotorcraft low-altitude maneuver for which flight test and simulation results were available. The addition of a handling qualities sensitivity function to a previously developed model-based assessment criteria allows an analytical comparison of both performance and handling qualities between simulation and flight test. Model predictions regarding the existence of simulator fidelity problems are corroborated by experiment. The modeling approach is used to assess analytically the effects of modifying simulator characteristics on simulator fidelity. Author

A92-56003
NEW 1.27-M LEG OF THE NATIONAL AEROSPACE LABORATORY HYPERSONIC WIND TUNNEL
S. NOMURA, S. SAKAKIBARA, K. HOZUMI, K. SOGA, N. HIRABAYASHI, T. KOYAMA, and S. TUDA (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 12-15. In Japanese.

The current status and design of the National Aerospace Laboratory hypersonic wind tunnel are presented. The working range of the tunnel is discussed and problems such as the heating system are analyzed. Y.P.Q.

A92-56005
MEASUREMENTS OF TURBULENCE IN HYPERSONIC FLOW
Y. AIHARA, T. OKUNUKI, and T. TAMURA (Tokyo, University, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 20-23. In Japanese. refs

This paper deals with the measurements of turbulence in super- and hypersonic flow by using multichannels of constant-temperature hot-wire anemometers. Experiments were performed for the hypersonic flow ($M = 7$) at the University of Tokyo, and as to preliminary results, the intensity and spectral distribution of temperature fluctuations were obtained. Author

A92-56011
EVALUATION OF SIDEWALL INTERFERENCE IN THE NAL TWO-DIMENSIONAL TRANSONIC WIND TUNNEL

NORIKAZU SUDANI, HIROSHI KANDA, and MAMORU SATO (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 44-47. In Japanese. refs

Surface pressure and drag measurements on the NACA 0012 airfoil were conducted in the NAL two-dimensional transonic wind tunnel. Using a comparison with other wind tunnel data, the wall interference effects are discussed, especially those from the sidewall. The results suggest that the Mach number of the actual flow around the airfoil is lower than the setting Mach number. The Mach number correction for the sidewall boundary-layer based on the similarity rule was applied to the present measurements, thereby showing that the shock positions, the pressure distributions and the minimum drag coefficients are in good agreement with both other wind tunnel results and the Navier-Stokes calculation. It is shown that the evaluation indicates satisfactory transonic airfoil test results. Author

A92-56012
ON IMPROVEMENTS OF THREE-DIMENSIONAL POSITION MEASURING SYSTEM FOR DYNAMIC WIND TUNNEL TESTING
OSAMU NONAKA, SEIZO SUZUKI, SHUICHI SASA, MINORU TAKIZAWA, and TAKASHI SIMOMURA (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 48-51. In Japanese. refs

This paper describes some factors in relation to the measurement accuracy of the three-dimensional position of the model at the dynamic wind tunnel testing and some improvements of the system tried in order to get more accurate data. As the result of this improvement, it is shown that the measurement accuracy became better by about 50 pct than the previous method. Author

A92-56013
MEASUREMENTS OF LONGITUDINAL STATIC AERODYNAMIC COEFFICIENTS WITH CABLE MOUNT SYSTEM
KATSUICHI MUROTA, MASAAKI YANAGIHARA, and SHIGEO KAYABA (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 52-55. In Japanese. refs

Measurements of the longitudinal static aerodynamic coefficients of the 5 pct spaceplane model was performed in the NAL large scale low-speed wind tunnel. The model was supported on the cable mount system whose aerodynamic influence is less than with the strut type. This paper describes a method to measure the trimmed longitudinal aerodynamic coefficients with such a cable mount system and some testing results. Author

A92-56023
MEASUREMENTS OF BLADE FLAPPING MOTION ON A WIND TUNNEL MODEL
NAOHIRO IBOSHI and TOMOARI NAGASHIMA (National Defense Academy, Yokosuka, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 92-95. In Japanese.

From the educational viewpoints, the possibility, problems, and accuracy of the wind tunnel test for helicopter models are examined. A commercial radio controlled helicopter is used as the test model with necessary modifications, and measurements of blade flapping motions in forward flight are made. Reasonable results can be obtained. It is ascertained by experiments that the radio controlled helicopter with suitable modifications and installation of detectors is available for an effective apparatus for instruction. Author

A92-56043
AEROTHERMODYNAMIC TEST OF SPACEPLANE BY THIN-SKIN METHOD
YASUTOSHI INOUE, YUKIMITU YAMAMOTO, KOICHI HOZUMI, AKIRA YOSHIZAWA (National Aerospace Laboratory, Chofu, Japan), TADASHI KATSURAHARA, and YOSHIHARU TANAHASHI (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 186-189. In Japanese. refs

An aerothermodynamic test was conducted on a NAL spaceplane in a hypersonic wind tunnel. High-quality aerothermal distribution data were obtained using a thin-skin-metal model at a freestream Mach number of 7.1. These data showed high heating regions at the body, nose, and wing leading-edges. They also revealed some aerothermal features concerning hypersonic flight such as shock interference and boundary-layer transitions. Author

A92-56076
HELICOPTER ROTOR TESTING USING SCALED MODEL
M. NAKADATE, T. SEKIGUCHI, T. NAGAO, and M. OBUKATA (Fuji Heavy Industries, Ltd., Aerospace Div., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 330-333. In Japanese. refs

Two types of 1/5-scale-model rotors of an intermediate-sized helicopter were tested in hover and forward flight. One was a dynamically scaled model of 'baseline' rotors, while the other was that of 'advanced' rotors. The results showed good agreement between model and full-scale tower test, and the advanced rotor model showed substantially higher performance than the baseline. Author

A92-56111
GROOVED RUNWAY SURFACE TEXTURE BEFORE AND AFTER RUBBER REMOVAL
TOKUO SOTOZAKI and KOSABURO YAMAME (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 498-501. In Japanese. refs

The necessity of the roughness measurement of grooved runway surfaces is addressed. The average texture depth (ATD) of the grooved runway surface is analyzed. Y.P.Q.

A92-56114
AERODYNAMIC MODEL IDENTIFICATION OF A SPACEPLANE MODEL FROM A CABLE-MOUNT DYNAMIC WIND-TUNNEL TEST
M. NAGAYASU, S. SUZUKI, Y. HAYASHI, M. TAKIZAWA, S. SASA, M. YANAGIHARA, T. SHIMOMURA, S. KAYABA, K. MUROTA, and O. NONAKA (National Aerospace Laboratory, Chofu, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 512-515. In Japanese. refs

A cable mount system (CMS) for a dynamic wind tunnel test on a spaceplane model is presented. The parameters of the aerodynamic model are given, and the measurement system is described. Y.P.Q.

A92-56280
DESIGN AND DEVELOPMENT OF TEST RIGS FOR MAIN ROTOR AND MAIN ROTOR TRANSMISSION OF A HELICOPTER IN THE 6-TON-CLASS
P. RICHTER and W.-G. FISCHER (Henschel Flugzeug-Werke GmbH, Kassel, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 12 p.

The design, development, manufacturing, assembly, and operation of a main rotor test rig and a main transmission test rig for a six-ton class helicopter are presented. The state-of-the-art test rig technology and its variants with respect to different test functions and chosen solutions are described. The characteristic test rig construction types developed to date and the respective values and tolerances realized are discussed. R.E.P.

A92-56313
HEPO MISSION SIMULATOR - DEVELOPMENT AND USAGE FOR NH90 HELICOPTER
G. PERREY European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 7 p.

The HEPO helicopter mission simulator is discussed specifically in terms of its use for the concept study of the naval version of the NH90 helicopter. HEPO was developed to provide for studying: (1) crew workload; (2) degraded modes; and (3) the definition of the type and nature of interfaces. The helicopter mock-up is shown, and software modules and hardware interfaces are described. The simulator was employed to assess the feasibility of the three-crewmember concept and to support the definition of the man/machine interfaces. Assessment of the demands of the system for typical tasks was accomplished, and crew-task allocation is optimized as a result. The HEPO mission simulator is shown to provide data that can be useful to the design and development of the NH90 helicopter and crew concept. C.C.S.

A92-56726#
THE DESIGN OF A SUBSONIC LOW-NOISE, LOW-TURBULENCE WIND TUNNEL FOR ACOUSTIC MEASUREMENTS
T. J. MUELLER, D. F. SCHARPF, S. M. BATILL, R. B. STREBINGER, C. J. SULLIVAN, and S. SUBRAMANIAN (Notre Dame, University, IN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 15 p. Research supported by University of Notre Dame. refs
(Contract N00014-89-J-1783)
(AIAA PAPER 92-3883) Copyright

The design, fabrication, and calibration of a new subsonic facility for aeroacoustic measurements are described. The facility includes an anechoic chamber and a subsonic low-noise, low-turbulence free-jet wind tunnel. During the tests, a uniform mean velocity was produced at the exit of the inlet, and the turbulent intensity was about 0.04 percent. The speed range was from 7 to 92 ft/sec for the worst case of a 7-foot long free jet. The acoustic performance of the free-jet test section as well as the diffuser/muffler and inlet is found to be well within the limits necessary for low-speed aeroacoustic experiments. V.L.

A92-56727*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A QUIET-FLOW LUDWIEG TUBE FOR EXPERIMENTAL STUDY OF HIGH SPEED BOUNDARY LAYER TRANSITION
STEVEN P. SCHNEIDER (Purdue University, West Lafayette, IN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 14 p. refs
(Contract NAG1-1133; NAG1-1201)
(AIAA PAPER 92-3885) Copyright

A new low Reynolds number quiet-flow Ludwieg tube facility, now under construction, is briefly described, and its advantages outlined. The facility is characterized by good optical access and may be particularly useful for the development of optical instrumentation for the generation and measurement of instability waves. Initial research plans also include work on hot-wire instrumentation, wave generation techniques, roughness and receptivity effects, and suction distribution effects. V.L.

A92-56729#
HIGH ENTHALPY WIND TUNNEL FOR EROSION TESTING OF ADVANCED MATERIALS
KIRK HANAWA, Y. TOMIOKA, S. MORIMOTO, M. ISHII, T. FUJIMOTO, and M. MATSUMOTO (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 8 p. refs
(AIAA PAPER 92-3888) Copyright

The plasma arc-heated wind tunnel of 20 kW was delivered in late November, 1991, after successful commissioning of various required testings. This tunnel is now owned and operated, as Erosion Testing Machine, by Japan Ultra-High Temperature Materials Research Center (JUTEM) Ltd. in Tajimi, Japan. This apparatus may be utilized mainly for the erosion testing of advanced materials such as composite materials, and function-gradient-material for the future hypersonic aircraft and aerospace planes. Author

A92-56738#
FUTURE REQUIREMENTS FOR HYPERSONIC AERODYNAMIC AND AEROTHERMODYNAMIC FACILITIES
NORMAN E. SCAGGS (USAF, Wright Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 9 p. refs
(AIAA PAPER 92-3903)

An attempt is made to predict the future requirements for hypersonic aerodynamic and aerothermodynamic facilities, with particular attention given to external flow past air-breathing hypersonic vehicles. Ground testing is discussed with emphasis on overall aerodynamic and aerothermodynamic performance, prediction methodology evaluation, physical modeling of fluid mechanics phenomena, and the development of testing techniques. The quality of the existing hypersonic facilities is assessed, and recommendations are given concerning further improvements to the existing facilities. V.L.

A92-56743*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC AND HYPERSONIC QUIET TUNNEL TECHNOLOGY AT NASA LANGLEY
S. P. WILKINSON, S. G. ANDERS, F.-J. CHEN (NASA, Langley Research Center, Hampton, VA), and I. E. BECKWITH (Joint Institute for Applied Flight Sciences; NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 26 p. refs
(Contract NAS1-18458)
(AIAA PAPER 92-3908)

Quiet tunnel technology at NASA Langley is reviewed focusing on historical background, basic quiet tunnel concepts, design methodology, and significant results. Each of the NASA Langley quiet tunnels and recent flow quality results for a refurbished Mach 6 quiet nozzle are presented. It is concluded that high-speed quiet tunels should be viewed as a required adjunct to computational and experimental tools being developed to explore issues of instability and transition physics. The quiet tunnel technology can produce and maintain an adequately smooth nozzle finish, control settling chamber disturbances, and keep the facility clean and is capable of adequately measuring flow disturbances. O.G.

A92-56744*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE ASU TRANSITION RESEARCH FACILITY
WILLIAM S. SARIC (Arizona State University, Tempe) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 14 p. refs
(Contract AF-AFOSR-90-0234; NAG1-1032; NAG1-937; NAG1-1111; N00014-85-K-0527)
(AIAA PAPER 92-3910) Copyright

The ASU Transition Research Facility is commonly called the ASU Unsteady Wind Tunnel because of its unsteady-flow capability. This facility has been in operation since 1988. It is a closed return tunnel within which oscillatory flows of air can be generated for the study of unsteady problems in low-speed aerodynamics. Because it also has excellent low-turbulence characteristics, it has been used principally as a boundary-layer transition research facility. The wind tunnel is described along with its unsteady calibration data. Examples of freestream turbulence and boundary-layer transition measurements are given. Author

A92-56745*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A CLEAN AIR CONTINUOUS FLOW PROPULSION FACILITY
R. H. KRAUSS and J. C. MCDANIEL, JR. (Virginia, University, Charlottesville) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 9 p. refs

(Contract NAG1-795)
(AIAA PAPER 92-3912) Copyright

Consideration is given to a contaminant-free, high enthalpy, continuous flow facility designed to obtain detailed code validation measurements of high speed combustion. The facility encompasses uncontaminated air temperature control to within 5 K, fuel temperature control to 2 K, a ceramic flow straightener, drying of inlet air, and steady state continuous operation. The air heating method provides potential for independent control of contaminant level by injection, mixing, and heating upstream. Particular attention is given to extension of current capability of 1250 K total air temperature, which simulates Scramjet enthalpy at Mach 5. O.G.

A92-56746#
TOHOKU UNIVERSITY LOW-TURBULENCE WIND TUNNEL
Y. KOHAMA, R. KOBAYASHI (Tohoku University, Sendai, Japan), and H. ITO (Nihon University, Koriyama, Japan) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 13 p. refs
(AIAA PAPER 92-3913) Copyright

A general-purpose low turbulence wind tunnel was constructed using the design method of Bradshaw. Sound-absorbent material was used in all four corners to decrease sound intensity produced by a fan. The longitudinal component of turbulence intensity at the center of the closed working section is less than 0.02 pct of the mean velocity in the speed range between 18 m/s and 53 m/s. The mean velocity variations across the working section are within +/-0.1 pct of the mean velocity. Performance measurements have been done at representative tunnel cross sections to clarify the behavior of flow in the tunnel. This work differs from previous studies in the sense that emphasis is placed not only on velocity distributions, but also on turbulence intensity distributions at several cross sections of the tunnel. The critical Reynolds number for a flat plate at zero incidence, measured in a stream of the very low turbulence intensity of 0.016 pct, is larger than that reported by Schubauer and Skramstad. Author

A92-56748*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FLOW QUALITY STUDIES OF THE NASA LEWIS RESEARCH CENTER 8- BY 6-FOOT SUPERSONIC/9- BY 15-FOOT LOW SPEED WIND TUNNEL
E. A. ARRINGTON (Sverdrup Technology, Inc., Lewis Research Center Group, Brook Park, OH) and MARK T. PICKETT (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 46 p. Previously announced in STAR as N92-28673. refs
(AIAA PAPER 92-3916) Copyright

A series of studies were conducted to determine the existing flow quality in the NASA Lewis 8 by 6 Foot Supersonic/9 by 15 Foot Low Speed Wind Tunnel. The information gathered from these studies was used to determine the types and designs of flow manipulators which can be installed to improve overall tunnel flow quality and efficiency. Such manipulators include honeycomb flow straighteners, turbulence reduction screens, corner turning vanes, and acoustic treatments. The types of measurements, instrumentation, and results obtained from experiments conducted at several locations throughout the tunnel loop are described. Author

A92-56749#
TEST DATA MODELS TO CHARACTERIZE TURBINE ENGINE OPERATION IN ALTITUDE TEST FACILITIES
DONALD J. MALLOY (Sverdrup Technology, Inc., AEDC Group, Arnold AFB, TN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 16 p. refs
(AIAA PAPER 92-3917)

Test data models employed in altitude test facilities to characterize turbine engine operation are described. These models provide an accurate definition of engine and component performance, operability, and durability characteristics using generalized methods and functional relationships which apply to arbitrary engine and test cell configurations. Particular attention is given to new and improved capabilities to relate propulsion system performance to aircraft operation and engine model validation and refinement. O.G.

A92-56753*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LASER-DRIVEN HYPERSONIC AIR-BREATHING PROPULSION SIMULATOR
PRAKASH B. JOSHI, EDMOND Y. LO, and EVAN R. PUGH (Physical Sciences, Inc., Andover, MA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 19 p. refs
(Contract NAS3-26146)
(AIAA PAPER 92-3922) Copyright

A feasibility study is presented of simulating airbreathing propulsion on small scale hypersonic models using laser energy. The laser heat addition scheme allows simultaneous inlet and exhaust flows during wind tunnel testing of models with scramjet models. The proposed propulsion simulation concept has extended the Kantrowitz (1974) idea to propulsive wind tunnel models of hypersonic aircraft. Critical issues in aeropropulsive testing of models based on a ramjet power plant are addressed which include transfer of the correct amount of energy to the flowing gas, efficient absorption of laser energy into the gas, and test performance under tunnel reservoir conditions and at reasonable Reynolds numbers. O.G.

A92-56755#
THE RESEARCH OF REDUCING 3-D LOW SUPERSONIC SHOCK WAVE REFLECTION IN A 2-D TRANSONIC FLEXIBLE WALLS ADAPTIVE WIND TUNNEL
JIA J. HE, PEI C. ZUO, HUA X. LI, and MIN XU (Northwestern Polytechnical University, Xian, China) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 7 p. Research supported by NNSFC. refs
(AIAA PAPER 92-3924) Copyright

This paper describes the research of reducing shock wave reflection for 3D model testing in transonic 2D flexible wall wind tunnel at Northwestern Polytechnical University. A 2D flexible wall test section was built into the NPU high speed wind tunnel in the spring of 1990. At first, a 20 deg cone-cylinder model with blockage epsilon = 1 pct was tested as preliminary research in the summer and autumn of 1990. The results were good. The further formal tests of epsilon = 2 pct model were done in July and August of 1991. Two improved methods were used. The results obtained with the 2 pct model were better than the former. It is shown that the effect of 3D shock wave reflection could be reduced greatly by using adaptive wall technique in 2D flexible wall test section. Author

A92-56756*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
BLOCKAGE CORRECTION IN THREE-DIMENSIONAL WIND TUNNEL TESTING BASED ON THE WALL SIGNATURE METHOD
N. ULBRICH, C. F. LO (Tennessee, University, Tullahoma), and F. W. STEINLE, JR. (Tennessee, University, Tullahoma; NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 12 p. refs
(Contract NAG2-733)
(AIAA PAPER 92-3925) Copyright

An improved wall interference assessment and correction method for three-dimensional wind tunnel testing is presented. Blockage corrections on the surface of a test article are calculated based on a limited number of wall pressure measurements. These measurements are combined with a signature analysis procedure and influence functions to determine an equivalent test article and wake representation. Pressure coefficient corrections are calculated based on this equivalent body. The signature analysis procedure is modified to improve the on-line operation of the wall signature method. A new geometry of the equivalent body is introduced which can be combined with existing panel codes more

effectively. The calculation of influence functions and the determination of pressure coefficient corrections are based on a panel code. Therefore it is possible to apply the present method to any closed tunnel cross section. A numerical simulation of the idealized flow field of a wing and its wake in a rectangular wind tunnel is used to verify the improved wall signature method. The present method is considered to calculate blockage corrections in the NASA/ARC 12ft Pressure Wind Tunnel. Author

A92-56757#
WIND TUNNEL BLOCKAGE EFFECTS ON SLENDER WINGS UNDERGOING LARGE AMPLITUDE MOTIONS
SCOTT A. THOMPSON and ROBERT C. NELSON (Notre Dame, University, IN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 12 p. Research sponsored by University of Notre Dame. refs
(Contract AF-AFOSR-90-0321)
(AIAA PAPER 92-3926) Copyright

An experimental wind tunnel investigation was performed using a series of 70 deg sweep delta wings. The wings were geometrically identical but had different chord lengths. The goal was to examine the effect of tunnel wall interference on the surface pressure field and the location of vortex breakdown, for both steady and unsteady changes in angle of attack. The effect of the model motion on the freestream conditions was also measured. The unsteady location of breakdown was not significantly effected by a change in wing size (and thus blockage). However, consistent differences were measured in both the steady and unsteady surface pressures due to wing size. These differences occurred primarily at angles of attack above 30 deg, and for surface locations upstream of the midchord. Typically, increasing wing size resulted in decreasing pressure. Some of the differences in the pressure data were attributed to variations in the freestream dynamic pressures during the unsteady pitching motion. However, despite the quantitative differences, the qualitative nature of the data remained unchanged by the change in wing size. This includes the hysteresis observed in both the unsteady breakdown position and the unsteady surface pressures. Author

A92-56758#
PERFORMANCE EVALUATION OF A TRANSONIC WIND TUNNEL COMPRESSOR
JAMES A. GUNN, W. R. MARTINDALE, and D. W. WAGNER (Sverdrup Technology, Inc., Tullahoma, TN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 16 p. refs
(AIAA PAPER 92-3927) Copyright

The design point for a modern transonic wind tunnel compressor is influenced by factors such as facility operating range which is unusually large, efficiency, flow quality, and stall margin. In order to meet all of the design requirements and constraints, there is a heavy reliance on compressor design and performance prediction codes to select the optimum design. This paper describes a comparison of two performance evaluation codes with data from a three-stage, axial-flow, transonic wind tunnel compressor. Compressor test results show that the prediction codes are reasonably accurate in defining performance characteristics at speeds up to approximately 120 percent of design point speed. The codes are moderately accurate at predicting compressor efficiency. Selection of the stall criteria is a critical issue and it was found that the diffusion factor should be 0.6 or less. Future transonic wind tunnel compressor designs may be improved by tuning the codes, providing bypass systems, or using casing treatment. Author

A92-56760#
DESIGN OF A VARIABLE CONTRACTION FOR A FULL-SCALE AUTOMOTIVE WIND TUNNEL
T. WOLF (Darmstadt, Technical University, Germany) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 10 p. refs
(AIAA PAPER 92-3929) Copyright

The design of a 3D contraction for a projected full-scale aeroacoustic wind tunnel is presented. The contours are designed utilizing a 3D potential flow method in combination with a 2D boundary layer technique. Results demonstrate that the design goals were achieved, but flow visualization tests revealed relaminarization and flow separation in the corners near the throat for both contraction models. R.E.P.

A92-56761*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONTROL OF LARGE CRYOGENIC TUNNELS
S. BALAKRISHNA, W. A. KILGORE (Vigyan, Inc., Hampton, VA), and J. J. THIBODEAUX (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 9 p. refs
(Contract NAS1-19125)
(AIAA PAPER 92-3930)

For the efficient and economic operation of large cryogenic wind tunnels, automatic control is necessary to precisely regulate the temperature, pressure, and Mach number. The features of the control system currently in operation at the U.S. National Transonic Facility are presented. Some unique features of the tunnel temperature control law are the automatic tunnel cool down utilizing structural temperature feedback and the fan power based liquid nitrogen nozzle switching logic that have played a key role in realizing good automatic tunnel control. R.E.P.

A92-56767*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HYPERSONIC AERODYNAMIC/AEROTHERMODYNAMIC TESTING CAPABILITIES AT LANGLEY RESEARCH CENTER
C. G. MILLER, III (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 31 p. refs
(AIAA PAPER 92-3937) Copyright

Capabilities of the Langley Hypersonic Facilities Complex that consists of nine blowdown-to-vacuum wind tunnels are reviewed. These tunnels complement one another to provide ranges of Mach number from 6 to 20, unit Reynolds number from 0.03 to 40 million per ft, and normal shock density ratio from 2 to 12. Topics under consideration include the basic components of each facility, status, and upgrades recently performed; instrumentation and testing techniques routinely used to measure forces and moments, surface pressures, surface temperature-time histories, flow properties within the shock layer about the model via survey probes, and flow visualization; and data acquisition systems and upgrades performed via a NASA revitalization program. O.G.

A92-56768*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE LANGLEY 15-INCH MACH 6 HIGH TEMPERATURE TUNNEL
JEFFREY S. HODGE (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 18 p. refs
(AIAA PAPER 92-3938) Copyright

The Langley 15-Inch Mach 6 High Temperature Tunnel was recently converted from the former Mach 10 Hypersonic Flow Apparatus. This conversion was made primarily to provide the capability of testing in Mach 6 air at higher reservoir temperatures than previously possible at Langley. These elevated temperatures allow the matching of the Mach number, Reynolds number, and ratio of wall-to-adiabatic-wall temperatures (Tw/Taw) between this facility and the Langley 20-Inch Mach 6 CF4 Tunnel; Tw/Taw is also matched for Langley's 31-Inch Mach 10 Tunnel. A brief history and general description of this facility are presented along with a discussion of the recently completed modifications and upgrades. Author

A92-56770*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TEST DESCRIPTION AND PRELIMINARY PITOT-PRESSURE SURVEYS FOR LANGLEY TEST TECHNIQUE DEMONSTRATOR AT MACH 6

JOEL L. EVERHART, GEORGE C. ASHBY, JR., and WILLIAM J. MONTA (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 19 p. refs
(AIAA PAPER 92-3940) Copyright

A propulsion/airframe integration experiment conducted in the NASA Langley 20-Inch Mach 6 Tunnel using a 16.8-in.-long version of the Langley Test Technique Demonstrator configuration with simulated scramjet propulsion is described. Schlieren and vapor screen visualization of the nozzle flow field is presented and correlated with pitot-pressure flow-field surveys. The data were obtained at nominal free-stream conditions of Re = 2.8 x 10 exp 6 and a nominal engine total pressure of 100 psia. It is concluded that pitot-pressure surveys coupled to schlieren and vapor-screen photographs, and oil flows have revealed flow features including vortices, free shear layers, and shock waves occurring in the model flow field. O.G.

A92-56773#
AN OVERVIEW OF THE PLANNED AEROSPACE TEST FACILITIES AT CAPUA, ITALY

ANGELO GARRONE (Centro Italiano Ricerche Aerospaziali, Capua, Italy) and LEON H. ZACHO (FluiDyne Engineering Corp., Minneapolis, MN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 6 p. refs
(AIAA PAPER 92-3944) Copyright

The paper describes the major wind tunnel facilities that will be built at the Centro Italiano Ricerche Aerospaziali (CIRA) located at Capua, Italy. These facilities include a low speed wind tunnel (LSWT), a high Reynolds number transonic wind tunnel (HRTT), and a plasma wind tunnel (PWT), providing state-of-the-art test capability in the subsonic, transonic, and hypersonic regimes. The HRTT design incorporates a unique drive concept to minimize the installed power requirement; a single stage fan will be used for operation at low speeds, and a compressed air injector will be used at transonic speeds. The LSWT and HRTT will support the research and development needs of the Italian and other European aerospace industries. The PWT will support the development of the European Space Agency's Hermes space plane. Author

A92-56774#
THE G-RANGE IMPULSE FACILITY - A HIGH-PERFORMANCE FREE-PISTON SHOCK TUNNEL

J. R. MAUS (Calspan Corp., Arnold AFB, TN), M. L. LASTER (USAF, Arnold Engineering Development Center, Arnold AFB, TN), and H. G. HORNUNG (California Institute of Technology, Pasadena) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 12 p. refs
(AIAA PAPER 92-3946)

A new high performance free-piston shock tunnel currently being constructed at AEDC is described. A one-dimensional mathematical model, developed to provide performance estimates for this facility, is presented. Results from this model have been compared with data from the Caltech tunnel T5, and adjustable parameters tuned to best fit those data. Example computations have been carried out for conditions anticipated for the G-Range Impulse Facility. Results of these computations are presented and discussed.
Author

A92-56775#
STUDY ON INTERNATIONAL COOPERATIVE TEST FACILITIES FOR FUTURE SST/HST

HIROTOSHI KUBOTA (Tokyo, University, Japan), TAKEO IWAKI, and TAKASHI TSUJIMOTO (Society of Japanese Aerospace Companies, Inc., Tokyo, Japan) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 7 p. refs
(AIAA PAPER 92-3945) Copyright

A plan is set forth for developing the facilities required for testing SST/HST vehicle concepts by envisaging an international collaboration on one large-scale testing infrastructure. The required technologies for next-generation SST/HSTs are examined and shown to include advances in the areas of lift/drag ratio, composite materials, and laminar flow control. The required testing facilities are outlined based on present directions in the areas of CFD technology and specimen loading particularly. The cost and complexity of the facilities to support these areas of research are argued to merit the attention of an international cooperative test facility. Such a facility requires the development of an international consortium of researchers as well as a pilot plant to demonstrate the technological promise in the area of SST/HST. C.C.S.

A92-56784#
INVESTIGATION OF A PLATE-RAMP-CONFIGURATION BY MEANS OF LASER DOPPLER ANEMOMETRY AT MACH 2.95

D. REISINGER, W. HEISER, D. OLEJAK, and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Munich, Germany) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 12 p. refs
(Contract DFG-SFB-255)
(AIAA PAPER 92-3956) Copyright

A 6-Watt argon-ion laser Doppler anemometer implemented in a ground testing facility for 2D investigations in supersonic flows is described, and first results are presented. The flow field investigated was a compression corner flow over a 5-deg ramp at a free-stream Mach number of 2.95. It is shown that accurate determination of the position of the probe volume is essential when taking LDA measurements close to the wall. An interferometric approach is presented whereby the position of the probe volume can be determined. Velocity and turbulent kinetic energy profiles are compared with calculations using an extended Wilcox-k-w-model. V.L.

A92-56789#
TSNIIMASH CAPABILITIES FOR AEROGASDYNAMICAL AND THERMAL TESTING OF HYPERSONIC VEHICLES

N. A. ANFIMOV (Central Research Institute of Machine-Building, Kaliningrad, Russia) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 12 p. refs
(AIAA PAPER 92-3962) Copyright

The paper contains a review of the capabilities of the Central Research Institute of Machine-Building (TSNIIMASH) experimental facilities, destined for study of aerogasdynamics and heat transfer of hypersonic vehicles. Some information about the history of hypersonic research progress at TSNIIMASH is presented. The following types of facilities are picked out: (1) electric-arc wind tunnels, (2) shock tubes, (3) piston gasdynamic units, (4) ballistic ranges, and (5) low density wind tunnels. For such types of facilities a general description is presented, the principal parameter ranges are described and some examples of results are illustrated.
Author

A92-56790#
MILLISECOND AERODYNAMIC FORCE MEASUREMENT WITH SIDE-JET MODEL IN THE ISL SHOCK TUNNEL

K. W. NAUMANN, H. ENDE, G. MATHIEU, and A. GEORGE (French-German Research Institute, Saint-Louis, France) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 9 p. refs
(AIAA PAPER 92-3963) Copyright

This paper presents a description of our novel millisecond aerodynamic force measurement technique and the first experiments in hypervelocity flow with a model, which is equipped with laterally blowing jets and a set of accelerometers. A fast-acting mounting support releases the model and grips it again after a free flight duration of some milliseconds. Using measured acceleration and Pitot pressure histories allows direct straightforward time-dependent evaluation of the aerodynamic coefficients. This procedure is insensitive against nonlinearities or disturbances in the starting phase of the flow and compensates flow variations, if the flow is quasi-stationary and maintains a roughly uniform Mach number. The results allow to quantify the time necessary to establish quasi-stationary flow for the actual test conditions. Quantitative results are also obtained for the force, which is produced by interaction of side-jets and ambient flow, and acts on the surface of the model. At the tropospheric

hypervelocity conditions of our test, interaction force on a flat plate substantially increases jet thrust. Author

A92-56791# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECTS OF OXYGEN DISSOCIATION ON HYPERVELOCITY COMBUSTION EXPERIMENTS
R. J. BAKOS, R. G. MORGAN (Queensland, University, Brisbane, Australia), and J. TAMAGNO (General Applied Science Laboratories, Ronkonkoma, NY) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 16 p. Research sponsored by NASA, National Aero-Space Plane Joint Program Office, and DEET. refs
(Contract NAGW-674)
(AIAA PAPER 92-3964) Copyright

Results are presented of a comparative experimental study conducted to measure the effects of the test gas oxygen dissociation produced in reflected shock tunnels on hypervelocity combustion. An identical combustor model was tested in a reflected shock tunnel with test gas containing about 50 pct by mass of oxygen in dissociated form, as either nitric oxide or atomic oxygen, and in an expansion tube with test gas having negligible dissociated oxygen. Comparisons are made at two test conditions that are energy equivalent to flight conditions at Mach 13.5 and 17. R.E.P.

A92-56795#
TEST FACILITIES AND INSTRUMENTATION FOR RESEARCH IN RAREFIED GAS DYNAMICS - AN HISTORICAL PERSPECTIVE
JOHN E. SCOTT, JR. (Virginia, University, Charlottesville) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 10 p. refs
(AIAA PAPER 92-3969) Copyright

An overview of experimental research in rarefied gas dynamics demonstrates that the nature and complexity of problems in gas dynamics have changed dramatically from those studied 50 years ago. The test facilities that have been developed to meet these requirements include the utilization of low-density wind tunnels, freely expanding jets, and the application of molecular beam techniques to problems in rarefied gas dynamics. Attention is focused on noninvasive optical diagnostic techniques such as electron beam fluorescence, laser-Rayleigh and laser-Raman scattering, and laser-induced fluorescence. R.E.P.

A92-56796*# National Aeronautics and Space Administration, Washington, DC.
A CODE VALIDATION STRATEGY AND FACILITY FOR NONEQUILIBRIUM, REACTING FLOWS
E. P. MUNTZ, G. PHAM-VAN-DIEP, M. K. BRADLEY, D. A. ERWIN, and J. A. KUNC (Southern California, University, Los Angeles, CA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 29 p. Research supported by USAF and NASA. refs
(AIAA PAPER 92-3970) Copyright

The rotational and vibrational population distributions in a hypersonic flow of hot iodine vapor were investigated using a pilot wind tunnel. The tunnel provides run times of about 20 min, with a scale-up to a larger facility appearing to be possible. It will provide a 20-cm-diameter, Mach 9 flow of iodine vapor with only small amounts of free stream nonequilibrium. An analysis of the flow response to a normal shock wave indicates that significant chemistry will occur in model flow fields in the larger facility. V.L.

A92-56797#
RAREFIED GAS RESEARCH AT BERKELEY - CURRENT STUDIES AND FUTURE POTENTIALS
F. C. HURLBUT (California, University, Berkeley) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 11 p. refs
(AIAA PAPER 92-3971) Copyright

Ground based investigations using rarefied gas wind tunnels are proposed as offering significant support to programs of in-space thermophysical and aerodynamic study. The methods and techniques of wind tunnel investigation are discussed with special emphasis on the determinations of the density, velocity, temperatures and compositional fields for high velocity flows. It is argued that such determinations will lead to improved molecular collision models for energy and momentum transfers and consequently to improved molecular flow simulations. Certain useful concepts and numerical relationships are developed. Support for the development and interpretation of satellite instrumentation is discussed. The modernized Berkeley wind tunnel is described and present research discussed. Author

A92-56798#
THE SR3 LOW DENSITY WIND TUNNEL - FACILITY CAPABILITIES AND RESEARCH DEVELOPMENT
J. ALLEGRE (SESSIA; CNRS, Laboratoire d'Aerothermique, Meudon, France) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 7 p. refs
(AIAA PAPER 92-3972) Copyright

The general layout, operation, and capabilities of the SR3 low-density wind tunnel are described. Through the use of different nozzles, the SR3 facility is capable of generating subsonic, supersonic, and hypersonic flows up to Mach 22, covering a wide range of Reynolds numbers. The discussion covers the operation of the principal components of the wind tunnel, including an electron gun, external and sting aerodynamic balances, pressure transducers, heat transfer gages, and an infrared thermography camera. Recently conducted experimental studies have included work on delta wing configurations and characterization of the flight performance of the Hermes space plane. V.L.

A92-56802#
THRUST STAND DESIGN PRINCIPLES
R. B. RUNYAN, J. P. RYND, JR., and J. F. SEELY (Sverdrup Technology, Inc., Arnold AFB, TN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 11 p. refs
(AIAA PAPER 92-3976)

Information used at the Engine Test Facility (ETF), Arnold Engineering Development Center (AEDC), to guide design of propulsion scale force measuring systems is summarized. Terms, procedures, operational characteristics, and design philosophies peculiar to this specialized engineering field are defined. Several aspects of force measuring systems are discussed, including stand configurations, design features and calibration system techniques which are employed at the ETF facilities. Discussion on a variety of thrust stand designs is presented with the intention of consolidating into one document much of the experience accumulated in the ETF. The discussion focuses on facilitating a better understanding of the 'why' of the system design and focuses on systems that have the capability to provide very accurate force measurements. Author

A92-56806# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SMALL ENGINE COMPONENTS TEST FACILITY COMPRESSOR TESTING CELL AT NASA LEWIS RESEARCH CENTER
RICHARD A. BROKOPP (NASA, Lewis Research Center, Cleveland, OH) and ROBERT S. GRONSKI (Sverdrup Technology, Inc., Brook Park; NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 12 p. Previously announced in STAR as N92-30508.
(Contract RTOP 505-62-84)
(AIAA PAPER 92-3980) Copyright

LeRC has designed and constructed a new test facility. This facility, called the Small Engine Components Facility (SECTF) is used to test gas turbines and compressors at conditions similar to actual engine conditions. The SECTF is comprised of a compressor testing cell and a turbine testing cell. Only the

compressor testing cell is described. The capability of the facility, the overall facility design, the instrumentation used in the facility, and the data acquisition system are discussed in detail. Author

A92-56807#
HIGH REYNOLDS NUMBER TESTING IN SUPPORT OF TRANSPORT AIRPLANE DEVELOPMENT
M. D. MACK and J. H. MCMASTERS (Boeing Commercial Airplane Group, Seattle, WA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 31 p. refs
(AIAA PAPER 92-3982) Copyright

The paper focuses on the requirements for testing large subsonic transport aircraft at Reynolds numbers that either equal full-scale values or allow reliable extrapolation to actual flight conditions. The discussion covers the high-lift characteristics of transport aircraft, the physics of high-lift flows, predicting the maximum lift characteristics of transport aircraft, and current status of high-lift technology development. Future directions are discussed with particular reference to the development of CFD methodology, improved wind tunnel test techniques, and instrumentation and flow diagnostics. V.L.

A92-56815#
A CONCEPTUAL STUDY FOR FUTURE ENGINE TEST FACILITY
Y. FUJITSUNA, A. TANAKA (Ishikawajima-Harima Heavy Industries, Co., Ltd., Tokyo, Japan), K. YOSHIDA (Kawasaki Heavy Industries, Ltd., Kobe, Japan), M. MATSUHAMA (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan), and H. KOBAYASHI (Fuji Heavy Industries, Ltd. Utsunomiya, Japan) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 11 p. refs
(AIAA PAPER 92-3992) Copyright

Results of a 2-year feasibility study concerned with the development of a future high-altitude test facility for hypersonic transport (HST) engine development are reported. The discussion covers HST engine performance characteristics, test requirements, relevant technology, and evolution of the test facility functions. The planned facility will cover the HST flight envelope (Mach 5, altitude 35 km) and provide the capabilities of both direct connect and freejet tests. V.L.

A92-56816# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED NOZZLE AND ENGINE COMPONENTS TEST FACILITY
LUIS R. BELTRAN, RICHARD L. DEL ROSO, and RUBEN DEL ROSARIO (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 17 p. Previously announced in STAR as N92-17059.
(Contract RTOP 505-62-84)
(AIAA PAPER 92-3993) Copyright

A test facility for conducting scaled advanced nozzle and engine component research is described. The CE-22 test facility, located in the Engine Research Building of the NASA Lewis Research Center, contains many systems for the economical testing of advanced scale-model nozzles and engine components. The combustion air and altitude exhaust systems are described. Combustion air can be supplied to a model up to 40 psig for primary air flow, and 40, 125, and 450 psig for secondary air flow. Altitude exhaust can be simulated up to 48,000 ft, or the exhaust can be atmospheric. Descriptions of the multiaxis thrust stand, a color schlieren flow visualization system used for qualitative flow analysis, a labyrinth flow measurement system, a data acquisition system, and auxiliary systems are discussed. Model recommeded design information and temperature and pressure instrumentation recommendations are included. Author

A92-56818# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ENGINE COMPONENT INSTRUMENTATION DEVELOPMENT FACILITY AT NASA LEWIS RESEARCH CENTER
ROBERT J. BRUCKNER, ALVIN E. BUGGELE (NASA, Lewis Research Center, Cleveland, OH), and JAN LEPICOVSKY (Sverdrup Technology, Inc., Brook Park; NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 9 p. Previously announced in STAR as N92-25449.
(Contract RTOP 505-62-84)
(AIAA PAPER 92-3995) Copyright

The Engine Components Instrumentation Development Facility at NASA Lewis is a unique aeronautics facility dedicated to the development of innovative instrumentation for turbine engine component testing. Containing two separate wind tunnels, the facility is capable of simulating many flow conditions found in most turbine engine components. This facility's broad range of capabilities as well as its versatility provide an excellent location for the development of novel testing techniques. These capabilities thus allow a more efficient use of larger and more complex engine component test facilities. Author

A92-56825*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN APPROACH FOR INCREASING AEROELASTIC DIVERGENCE DYNAMIC PRESSURE OF WIND-TUNNEL MODELS
R. W. EDWARDS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 10 p. refs
(AIAA PAPER 92-4002) Copyright

An approach for increasing the aeroelastic divergence dynamic pressure of wind-tunnel model support systems is presented. A study has been conducted to investigate the effect of increased flexibility of the forward portion of balances on the divergence pressure of wind-tunnel models. The study utilized prior divergence analyses completed for various models to be tested in NASA Langley Research Center's National Transonic Facility, the Engineering Analysis Language finite-element analysis code, and an in-house computer program which solves for divergence dynamic pressure utilizing a transfer-matrix method based on fourth-order Runge-Kutta integration. Analytical results for balance flexibility changes versus changes in divergence pressure were obtained and demonstrate that a significant increase in divergence pressure can be obtained from the increased flexibility of the balance's forward portion for many models and their support systems. Author

A92-56831#
A MULTI-DIAGNOSTIC APPROACH TO TESTING V/STOL CRAFT
S. M. FOLEY, R. B. FUNK, P. A. FAWCETT, and N. M. KOMERATH (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 13 p. Research supported by U.S. Army, Pittsburgh Supercomputer Center, NSF, and Georgia Institute of Technology. refs
(AIAA PAPER 92-4008) Copyright

The interactive aerodynamics of new V/STOL designs require a new approach to ground testing, where multiple properties are measured both and away from surfaces during continuous changes in test parameters. Using a set of experiments of increasing complexity, a new capability is demonstrated for capturing surface pressure, velocity fields and vortex flow features over a range of test parameters. Two-dimensional velocity fields are captured over a full-scale UH-1 helicopter stabilator, a wing/canard configuration, and under the hub of a rotor in forward flight. Surface pressures and vortex flow features are captured over a wing/rotor configuration. Short tunnel run-times are achieved at the expense of large computational post-processing resources. It is shown that such experiments can be performed while the configuration geometry and flow conditions are continuously varied through a wide range of parameters. This experiment led to the discovery and capture of massive flow separation caused by vortex interaction on wings at moderate angles of attack, large-scale deflection of vortex wake trajectories by wake/wing interaction, unsteady flows over wings generated by canard interaction, and quasi-steady separation phenomena caused by the difference in time scales between separation and reattachment. Author

A92-56838#
NUMERICAL PREDICTION OF THE FLOW CHARACTERISTICS IN AN ARC WIND TUNNEL
M. MITSUDA, T. KUROSAKA, Y. SAKAMOTO (Kobe Steel, Ltd., Mechanical Engineering Research Laboratories, Japan), T. WASHIDA, and T. ARAI (Kobe Steel, Ltd., Engineering and Machinery Div., Takasago, Japan) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 17 p. refs
(AIAA PAPER 92-4016) Copyright

Four kinds of numerical prediction were performed to examine the characteristics of the arc-wind tunnel flowfield. The flowfield in the constricted arc heater was calculated by solving the Navier-Stokes equation with the Joule heat source. Flow uniformity can be obtained in a longer arc heater. The flow in the throat region was computed by solving the quasi-1D Euler equation with chemical nonequilibrium reaction, and the flow is nearly frozen. The flowfield calculation in the conical nozzle under the assumption of the perfect gas of the ratio of specific heats of 1.4 agree with the experimental data, and the disturbance of the Mach number/pitot pressure at the nozzle exit is about 6 percent. With increase in the flat-plate inclination angle, the pressure and the heat flux increase simultaneously. Author

A92-56839#
THE WIND TUNNEL, ITS EVOLUTION FOR AEROSPACE TEST PURPOSES, PERSPECTIVE FOR CURRICULUM DEVELOPMENT
JEWEL B. BARLOW (Maryland, University, College Park) and K. S. NAGARAJA (USAF, Wright Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 16 p.
(AIAA PAPER 92-4017)

The role of experimental aerodynamics in the development of aesospace is considered with respect to the curricula in aerospace engineering in terms of details of the experiments and the relative weight on low and high-speed regimes. The current mix of experiments should include an introduction to detailed flowfield studies as well as an introduction to measurement methods and measurements of integrated forces on sections and complete configurations. As predictive capability improves there are more instances in which partial model experiments are cost-effective substitutes for whole vehicle simulations. It is concluded that educational programs should reflect this aspect. Author

A92-56840#
AERODYNAMICS LABORATORY EDUCATION AT PURDUE UNIVERSITY - GROUND TESTING FACILITIES
STEVEN P. SCHNEIDER and JOHN P. SULLIVAN (Purdue University, West Lafayette, IN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 7 p. Research supported by Boeing Co. and Northrop Corp. refs
(AIAA PAPER 92-4018) Copyright

The School of Aeronautics and Astronautics at Purdue University maintains a variety of wind and water tunnel facilities, located at the Aerospace Sciences Lab. These include small and large subsonic facilities, a supersonic jet and wind tunnel, water facilities, a quiet flow Ludwieg tube now under construction. These facilities are described, along with the undergraduate and graduate education program for which they are used. Some of our current challenges are also addressed. Author

A92-56841#
THE TRISONIC WIND TUNNEL MUENCHEN AND ITS INVOLVEMENT IN THE GERMAN SAENGER-PROGRAMME
D. REISINGER, W. HEISER, S. LERBS, and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Munich, Germany) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 9 p. refs
(AIAA PAPER 92-4019) Copyright

The use of the Trisonischer Windkanal (trisonic wind tunnel) Muenchen (TWM), a ground testing facility within the German Hypersonics Technology program based on a SAeNGER concept, for aerospace education purposes is described. The facility is capable of covering the subsonic, transonic, and supersonic portion of a typical trajectory and is used for both research and aerospace education. O.G.

A92-56843#
HYPERSONIC SHOCK TUNNEL TESTING FOR UNDERGRADUATE LABORATORY INSTRUCTION
I. KALKHORAN, P. M. SFORZA, and P. ADAM (Polytechnic University, Brooklyn, NY) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 6 p. refs
(AIAA PAPER 92-4021) Copyright

Development of a hypersonic shock tunnel suitable for use in undergraduate laboratory instruction and economical to construct and operate has been initiated in the Aerospace Engineering Department of Polytechnic University. Such a unique test facility will supplement the existing supersonic and shock tube laboratory experiments and will provide students with the opportunity to: (1) operate a short duration impulse type wind tunnel, (2) measure real-gas hypersonic flow properties and (3) utilize modern, computer based instrumentation for a short-duration facility. This paper discusses high speed laboratory experiments currently in use in the senior-level fluids laboratory courses while results of preliminary design analysis for the planned hypersoic shock tunnel is presented. Author

A92-56850#
FLOW CONTAMINATION AND FLOW QUALITY IN ARC HEATERS USED FOR HYPERSONIC TESTING
W. N. MACDERMOTT, D. D. HORN, and C. J. FISHER (Calspan Corp., Arnold AFS, TN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 12 p. refs
(AIAA PAPER 92-4028)

A survey has been made of available information on contamination in airflows from high-pressure arc heaters. There is evidence that only a small part of the mass flow is heated directly by the electric discharge. When an equilibrium reservoir is established downstream of the arc, the nonequilibrium chemistry in the subsequent rapid nozzle expansion is characteristic of that reservoir state and the nozzle scale, independent of the method of heating. Asymptotic frozen composition is found to correlate with reservoir entropy. Up to 6.5-percent frozen NO is possible, but chemical kinetics calculations indicate a minimal effect on a combustion-type test. Larger amounts of atomic oxygen are possible, but do not reach 1 percent until the simulated Mach number reaches 15. Author

A92-56854*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BUFFET TEST IN THE NATIONAL TRANSONIC FACILITY
CLARENCE P. YOUNG, JR., DENNIS W. HERGERT, THOMAS W. BUTLER, and FRED M. HERRING (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 13 p. refs
(Contract NCC1-141)
(AIAA PAPER 92-4032) Copyright

A buffet test of a commercial transport model was accomplished in the National Transonic Facility at the NASA Langley Research Center. This aeroelastic test was unprecedented for this wind tunnel and posed a high risk to the facility. This paper presents the test results from a structural dynamics and aeroelastic response point of view and describes the activities required for the safety analysis and risk assessment. The test was conducted in the same manner as a flutter test and employed onboard dynamic instrumentation, real time dynamic data monitoring, automatic, and manual tunnel interlock systems for protecting the model. The procedures and test techniques employed for this test are expected to serve as the basis for future aeroelastic testing in the National Transonic Facility. This test program was a cooperative effort between the Boeing Commercial Airplane Company and the NASA Langley Research Center. Author

A92-56856*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TRANSONIC TURBINE BLADE CASCADE TESTING FACILITY
VINCENT G. VERHOFF, WILLIAM P. CAMPERCHIOLI (NASA, Lewis Research Center, Cleveland, OH), and ISAAC LOPEZ (USAF, Propulsion Directorate; NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 12 p. Previously announced in STAR as N92-26129.
(AIAA PAPER 92-4034) Copyright

NASA LeRC has designed and constructed a new state-of-the-art test facility. This facility, the Transonic Turbine Blade Cascade, is used to evaluate the aerodynamics and heat transfer characteristics of blade geometries for future turbine applications. The facility's capabilities make it unique: no other facility of its kind can combine the high degree of airflow turning, infinitely adjustable incidence angle, and high transonic flow rates. The facility air supply and exhaust pressures are controllable to 16.5 psia and 2 psia, respectively. The inlet air temperatures are at ambient conditions. The facility is equipped with a programmable logic controller with a capacity of 128 input/output channels. The data acquisition system is capable of scanning up to 1750 channels per sec. This paper discusses in detail the capabilities of the facility, overall facility design, instrumentation used in the facility, and the data acquisition system. Actual research data is not discussed. Author

N92-32734# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
INTEGRATION OF WALL INTERFERENCE ASSESSMENT AND WALL ADAPTATION
J. SMITH 25 Mar. 1991 13 p Presented at the International Conference on Adaptive Wall Wind Tunnel Research and Wall Interference Correction, Xian, China, 10-14 Jun. 1991 Previously announced in IAA as A91-52782
(NLR-TP-91119-U; ETN-92-91998) Avail: CASI HC A03/MF A01

The fact that the normal velocity distribution on the test section walls suffices to calculate the associated harmonic perturbation flow field inside it is fully exploited for adaptive wall applications. It is shown to provide a key to test section design. In addition, wall adaptation is applied to obtain correctable, instead of zero, interference. Wall interference assessment is applied to determine, in succession, initial and residual interference. A major advantage of accepting correctability is that deviations of the center of the test section exit from the nominal test section center line, which may give rise to unnecessarily high losses in the diffuser entry area, are avoided. ESA

N92-32903# Army Cold Regions Research and Engineering Lab., Hanover, NH. Experimental Engineering Div.
PERFORMANCE OF INSULATED PAVEMENTS AT NEWTON FIELDS, JACKMAN, MAINE Final Report
MAUREEN A. KESTLER and RICHARD L. BERG May 1992 30 p
(Contract DTFA01-89-Z-02050)
(CRREL-92-9; DOT/FAA/RD-92/8) Avail: CASI HC A03/MF A01

In 1986, the runway at Newton Field, a small airport in Jackman, Maine, was reconstructed using a 2-inch thick layer of extruded polystyrene insulation as part of the pavement structure. At the same time, a nearby town road was reconstructed using a conventional uninsulated pavement cross section for relatively heavy loads. Both pavements were monitored for frost penetration, frost heave, and seasonal changes in pavement strength. Since frost penetration beneath the insulation layer of the runway at Newton field exceeded empirical estimates during the winter of 1986-1987, four additional test sections with varying combinations of insulation and subbase thicknesses were constructed adjacent to the airport's parking apron during the summer of 1987. Although the thermal performance of the insulated pavement test sections was comparable to design expectations for the following three years, evidence of discontinuities in the insulation layer in the Newton field runway demonstrates the insulated pavements' susceptibility to variations in construction. Discussed here is pavement performance at each of the test sites over the observation periods 1986-1990 and 1987-1990. Author

N92-33398# Army Materiel Systems Analysis Activity, Aberdeen Proving Ground, MD.
COST/BENEFIT ANALYSIS OF THE AH-64 (APACHE) HELICOPTER AUTOMATED TEST EQUIPMENT (ATE) Final Report
SCOTT P. PRIDGEON, ANN T. VOGT, and LARRY P. WAGGONER Jan. 1992 108 p
(AD-A252909; AMSAA-TR-519) Avail: CASI HC A06/MF A02

A cost/benefit analysis was conducted to evaluate the Automated Test Equipment (ATE) requirements to provide fault detection capability for electronic components for the support of the AH-64 Apache helicopter. The Apache currently uses a dedicated Electronic Equipment Test Facility (EETF) to provide this capability. It is Army policy, however, that the Integrated family of Test Equipment (IFTE) be the Army standard ATE for providing this capability. Due to a funding shortfall for IFTE and the current fielding of an upgrade to the EETF computer, the Commanding General of AMC requested that an economic analysis be conducted to compare EETF versus IFTE for the support of the Apache. A life cycle cost-analysis was conducted in which alternatives were compared over a 20-year time frame. The analysis compares the costs, benefits and feasibility of continuing to use EETF versus various options for transitioning to IFTE in support of Apache. In summary, the life cycle costs for EETF are significantly less than IFTE. While the sustainment costs for IFTE are less than EETF, they do not offset the higher acquisition costs. GRA

N92-33434# Federal Aviation Administration, Washington, DC.
ACCOMPLISHMENTS UNDER THE AIRPORT IMPROVEMENT PROGRAM, FY 1991 Annual Report No. 10
JEAN HETSKO 1991 124 p
(AD-A253046; DOT/FAA/RP-92/3) Avail: CASI HC A06/MF A02

Section 521 of the Airport and Airway Improvement Act of 1982 (Public Law 97-248) requires that the Secretary of Transportation submit an annual report to Congress describing the accomplishments of the Airport grant program. This report covers activities for the fiscal year ending September 30, 1991. Accomplishments and the Airport Improvement Program are reported. GRA

N92-33826*# Alabama Univ., Huntsville. Dept. of Chemical and Materials Engineering.
HIGH TEMPERATURE AIRCRAFT RESEARCH FURNACE FACILITIES Final Report
JAMES E. SMITH, JR. and JOHN L. CASHON Aug. 1992 109 p
(Contract NAS8-36955)
(NASA-CR-184384; NAS 1.26:184384) Avail: CASI HC A06/MF A02

Focus is on the design, fabrication, and development of the High Temperature Aircraft Research Furnace Facilities (HTARFF). The HTARFF was developed to process electrically conductive materials with high melting points in a low gravity environment. The basic principle of operation is to accurately translate a high temperature arc-plasma gas front as it orbits around a cylindrical sample, thereby making it possible to precisely traverse the entire surface of a sample. The furnace utilizes the gas-tungsten-arc-welding (GTAW) process, also commonly referred to as Tungsten-Inert-Gas (TIG). The HTARFF was developed to further research efforts in the areas of directional solidification, float-zone processing, welding in a low-gravity environment, and segregation effects in metals. The furnace is intended for use aboard the NASA-JSC Reduced Gravity Program KC-135A Aircraft. Author

N92-34141*# Texas A&M Univ., College Station. Dept. of Aerospace Engineering.
EXPERIMENTAL STUDY OF PERFORMANCE DEGRADATION OF A ROTATING SYSTEM IN THE NASA LEWIS RC ICING TUNNEL Final Report, 21 Feb. 1989 - 28 Jun. 1991
KENNETH KORKAN 3 Sep. 1992 63 p
(Contract NCC3-132)
(NASA-CR-190684; NAS 1.26:190684) Avail: CASI HC A04/MF A01

The Helicopter Icing Consortium (HIC) conducted one of the first U.S. tests of a heavily instrumented model in the controlled environment of a refrigerated tunnel. In the Icing Research Tunnel (IRT) at NASA LeRC, ice was accreted on the main rotor blade of the BMTR-1 Sikorsky model helicopter under a variety of environmental conditions, such that liquid water content (LWC) and volume mean droplet diameter (VMD) ranges reflected the Federal Aviation Agency and Department of Defence icing condition envelopes. This report gives the correlated results of the data provided by NASA LeRC. The method of statistical analysis is discussed. Lift, thrust, and torque coefficients are presented as a function of icing time, as correlated with changes in ambient temperature, LWC, and VMD. The physical significance of these forces is discussed. Author

N92-34213*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PILOT-PRESSURE PROBE FOR MEASURING PRESSURE IN A HYPERSONIC WIND TUNNEL Patent Application
GEORGE C. ASHBY, JR., *inventor (to NASA)* 16 Jul. 1992 11 p
(NASA-CASE-LAR-14232-1; NAS 1.71:LAR-14232-1; US-PATENT-APPL-SN-914905) Avail: CASI HC A03/MF A01

A device for measuring pressure in high-velocity fluid streams in wind tunnels in which a transducer is mounted within a housing located within the wind tunnel and separated by a relatively short distance from a pitot tube in the free stream area of the wind tunnel is presented. Because the tunnel must be heated to a very high temperature, the transducer is water cooled. Additionally, the construction of this pressure probe is such that the pitot tube may move rotationally or radially relative to the transducer housing. NASA

N92-34222*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
DYNAMICS AND CONTROL OF A FIVE DEGREE-OF-FREEDOM MAGNETIC SUSPENSION SYSTEM Thesis Progress Report, 1 Nov. 1991 - 30 Apr. 1992
ANWAR MOHAMMED HAJ and COLIN P. BRITCHER Jun. 1992 91 p
(Contract NAG1-1056)
(NASA-CR-191259; NAS 1.26:191259) Avail: CASI HC A05/MF A01

A large-gap magnetic suspension system with five degrees-of-freedom is presented. The system is multi-input/multi-output with coupling between degrees-of-freedom. Simulation was performed on this multi degree-of-freedom system in order to control each degree-of-freedom separately. Two types of controllers are considered by adding white noise to a single degree-of-freedom system in order to test their behavior and determine which is the best choice for the system. The responses of the system are produced in continuous and discrete time where a sample interval and delay time was introduced. Using these responses, a comparison between each degree-of-freedom was made and the maximum value of the delay time was determined. Author

N92-34247# Resource International, Inc., Westerville, OH.
CRITERIA FOR USE OF SEAL COATS ON AIRPORT PAVEMENTS Final Report
L. SARAF CHHOTE, KAMRAN MAJIDZADEH, and V. R. KUMAR Aug. 1992 121 p
(Contract DTFA01-90-C-00029)
(DOT/FAA/RD-92/18) Avail: CASI HC A06/MF A02

Seal coats are generally used to protect the pavement surfaces from oxidation and ingress of water to layers below. Additionally, seal coats on airport pavements are expected to protect the pavement from the potential damage of fuel spillage. This report describes the results of literature search conducted for this study. It also describes the information gathered from visits to eight airport sites located throughout the U.S. Samples of seal coat materials obtained from five airport sites were tested in the laboratory to determine their performance characteristics. Also, the characteristics of asphalt and coal tar seal coat mixes were tested under dry and wet freeze-thaw cycling to determine the effect of wet freeze-thaw cycling on cracking of sixteen different mixes. The results of all these tests are included in this report along with a summary and conclusion, and a list of recommendations. Author

10

ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A92-53545
STABILITY AND DYNAMIC COUPLING OF ELASTIC VEHICLES WITH UNSTEADY AERODYNAMIC FORCES CONSIDERED
SHILU CHEN, SHOU TANG, HENGYUAN YAN, and XIUFANG HUO (Northwestern Polytechnical University, Xian, China) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, AGNE Publishing, Inc., 1990, p. 693-698. refs
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In this paper, the stability problem of elastic vehicles is studied with the effect of unsteady aerodynamic forces considered. Longitudinal equations of disturbance motions including actions of unsteady aerodynamic forces are derived. A method of analysis of the effect of aeroelasticity on the stability of elastic vehicles by using a simplified mathematical model of unsteady aerodynamic forces is proposed. A method is developed for quantitative analysis of the coupling characteristics of elastic vehicles to show the interactions between the rigid-body motion, elastic vibrations, and controller motion modes. Author

A92-53565
FLOW MEASUREMENTS IN SCRAMJET INLETS
KOUICHIRO TANI, TAKESHI KANDA, TOMOYUKI KOMURO, ATSUO MURAKAMI, KENJI KUDOU, YOSHIO WAKAMATSU, GORO MASUYA, and NOBUO CHINZEI (National Aerospace Laboratory, Kakuda, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 831-836. refs
Copyright

The experiments of scramjet inlets were made with varying sweep angle and contraction ratio. For each configuration of inlets, wall pressure, pilot pressure, and flow direction at the throat were measured. The flow patterns on the top and side walls were observed by surface flow visualization. Author

A92-53578
SPACEPLANE AERODYNAMIC HEATING AND THERMAL PROTECTION DESIGN METHOD
HIROTOSHI KUBOTA (Tokyo, University, Japan), NORIHIKO ITODA (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan), KIYOSHI YAMAMOTO, and YUKIMITSU YAMAMOTO (National Aerospace Laboratory, Chofu, Japan) IN: International Symposium on Space

Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 915-920. refs
Copyright

At the first phase of concept design of spaceplanes, parametric studies and optimization for the various body configurations and trajectories are needed. For that purpose, the aerodynamic heating is predicted by a simple method. The wall temperature is estimated from the predicted aerodynamic heating against the various wall thickness and coolant heat transfer coefficients. A method for designing a thermal protection system is discussed. Author

A92-53603
SPACE PLANE NAVIGATION SIMULATION
KOICHI MATSUSHIMA, MASAAKI MURATA, HIROKIMI SHINGU (National Aerospace Laboratory, Chofu, Japan), TETSUO SHIMIZU (Fujitsu, Ltd., System Laboratory, Tokyo, Japan), TATSUO MIKAMI, and YOSHIKAZU HASHIDA (Fujitsu, Ltd., Kawasaki, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 1091-1096. refs
Copyright

A simulation program for a future Japanese space-plane (SP) considered for development is presented along with the results of the analysis of a candidate navigation configuration, focused on the terminal area energy management phase and the approach/landing phase of SP. The guidance laws and aerodynamic parameters which are applied to the program for the analysis are modeled using the laws and parameters of the U.S. Space Suttle, assuming typical values for the accuracy of sensors. I.S.

A92-53635
CONCEPTS OF FLIGHT EXPERIMENTS FOR HOPE DEVELOPMENT
HIROSHI SASAKI, TETSUICHI ITO, TOSHIO AKIMOTO, HIROSHI MIYABA, and MOTOYUKI INABA (NASDA, Tsukuba Space Center, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 2. Tokyo, AGNE Publishing, Inc., 1990, p. 1319-1324.
Copyright

In connection with NASDA's design studies for HOPE, the H-II launch vehicle-lofted manned orbiter whose first flight is projected for the late 1990s, efforts are being made toward proof-of-concept (1) orbital reentry, 'OREX', (2) hypersonic flight, 'HYFLEX', and (3) approach and landing, 'ALEX' experiments, using small, simplified scale models of HOPE. Structures and materials suited to the mission segment in question are used in each of the three test series. O.C.

A92-53639
AERODYNAMIC STUDY OF H-II ORBITING PLANE, HOPE
TOSHIO AKIMOTO, TETSUICHI ITO, NORIO SUZUKI (NASDA, Tsukuba Space Center, Japan), KOKUICHI HOZUMI, SEIZOU SAKAKIBARA, and IWAO KAWAMOTO (National Aerospace Laboratory, Chofu, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 2. Tokyo, AGNE Publishing, Inc., 1990, p. 1349-1354.
Copyright

NASDA's HOPE will be launched by an H-II vehicle and inserted into 250-km altitude orbit; after four days in orbit either conducting experiments or Space Station rendezvous and docking missions, HOPE will deorbit and automatically land on a runway. An account is given of the results of a study of the aerodynamics of the HOPE vehicle which was conducted in cooperation with Japan's NAL. Wind tunnel test results show that the double-delta planform must have long wingtip fins in order to possess positive static directional stability at low speed, as well as the requisite viscous-interaction parameter effects at hypersonic speeds and better aerodynamic heating distribution. O.C.

A92-53640
PRE-FLIGHT PHYSICAL SIMULATION TEST OF HIMES REENTRY TEST VEHICLE
JUN'ICHIRO KAWAGUCHI, YOSHIFUMI INATANI (Institute of Space and Astronautical Science, Sagamihara, Japan), KOICHI YONEMOTO (Kawasaki Heavy Industries, Ltd., Kakamigahara, Japan), and SHIGERU HOSOKAWA (Mitsubishi Precision Co., Ltd., Kamakura, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 2. Tokyo, AGNE Publishing, Inc., 1990, p. 1355-1363. refs
Copyright

ISAS is now developing a small reentry test vehicle, which is 2m long with a 1.5m wing span and weighs about 170 kg, for the purpose of exploring high angle-of-attack aerodynamic attitude control issue in supersonic and hypersonic speed. The flight test, employing 'Rockoon' launch system, is planned as a preliminary design verification for a fully reusable winged rocket named HIMES (Highly Maneuverable Experimental Space) vehicle. This paper describes the results of preflight ground test using a motion table system. This ground system test is called 'physical simulation' aimed at: (1) functional verification of side-jet system, aerodynamic surface actuators, battery and onboard avionics; and (2) guidance and control law evaluation, in total hardware-in-the-loop system. The pressure of side-jet nozzles was measured to provide exact thrust characteristics of reaction control. The dynamics of vehicle motion was calculated in real-time by the ground simulation computer. Author

A92-54019#
EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF SCALING PHENOMENA IN A LARGE CALIBER RAM ACCELERATOR
D. L. KRUCZYNSKI and M. J. NUSCA (U.S. Army, Ballistic Research Laboratory, Aberdeen Proving Ground, MD) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 19 p. refs
(AIAA PAPER 92-3245)

Development efforts with a 38-mm caliber ram-accelerator apparatus to date have demonstrated muzzle velocities in excess of 2.6 km/sec; theoretical considerations indicate that velocities of 7 km/sec may be possible, and that the projectile may be scalable to much higher calibers and launch masses. Such up-scaling, however, requires deeper understanding of the highly complex interactions occurring during the projectile's entrance into the ram-accelerator tube. CFD simulations are presented for 38- and 120-mm systems which, with some simplifications, model projectile entry and give attention to the dynamics of previously ignored components. O.C.

A92-55098
HOPE RE-ENTRY EXPERIMENTAL VEHICLE
SHO MIYAKE, SHOICHIRO ASADA (Mitsubishi Heavy Industries, Ltd., Nagoya Aerospace Systems Works, Japan), and TOSHIO AKIMOTO (NASDA, Tokyo, Japan) Mitsubishi Heavy Industries Technical Review (ISSN 0026-6817), vol. 29, no. 2, June 1992, p. 137-144.
Copyright

An Orbital Reentry Experiment Vehicle (OREX) that is scheduled to be flown onboard the H-II Orbiting Plane (HOPE) in February, 1993 by NASDA is described focusing on the plan of the experiment and vehicle configurations. The OREX is expected to provide valuable data on hypersonic aerodynamics, aerothermodynamics, thermal protection systems, etc. during atmospheric reentry. Particular attention is given to the relationship between the vehicle's shape and aerodynamic characteristics and a concept of heat-resisting structure and thermal protection systems. O.G.

A92-55310#
OPTIMAL LAUNCH TRAJECTORY OF A HYPERSONIC RESEARCH VEHICLE
YOSHINORI OKUNO and SHIGEYA WATANABE (National Aerospace Laboratory, Tokyo, Japan) IN: AIAA Guidance,

Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1612-1617. refs
(AIAA PAPER 92-4302) Copyright

A formulation is proposed for calculating the optimal launch trajectory of a hypersonic research vehicle boosted by a two-stage solid rocket motor. The formulation is shown to be capable of simultaneously optimizing the pitch rate control profile, second-stage propellant loading and its ignition timing, as well as the launch vehicle aerodynamic characteristics by varying the first-stage tail plane area. Numerical results are presented for a 500-kg research vehicle boosted up to 4 km/s (M = 12) by a two-stage launch vehicle. V.L.

A92-55311#
A GUIDANCE LAW FOR HYPERSONIC DESCENT TO A POINT
G. R. EISLER (Sandia National Laboratories, Albuquerque, NM) and DAVID G. HULL (Texas, University, Austin) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1618-1624. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 92-4303)

A neighboring extremal control problem is formulated for a hypersonic glider to execute a maximum-terminal-velocity descent to a stationary target. The resulting two-part, feedback control scheme initially solves a nonlinear algebraic problem to generate a nominal trajectory to the target altitude. Secondly, a neighboring optimal path computation about the nominal provides the lift and side-force perturbations necessary to achieve the target downrange and crossrange. On-line feedback simulations of the proposed scheme and a form of proportional navigation are compared with an off-line parameter optimization method. The neighboring optimal terminal velocity compares very well with the parameter optimization solution and is far superior to proportional navigation. Author

A92-56069
LATERAL CONTROL OF SPACEPLANE AT HYPERSONIC FLIGHT
SHINJI SUZUKI and MASAKI TORIUMI IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 302-305. In Japanese. refs

A spaceplane at hypersonic flight with a high angle of attack does not have the sufficient control power of aerodynamic control surfaces. Therefore, spaceplanes generally utilize the reaction jet for lateral attitude control. This paper applies the optimum pulse control theory, which optimizes the amount of roll and yaw jet impulse, with the assistance of an elevon deflection for a bank angle control. Numerous simulations are studied to investigate an effectiveness of the present control system. Author

A92-56121
EVALUATION OF A IMU WITH OPTICAL FIBER GYROS IN DYNAMIC WINDTUNNEL TESTS
MINORU TAKIZAWA, SHUICHI SASA, MASAHIKO NAGAYASU (National Aerospace Laboratory, Chofu, Japan), HIROSHI KAJOKA, and TOSHIO IIZUKA (Hitachi Cable, Ltd., Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 540-543. In Japanese. refs

A study of dynamic windtunnel tests using a 5 percent cable-mounted model of the NAL spaceplane was carried out to identify aerodynamic parameters of the Spaceplane at National Aerospace Laboratory (NAL). In this study, an inertial measuring unit with optical fiber gyros, which will be installed on the model and will be used to measure angular rates about three axes of the model, has been developed and evaluated in dynamic windtunnel tests. It is reported that the IMU has been used effectively in the control system of the model; however, the accuracy, resolution, and frequency response of the OFG-3 were insufficient for the dynamic windtunnel tests. Author

A92-56772#
THE HIGH ENTHALPY SHOCK TUNNEL IN GOETTINGEN
G. EITELBERG, T. J. MCINTYRE, W. H. BECK (DLR, Institut fuer Experimentelle Stroemungsmechanik, Goettingen, Germany), and J. LACEY (Interatom GmbH, Bergisch Gladbach, Germany; FluiDyne Engineering Corp., Minneapolis, MN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 11 p. Research supported by ESA. refs
(AIAA PAPER 92-3942) Copyright

A high enthalpy shock tunnel in Goettingen which is currently being established for operation in the hypervelocity flow regime is described. To date the facility operating conditions produce specific stagnation enthalpies of about 20 in taylored shock tube which correspond to equivalent flight velocities of 6.3 km/s. At the stagnation point of a blunt body under the obtained flow conditions the equilibrium degree of dissociation of nitrogen is about 0.3. O.G.

A92-56847*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
LABORATORY SIMULATION OF AEROTHERMODYNAMIC PHENOMENA - A REVIEW
CHUL PARK (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 27 p. refs
(AIAA PAPER 92-4025) Copyright

The issues of laboratory simulation of aerothermodynamic phenomena are discussed. The paper first enumerates the seven aerothermodynamic phenomena that affect the performance of high speed aerospace vehicles but are presently beyond our ability to predict accurately, and defines the types of experiments that need to be made to understand and quantify the phenomena. The facilities suited for these experiments are identified. The causes of uncertainty and difficulty in the experiments are cited. The procedures for calibrating the facilities for these purposes are proposed, and the research and development needed for successful laboratory simulation of aerothermodynamic phenomena are identified. Author

A92-57102
COMBINED EXO/ENDOATMOSPHERIC TRANSPORT ALTERNATIVES
CHARLES A. LINDLEY and JAY PENN (Aerospace Corp., El Segundo, CA) IAF, International Astronautical Congress, 43rd, Washington, Aug. 28-Sept. 5, 1992. 18 p. refs
(IAF PAPER 92-0663) Copyright

An approach based on the use of an exo-atmospheric rocket-propelled vehicle as a commercial hypersonic transport is proposed as an alternative to a conventional cruise vehicle. A case is examined involving rocket boost to a somewhat higher speed, followed by unpowered flight through space, reentry, and a kinetic energy glide in the atmosphere. Fanjets are incorporated to handle takeoff, landing wave-offs, ferrying, and abort-mode propulsion. It is noted that the technologies necessary for utilizing this alternative flight path are aimed at the mission of delivering reusable boosters to LEO. Turning applicable parts of this technology to the easier task of hypersonic transport may provide shorter flight times with larger payloads and lower stressed components. O.G.

A92-57254
OPTIMIZATION OF TWO STAGE REUSABLE SPACE TRANSPORTATION SYSTEMS WITH ROCKET AND AIRBREATHING PROPULSION CONCEPTS
M. HILLESHEIMER, U. M. SCHOETTLE, and E. MESSERSCHMID (Stuttgart, Universitaet, Germany) IAF, International Astronautical Congress, 43rd, Washington, Aug. 28-Sept. 5, 1992. 10 p. refs
(Contract DFG-SFB-259)
(IAF PAPER 92-0863) Copyright

The application and the results of a knowledge-based

semiautomated multistep system optimization technique recently developed to support trade-off studies of future space transportation systems are discussed. The technique is applied to two different launch vehicle concepts: a two-stage rocket launcher designed for vertical take-off and horizontal landing, and a two-stage transportation system with airbreathing engines in the booster stage designed for horizontal take-off and landing. A considerable increase of 28.6 percent is obtained as compared to the previous suboptimum vehicle design. The results indicate that the algorithm is capable of providing solutions to a wide range of flight and system optimization problems. P.D.

A92-57258
THE GERMAN HYPERSONICS TECHNOLOGY PROGRAMME - STATUS REPORT 1992
HERIBERT KUCZERA and HELMUTH HAUCK (Deutsche Aerospace AG, Munich, Germany) IAF, International Astronautical Congress, 43rd, Washington, Aug. 28-Sept. 5, 1992. 13 p. Research supported by BMFT. refs
(IAF PAPER 92-0867) Copyright

A review is presented of the current Phase I of the German Hypersonics Technology Programme that continues until the end of 1992. Attention is given to the overall hypersonics technology program, the status of the Saenger reference concept, alternatives for a flight test vehicle, and the status of technological activities in the area of airbreathing propulsion. Consideration is given to aerothermodynamics and propulsion integration, materials and structures, and general program aspects. R.E.P.

A92-57259* National Aeronautics and Space Administration, Washington, DC.
TECHNOLOGIES FOR THE NATIONAL AERO-SPACE PLANE
VINCENT L. RAUSCH and CHARLES E. K. MORRIS, JR. (NASA, Washington) IAF, International Astronautical Congress, 43rd, Washington, Aug. 28-Sept. 5, 1992. 14 p. refs
(IAF PAPER 92-0868) Copyright

Technologies for SSTO and hypersonic atmospheric cruise flight being developed in the context of the National Aero-Space Plane (NASP) program are discussed. Emphasis is given to research in aerothermodynamics, propulsion, fuel technology, structures and materials, vehicle management systems, and CVD and instrumentation tools. Brief attention is also given to the X-30 vehicle and to long-term applications of NASP technologies. C.D.

N92-33763# Mitsubishi Space Software Corp. (Japan).
ANALYSIS OF SPACECRAFT ENTRY INTO MARS ATMOSPHERE [KASEI TAIKI TOTSUNYUU KAISEKI]
KEN NAKAJIMA and KOUTAROU NAGANO *In* NASDA, Future Space Activities Workshop: Lunar Base Workshop 1991 23 p 17 Jul. 1991 In JAPANESE
Avail: CASI HC A03/MF A10

The effects on a spacecraft body while entering the Martian atmosphere and the resulting design constraints are analyzed. The analyses are conducted using the Viking entry phase restriction conditions and a Mars atmosphere model. Results from analysis conducted by the Program to Optimize Simulated Trajectories (POST) are described. Results obtained from the analysis are as follows: (1) flight times depend greatly on lift-to-drag ratio and less on ballistic coefficients; (2) terminal landing speeds depend greatly on ballistic coefficients and less on lift-to-drag ratios; (3) the dependence of the flight path angles on ballistic coefficients is slightly larger than their dependence on lift-to-drag ratios; (4) as the ballistic coefficients become smaller and the lift-to-drag ratios become larger, the deceleration at high altitude becomes larger; (5) small ballistic coefficients and low lift-to-drag ratios are required to meet the constraints of Mach number at parachute deployment and deployment altitude; and (6) heating rates at stagnation points are dependent on ballistic coefficients. It is presumed that the aerodynamic characteristics will be 0.2 for the lift-to-drag ratio and 75 kg/sq m for the ballistic coefficient for the case of a Mars landing using capsules similar to those used in the Viking program. Author (NASDA)

11

CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A92-53516
FABRICATION TEST AND EVALUATION OF GRAPHITE/PMR-15 POLYIMIDE FOR HOPE PRIMARY STRUCTURE
HIROBUMI TAMURA, HIDEHIKO MITSUMA, TOMOYUKI KOBAYASHI, and MOTOHIRO ATSUMI (NASDA, Tsukuba, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, AGNE Publishing, Inc., 1990, p. 483-488. refs
Copyright

This paper reports the current status of research and development of graphite/polyimide composite for the primary structure of the H-II Orbiting Plane (HOPE). The HOPE structure with graphite/polyimide will be required to employ the Thermal Protection System (TPS) on its outer surface and a thermal blanket on the inner surface which shields onboard equipment from heat soak. HOPE will be launched by the H-II rocket. After operation on orbit, HOPE will reenter the earth's atmosphere, maneuver, and land horizontally; the HOPE structure should endure this mission environment. Mechanical properties of graphite/polyimide under the expected flight environment of HOPE and the results of fabrication tests are described. Author

A92-53875
VISCOSITY CHARACTERISTICS OF SYNTHETIC AVIATION OILS AT LOW TEMPERATURES [VIAZKOSTNYE KHARAKTERISTIKI SINTETICHESKIKH AVIATSIONNYKH MASEL PRI NIZKIKH TEMPERATURAKH]
A. I. ECHIN, V. N. BAKUNIN, and T. N. TARANNIKOVA (Gosudarstvennyi NII Khimicheskoi Promyshlennosti, Russia) Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 6, 1992, p. 23-25. In Russian. refs
Copyright

The viscosity characteristics of synthetic aviation motor oils are examined in relation to their cold start and high-temperature operation performance. An exponential relationship is established between the kinematic and dynamic viscosities of low-viscosity synthetic oils, and conversion coefficients are determined. Under operation near the limiting state, oxidized low-viscosity synthetic oils retain the properties of Newtonian fluids. V.L.

A92-53878
HIGH-TEMPERATURE METAL MATRIX COMPOSITE [VYSOKOTEMPERATURNYI KOMPOZITSIONNYI MATERIAL S METALLICHESKOI MATRITSEI]
O. A. BANNYKH, K. B. POVAROVA, V. A. KUT'ENKOV, A. G. FRIDMAN, T. E. GOLOVKINA, and E. K. ZAVARZINA Metally (ISSN 0568-5303), no. 3, May-June 1992, p. 145-149. In Russian. refs
Copyright

A high-strength composite based on the thermally stable Cr-W system has been developed which can be used at temperatures up to 1600-1900 K in oxidizing media. The compositions of the composite components, a chromium alloy, VKh2U, and a tungsten alloy, VMRK, are discussed, as are processes for fabricating various types of products from the Cr-W composite. The material has a high strength at 1473-1773 K and has been successfully tested at 1900 K, which exceeds the melting temperature of current high-temperature nickel alloys. V.L.

A92-55134* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NEW MATERIALS DRIVE HIGH-PERFORMANCE AIRCRAFT
DOUGLAS C. RUHMANN (McDonnell Douglas Missile Systems

Co., Saint Louis, MO), WILLIAM F. BATES, JR. (Lockheed Aeronautical Systems Co., Burbank, CA), H. B. DEXTER (NASA, Langley Research Center, Hampton, VA), and REID B. JUNE (Boeing Advanced Systems, Seattle, WA) Aerospace America (ISSN 0740-722X), vol. 30, no. 9, Sept. 1992, p. 46-49.
Copyright

This report shows how advanced composite materials and new processing methods are enabling lighter, lower cost aircraft structures. High-temperature polymers research will focus on systems capable of 50,000 to 100,000 hours of operation in the 212-400 F temperature range. Prospective materials being evaluated include high-temperature epoxies, toughened bismaleimides, cyanates, thermoplastics, polyimides and other polymers. R.E.P.

A92-56002
CURRENT STATUS OF R&D ON MATERIALS FOR SUPER/HYPERSONIC TRANSPORTS
MEGUMI SUNAKAWA (Yokohama National University, Japan) and AKIRA SAKAMOTO (R&D Institute of Metals and Composites for Future Industries, Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 2-11. In Japanese. refs

The current status of R&D on materials for super/hypersonic transports and space planes is outlined. The state of the art in materials, materials characteristics, and materials techniques are addressed and advances that need to be made are considered. Emphasis is given to the availability of lightweight and heat-resistant materials such as high-temperature polymer matrix composites, metal matrix composites, intermetallic compounds, ceramic matrix composites, and carbon-carbon composites. C.D.

A92-56102
MECHANICAL PROPERTIES OF LAMINATE ALUMINUM MATRIX COMPOSITES
HIROSHI NAKATANI, TOSHIYUKI AOKI, MAMORU IMUTA, and HIROTOSHI NAKAYAMA (Kawasaki Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 462-465. In Japanese.

To use metal matrix composites (MMCs) in aircraft structures, design techniques and low cost fabrication processes of laminate MMCs must be developed. Here, the mechanical properties and the low-pressure process of laminate aluminum matrix composite production are described. C.D.

A92-56103
TITANIUM ALLOY CASTING FOR AEROSPACE
SHOHEI HAMAI (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 466-469. In Japanese. refs

Recent advances in foundary technology have enabled titanium/graphite and investment castings to be applied to large, more complex and critical application, these technologies include large part size capability, HIP, preformed core, alternate alloys, and heat treatments, and rigorous quality and process controls. The mechanical properties, characteristics, and applications of titanium alloy castings are reported. Author

A92-56105
PRESENT STATUS OF AL-LI ALLOYS
TOSIO SAKAKIBARA, EIJI TANIKAWA, and OSAMU MISHIWAKI (Fuji Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 474-477. In Japanese.

Al-Li alloys have low density and high modulus, which makes them attractive for advanced airframe structure. Formerly, the alloy 2020 was developed and used. However, application of the alloy was limited to only RA-5C due to low ductility and low fracture toughness of the alloy. The work began in the 1970s, when aluminum producers accelerated the development of Al-Li alloys as replacements for conventional airframe alloys. The mechanical properties of Al-Li alloys such as 2090, 2091, 8090, are described in this paper. Author

A92-56326
ALUMINIUM-LITHIUM ALLOYS - APPLICATION ON HELICOPTERS
G. DONZELLI, G. CRESPI, C. ZANOTTI (Agusta S.p.A., Cascina Costa di Samarate, Italy), and A. F. SMITH (Westland Helicopters, Ltd., Yeovil, United Kingdom) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 15 p.

The work performed on investigating the feasibility of applying low-density Al-Li alloys to EH101 helicopter structures is described together with the results on the property characterization of 8090 and Al-905XL Al-Li alloys. Statistically derived design allowables were generated for these alloys and compared to engineering properties of commonly used alloys, showing that the properties of 8090 and Al-905XL match those of the 2024-T3 and 2014-T6 alloys. The 8090 alloy has the added advantage in that the formability in the T3 temper is superior to that of 2024-T3 and 2024-W. I.S.

A92-57100* National Aeronautics and Space Administration, Washington, DC.
FREE-RADICALS AIDED COMBUSTION WITH SCRAMJET APPLICATIONS
YONGSHENG YANG and RAMOHALLI KUMAR (Arizona, University, Tucson) IAF, International Astronautical Congress, 43rd, Washington, Aug. 28-Sept. 5, 1992. 11 p. Research supported by NASA and Universities Space Research Association. refs
(IAF PAPER 92-0659) Copyright

Theoretical and experimental investigations aimed at altering 'nature-prescribed' combustion rates in hydrogen/hydrocarbon reactions with (enriched) air are presented. The intent is to anchor flame zones in supersonic streams, and to ensure proper and controllable complete combustion in scramjets. The diagnostics are nonintrusive through IR thermograms and acoustic emissions in the control and free-radicals altered flame zones. R.E.P.

A92-57101
STUDY ON SUPERSONIC COMBUSTION IN A HYPERSONIC FLIGHT
J. M. CHAR (Chinese Air Force Academy, Gunshan, Taiwan), J. S. MU, and J. H. YEH (National Cheng Kung University, Tainan, Taiwan) IAF, International Astronautical Congress, 43rd, Washington, Aug. 28-Sept. 5, 1992. 10 p. Research supported by Chung Shan Institute of Science and Technology. refs
(Contract NSCRC-80-0210-D006-04)
(IAF PAPER 92-0661) Copyright

Droplets ignition and combustion in the supersonic environment is performed using a shock tube. In the test section, there exist three highly dynamic pressure transducers, one photo detector, two quartz windows, and a droplet generator. A high-speed movie camera is also used to observe the deformation, shattering, and ignition process of fuel droplets in the supersonic flow field. Based on the recorded data and observation, droplets ignition behavior can be affected by several parameters. Using regression analysis, an empirical correlation for ignition delay time is obtained. Author

N92-32513*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EIGHTH DOD/NASA/FAA CONFERENCE ON FIBROUS COMPOSITES IN STRUCTURAL DESIGN, PART 1
JAMES H. STARNES, JR., comp., HERMAN L. BOHON, comp. (Lockheed Engineering and Sciences Co., Hampton, VA.), and SHERRY B. GARZON, comp. Sep. 1990 383 p Conference held in Norfolk, VA, 28-30 Nov. 1989
(Contract RTOP 505-63-01-09)
(NASA-CP-3087-PT-1; L-16832-PT-1; NAS 1.55:3087-PT-1)
Avail: CASI HC A17/MF A03

The status, problems, and requirements in the technical

disciplines related to the design of composite structures are discussed. Papers are presented in the areas of applications in design; concepts in design; and methodology in design.

N92-32514*# Grumman Aerospace Corp., Bethpage, NY.
DESIGN, EVALUATION AND EXPERIMENTAL EFFORT TOWARD DEVELOPMENT OF A HIGH STRAIN COMPOSITE WING FOR NAVY AIRCRAFT
JOSEPH BRUNO and MARK LIBESKIND (Naval Air Development Center, Warminster, PA.) *In* NASA. Langley Research Center, Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, Part 1 p 3-27 Sep. 1990
Avail: CASI HC A03/MF A03

This design development effort addressed significant technical issues concerning the use and benefits of high strain composite wing structures (Epsilon(sub ult) = 6000 micro-in/in) for future Navy aircraft. These issues were concerned primarily with the structural integrity and durability of the innovative design concepts and manufacturing techniques which permitted a 50 percent increase in design ultimate strain level (while maintaining the same fiber/resin system) as well as damage tolerance and survivability requirements. An extensive test effort consisting of a progressive series of coupon and major element tests was an integral part of this development effort, and culminated in the design, fabrication and test of a major full-scale wing box component. The successful completion of the tests demonstrated the structural integrity, durability and benefits of the design. Low energy impact testing followed by fatigue cycling verified the damage tolerance concepts incorporated within the structure. Finally, live fire ballistic testing confirmed the survivability of the design. The potential benefits of combining newer/emerging composite materials and new or previously developed high strain wing design to maximize structural efficiency and reduce fabrication costs was the subject of subsequent preliminary design and experimental evaluation effort. Author

N92-32522*# Boeing Military Airplane Development, Wichita, KS.
DEVELOPMENT OF THERMOPLASTIC COMPONENTS FOR STRUCTURAL VALIDATION
JOHN G. AVERY and GARY G. CASSATT *In* NASA. Langley Research Center, Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, Part 1 p 179-198 Sep. 1990
Avail: CASI HC A03/MF A03

Recent activity directed toward advancing the development and validation of graphite reinforced thermoplastic primary and secondary structures is described. The efforts discussed include the design, manufacture and test of a highly-loaded multi-spar wing-box component, and the development of a flight-worthy article that is form, fit and functionally replaceable with the nose landing gear door of the V-22 Osprey. Author

N92-32523*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A PROTECTION AND DETECTION SURFACE (PADS) FOR DAMAGE TOLERANCE
M. J. SHUART, C. B. PRASAD (Analytical Services and Materials, Inc., Hampton, VA.), and S. B. BIGGERS (Lockheed Aeronautical Systems Co., Burbank, CA.) *In its* Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, Part 1 p 199-219 Sep. 1990
Avail: CASI HC A03/MF A03

A protection and detection surface (PADS) concept was studied for application to composite primary aircraft structures. A Kevlar-epoxy woven face sheet with a Rohacell foam core was found to be the most effective PADS configuration among the configurations evaluated. The weight of the PADS configuration was estimated to be approximately 17 percent of the structural weight. The PADS configuration was bonded to graphite-epoxy base laminates, and up to a 70 percent improvement in compression-after-impact failure strains was observed. Author

N92-32525*# Northrop Corp., Hawthorne, CA.
STRUCTURAL ASSESSMENT OF ULTRALIGHTWEIGHT COMPOSITES
DAVID M. KANE, M. A. JANKOWSKI, and ROBIN S. WHITEHEAD *In* NASA. Langley Research Center, Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, Part 1 p 227-243 Sep. 1990
(Contract F33615-88-C-5447)
Avail: CASI HC A03/MF A03

The potential weight savings of advanced ultralightweight (ULW) materials were investigated using the F/A-18 and 747 as baseline aircraft. Weight savings were calculated using a weight ratio methodology. Material properties used in the analysis were those projected for 1993 ULW production materials. The study results indicated that these ULW materials could save 30 percent airframe weight for both baseline aircraft studied. Author

N92-32527*# McDonnell Aircraft Co., Saint Louis, MO.
OUT OF PLANE ANALYSIS FOR COMPOSITE STRUCTURES
P. C. PAUL, C. R. SAFF, KENNETH B. SANGER, M. A. MAHLER (Northrop Corp., Hawthorne, CA.), HAN PIN KAN (Northrop Corp., Hawthorne, CA.), and EDWARD F. KAUTZ (Naval Air Development Center, Warminster, PA.) *In* NASA. Langley Research Center, Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, Part 1 p 263-279 Sep. 1990
(Contract N62269-87-C-0226)
Avail: CASI HC A03/MF A03

Simple two dimensional analysis techniques were developed to aid in the design of strong joints for integrally stiffened/bonded composite structures subjected to out of plane loads. It was found that most out of plane failures were due to induced stresses arising from rapid changes in load path direction or geometry, induced stresses due to changes in geometry caused by buckling, or direct stresses produced by fuel pressure or bearing loads. While the analysis techniques were developed to address a great variety of out of plane loading conditions, they were primarily derived to address the conditions described above. The methods were developed and verified using existing element test data. The methods were demonstrated using the data from a test failure of a high strain wingbox that was designed, built, and tested under a previous program. Subsequently, a set of design guidelines were assembled to assist in the design of safe, strong integral composite structures using the analysis techniques developed. Author

N92-32528*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
GLOBAL/LOCAL METHODS RESEARCH USING THE CSM TESTBED
NORMAN F. KNIGHT, JR., JONATHAN B. RANSOM, O. HAYDEN GRIFFIN, JR. (Virginia Polytechnic Inst. and State Univ., Blacksburg.), and DANNIELLA M. THOMPSON (Virginia Polytechnic Inst. and State Univ., Blacksburg.) *In its* Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, Part 1 p 281-309 Sep. 1990
Avail: CASI HC A03/MF A03

Research activities in global/local stress analysis are described including both two- and three-dimensional analysis methods. These methods are being developed within a common structural analysis framework. Representative structural analysis problems are presented to demonstrate the global/local methodologies being developed. Author

N92-32575*# Army Aviation Systems Command, Hampton, VA. Aerostructures Directorate.
EVALUATION OF COMPOSITE COMPONENTS ON THE BELL 206L AND SIKORSKY S-76 HELICOPTERS
DONALD J. BAKER *In* NASA. Langley Research Center, Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, Part 2 p 393-428 Sep. 1990
Avail: CASI HC A03/MF A03

Progress on two programs to evaluate structural composite components in flight service on Bell 206L and Sikorsky S-76 commercial helicopters is described. Forty ship sets of composite

components that include the litter door, baggage door, forward fairing, and vertical fin have been installed on Bell Model 206L helicopters that are operating in widely different climates. Component installation started in 1981 and selected components were removed and tested at prescribed intervals over a ten year evaluation. Four horizontal stabilizers and eleven tail rotor spars that are production components on the S-76 helicopter were tested after prescribed periods of service to determine the effects of the operating environment on their performance. Concurrent with the flight evaluation, materials used to fabricate the components were exposed in ground racks and tested at specified intervals to determine the effects of outdoor environments. Results achieved from 123,000 hours of accumulated service on the Bell 206L components and 53,000 hours on the Sikorsky S-76 components are reported. Seventy-eight Bell 206L components were removed and tested statically. Results of seven years of ground exposure of materials used to fabricate the Bell 206L components are presented. Results of tests on four Sikorsky S-76 horizontal stabilizers and eleven tail rotor spars are also presented. Panels of material used to fabricate the Sikorsky S-76 components that were exposed for six years were tested and results are presented. Author

N92-32576*# Northrop Corp., Hawthorne, CA. Aircraft Div.
SUPPORTABILITY EVALUATION OF THERMOPLASTIC AND THERMOSET COMPOSITES
G. R. CHANANI, D. BOLDI, S. G. CRAMER, and M. W. HEIMERDINGER *In* NASA. Langley Research Center, Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, Part 2 p 429-437 Sep. 1990
Avail: CASI HC A02/MF A03

Nearly 300 advanced composite components manufactured by Northrop Corporation are flying on U.S. Air Force and U.S. Navy supersonic aircraft as part of a three-year Air Force/Navy/Northrop supportability evaluation. Both thermoplastic and high-temperature thermoset composites were evaluated for their in-service performance on 48 USAF and Navy F-5E fighter and USAFT-38 trainer aircraft in the first large-scale, long-term maintenance evaluation of these advanced materials. Northrop manufactured four types of doors for the project-avionics bay access, oil fill, inlet duct inspection, and a main landing gear door. The doors are made of PEEK (polyetheretherketone) thermoplastic, which is tougher and potentially less expensive to manufacture than conventional composites; and 5250-3 BMI (bismaleimide) thermoset, which is manufactured like a conventional epoxy composite but can withstand higher service temperatures. Results obtained so far indicate that both the BMI and PEEK are durable with PEEK being somewhat better than BMI. Author

N92-32577*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESIDUAL STRENGTH OF REPAIRED GRAPHITE/EPOXY LAMINATES AFTER 5 YEARS OF OUTDOOR EXPOSURE
JERRY W. DEATON *In its* Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, Part 2 p 439-454 Sep. 1990
Avail: CASI HC A03/MF A03

The NASA Langley Research Center has sponsored research to develop generic repair techniques and processes for advanced graphite/epoxy (Gr/Ep) composites applicable to secondary structures for commercial transport aircraft. The long-term durability of such repairs is being addressed in a 10-year outdoor exposure program at the Langley Research Center. Details of the program and results of residual strength tests after 5 years of outdoor exposure are presented. Four repair methods are being evaluated. These include: (1) externally bolted aluminum-plus adhesive; (2) precured, bonded external Gr/Ep; (3) cure-in-place external Gr/Ep; and (4) cure-in-place flush Gr/Ep. Repaired specimens as well as undamaged and damaged unrepaired controls are being exposed outdoors for 1, 3, 5, 7, and 10 years. The residual tensile strength of stressed, unstressed, and fatigue specimens from each group is reported and compared with the tensile strength of baseline specimens which received no outdoor exposure. Identification of the commercial products and companies is used to describe adequately the test materials. The identification of these commercial products does not constitute endorsement, expressed or implied, of such products by the National Aeronautics and Space Administration. Author

N92-32579*# Northrop Corp., Hawthorne, CA.
DAMAGE TOLERANCE CERTIFICATION METHODOLOGY FOR COMPOSITE STRUCTURES
HAN PIN KAN, ROBIN S. WHITEHEAD, and EDWARD F. KAUTZ (Naval Air Development Center, Warminster, PA.) *In* NASA. Langley Research Center, Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, Part 2 p 479-498 Sep. 1990
(Contract N62269-87-C-0259)
Avail: CASI HC A03/MF A03

An advanced certification methodology was developed for composite structures to include the effects of impact damage. The methodology has the capability to determine the reliability of impact damaged structure at any prescribed load level and impact threat, which may be specified in terms of impact energy or C-scan damage area. In addition, the methodology can also calculate the allowable impact threat level at a given applied load and specified reliability. The developed damage tolerance certification methodology was demonstrated on the F/A-18 inner wing. The results of the methodology demonstration showed that the F/A-18 inner wing has excellent damage tolerance capability. Author

N92-32586*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
INITIAL POSTBUCKLING RESPONSE OF AN UNSYMMETRICALLY LAMINATED RECTANGULAR PLATE
RAPHAEL T. HAFTKA and ERIC R. JOHNSON *In* NASA. Langley Research Center, Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, Part 2 p 609-623 Sep. 1990
(Contract NAG1-168; NAG1-537)
Avail: CASI HC A03/MF A03

It was shown that anisotropic plates can have unstable postbuckling behavior resulting in potential imperfection sensitivity. The degree of instability for rectangular, simply-supported, cross-ply laminated plates is quantified. The analysis is based on asymptotic Koiter-type expansion of postbuckling response. The degree of postbuckling instability is quantified in terms of the reduction in load carrying capacity in the immediate postbuckling range. For graphite-epoxy plates it is found that this measure of instability is very small. Only a low aspect ratio plate with a high degree of anisotropy can have any significant reduction in its buckling load. Author

N92-32629# South Carolina Research Authority. Charleston.
PDES APPLICATION PROTOCOL SUITE FOR COMPOSITES (PAS-C). FUNCTIONAL NEEDS REPORT FOR THE PAS-C PROGRAM Final Report, Jul. - Aug. 1991
MIKE STOWE, RAY GRELLA, JON JUDD, KEITH HUNTEN, and GREG PAUL Sep. 1991 123 p
(Contract F33615-91-C-5713)
(AD-A247886; PASC002-01-00; WL-TR-92-8017) Avail: CASI HC A06/MF A02

This document addresses the first portion of an informational needs analysis for composites parts. A sample part set of Aircraft Composite Structural Components is described with the supporting life-cycle functional activities node trees. An attempt was made to standardize a set of terminology and informational constructs so that a Framework/Building-Block (FW/BB) approach could be established which would organize and capture the information into a usable/reusable structure. The sample part set was then mapped to the FW/BB structure identifying what was in and out of scope for the PDES Application Protocol Suite for Composites (PAS-C) Project. There have been many attempts to analyze the needs of composites parts, in particular, the informational needs that support data exchange of composite data between life-cycle applications. The challenge has been to scope the needs gathering process into a structured, achievable task that provides usable/reusable

knowledge. Most previous composite needs analyses have been focused on a narrow application view or particular part type which has limited the reusability of the information. What has been lacking is a methodology that allows for the informational needs of all aspects of composite parts to be captured. This methodology requires an approach that manages and utilizes existing needs-gathering methods to capture existing composite needs-analysis work. GRA

N92-32791# Institute for Aerospace Research, Ottawa (Ontario). Structures and Materials Lab.
PROCESSING AND ENVIRONMENTAL EFFECTS ON MECHANICAL PROPERTIES OF COMPOSITE REPAIRS
F. ELALDI (Middle East Technical Univ., Ankara, Turkey), S. LEE, and R. F. SCOTT 22 May 1991 28 p Sponsored by National Research Council of Canada
(NRC-LTR-ST-1826; CTN-92-60370) Avail: CASI HC A03/MF A01

The scarf joint technique is one of the latest techniques used for repairing composite aircraft structures. This paper describes scarf joints comprised of vacuum and autoclave precured and co-cured fiber glass epoxy patches bonded to autoclave and vacuum precured parent fiber glass epoxy laminates. Autoclave and vacuum cured parent laminates and the scarf joints were prepared and exposed to the same temperature and moisture environment for comparison. All specimens were loaded in tension at three temperatures. Interlaminar shear strength (ILSS) tests were also carried out for the parent materials. As expected, the tensile strength and ILSS decrease when the material has been exposed to moisture and tested at elevated temperature. No significant difference was reported for either tensile strength or ILSS between autoclave and vacuum cured materials. The room temperature repair efficiencies are reported for single scarf repairs comprised of vacuum co-cured and precured patches. These repair efficiencies were found to be similar to the efficiency of the autoclave precured patch repair. This result supports the feasibility of scarf joint repairs in base level facilities. Author (CISTI)

N92-32846# Defence Research Establishment Pacific, Victoria (British Columbia). Research and Development Branch.
DETECTION OF HONEYCOMB DAMAGE USING HEXAGONAL GRID DISCONTINUITIES
J. E. BOYD May 1989 37 p
(DREP-89-9; CTN-92-60350) Avail: CASI HC A03/MF A01

Inspection of an aircraft structure with film radiography can be time consuming and wasteful of human resources. Filmless real-time radiography provides one method of streamlining the inspection process. It also permits implementation of automated inspection systems. The report presents a method for automatically inspecting honeycomb sandwich panels for certain types of damage. The hexagonal grid discontinuity (HGD) inspection exploits the regularity of the grid of a honeycomb in order to locate irregularities and possible damage. Teflon inserts, which simulate disbonds, and entrapped water were successfully detected by the HGD method. Undamaged honeycomb did not produce false alarms in the detection system. The method is suitable for use with a real-time video x-ray inspection system. Author (CISTI)

N92-32863*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LIQUID LUBRICANTS FOR ADVANCED AIRCRAFT ENGINES
WILLIAM R. LOOMIS and ROBERT L. FUSARO Aug. 1992 28 p
(Contract RTOP 505-63-5A)
(NASA-TM-104531; E-6407; NAS 1.15:104531) Avail: CASI HC A03/MF A01

An overview of liquid lubricants for use in current and projected high performance turbojet engines is discussed. Chemical and physical properties are reviewed with special emphasis placed on the oxidation and thermal stability requirements imposed upon the lubrication system. A brief history is given of the development of turbine engine lubricants which led to the present day synthetic oils with their inherent modification advantages. The status and state of development of some eleven candidate classes of fluids for use in advanced turbine engines are discussed. Published examples of fundamental studies to obtain a better understanding of the chemistry involved in fluid degradation are reviewed. Alternatives to high temperature fluid development are described. The importance of continuing work on improving current high temperature lubricant candidates and encouraging development of new and improved fluid base stocks are discussed. Author

N92-33033# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
THE UTILIZATION OF ADVANCED COMPOSITES IN MILITARY AIRCRAFT [L'EMPLOI DES MATERIAUX COMPOSITES DE POINTE POUR LES AVIONS MILITAIRES]
Apr. 1992 194 p In ENGLISH and FRENCH The 73rd meeting was held in San Diego, CA, 7-11 Oct. 1991
(AGARD-R-785; ISBN-92-835-0666-9; AD-A253004) Copyright Avail: CASI HC A09/MF A03

The purpose of this workshop was to identify the current state of the art in key issues related to compression loading and fluid effects in composite materials. In the area of compression loading, there was considerable concern over the different results obtained from various test methods. It was agreed that failure modes produced by the various test methods along with a better fundamental understanding of compression failure were key issues in the development of compression test methods. In the area of fluid effects, a lack of a comprehensive data base hampers identification of key mechanisms leading to fluid degradation. This is further complicated by the fact that interactions depend on the fluid and composite under consideration.

N92-33036# British Aerospace Aircraft Group, Warton (England). Materials and Development Dept.
ASPECTS OF COMPRESSION IN AEROSPACE COMPOSITES: FUTURE REQUIREMENTS
STUART GREEN *In* AGARD, The Utilization of Advanced Composites in Military Aircraft 13 p Apr. 1992
Copyright Avail: CASI HC A03/MF A03

To keep the overall mass of combat aircraft to a minimum level, and to optimize performance, designers have exploited the benefits offered by advanced polymer composite materials. The ability to resist load in compression is, however, particularly important in some aircraft structures such as wings. Advantages in terms of reduced mass and increased performance to be gained with composite materials is highlighted in this paper. A general overview is given of the materials science aspects of compression and compression after impact. Recent developments aimed at improving the reliability of compression test data is reviewed. Author

N92-33044# Alenia, Foggia (Italy). Engineering Dept. for Advanced Composite Structures.
CFRP STIFFENED PANELS UNDER COMPRESSION
A. BUCCI and U. MERCURIO *In* AGARD, The Utilization of Advanced Composites in Military Aircraft 14 p Apr. 1992
Copyright Avail: CASI HC A03/MF A03

The purpose was to experimentally demonstrate the validity of the conceptual carbon fiber reinforced plastics (CFRP) stiffened panel suitable for application in the unpressurized aft fuselage of a middle size aircraft. Both theoretical and experimental behavior have been analyzed taking into account the effects of different materials, curvature, impact damage, and static and fatigue loads. Composite materials with stiff fibers of the last generation coupled with toughened thermosetting resin systems were used. Author

N92-33048# Centre d'Essais Aeronautique Toulouse (France).
EVALUATION OF THE EFFECTS OF THE ENVIRONMENT ON THE BEHAVIOR OF THE PRIMARY STRUCTURES OF COMPOSITE MATERIAL AIRCRAFT IN SERVICE: HISTORIC AND CURRENT SITUATION [PRISE EN COMPTE DES EFFETS DE L'ENVIRONNEMENT SUR LE COMPORTEMENT EN SERVICE DES STRUCTURES PRIMAIRES D'AVIONS EN MATERIAU COMPOSITE: HISTORIQUE ET SITUATION ACTUELLE]
JEAN ROUCHON *In* AGARD, The Utilization of Advanced Composites in Military Aircraft 7 p Apr. 1992 In FRENCH
Copyright Avail: CASI HC A02/MF A03

When the first application of composite materials with an organic base in the working structures of aircraft were envisaged, the greatest preoccupation of the designers and service officials was their behavior while aging. Some fifteen years later, the experience acquired in service associated with the numerous results obtained from the laboratory has greatly dissipated those fears, at least for structures not calling for extensive usage of composite technology. This does not mean that the aging of composites does not occur, but rather that the consequences are now considered to have limited and predictable impact. In other words, they are susceptible to being accounted for at the level of conception, certification, and thereafter in use in the structures. The principal steps leading to the current situation are retraced, and then analyzed to account for the phenomena of aging, in particular the determination of the concentration of water absorbed by the composite during use.
Transl.

N92-33049# Wright Lab., Wright-Patterson AFB, OH.
FLUID EFFECTS: THERMOSET AND THERMOPLASTIC MATRIX COMPOSITES
D. B. CURLISS *In* AGARD, The Utilization of Advanced Composites in Military Aircraft 8 p Apr. 1992
Copyright Avail: CASI HC A02/MF A03

The sensitivity of several advanced composites to military jet fuel, JP-4, was investigated. The materials were processed into laminates using the manufacturer's recommended process. The test specimens were immersed in JP-4 in a sealed pressure vessel at 180 F. After 1680 hours of exposure, the mechanical properties of the composites along with any weight gain were examined. Material property degradation and other physical effects from exposure to jet fuel are presented in this study. Author

N92-33050# Patras Univ. (Greece). Dept. of Mechanical Engineering.
JET FUEL ABSORPTION AND DYNAMIC MECHANICAL ANALYSIS OF CARBON FIBRE COMPOSITES
S. A. PAIPETIS and V. KOSTOPOULOS *In* AGARD, The Utilization of Advanced Composites in Military Aircraft 6 p Apr. 1992
Copyright Avail: CASI HC A02/MF A03

Fluid absorption of carbon fiber composites, both thermosetting and thermoplastic, immersed in jet fuel under controlled conditions of time and temperature, was determined and, in the sequence, DMA studies were performed. Storage modulus, loss factor, and glass transition temperature were the parameters utilized for the evaluation of the dynamic behavior of these materials. Author

N92-33054*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLIGHT SERVICE ENVIRONMENTAL EFFECTS ON COMPOSITE MATERIALS AND STRUCTURES
H. BENSON DEXTER and DONALD J. BAKER (Army Aviation Research and Technology Activity, Hampton, VA.) *In* AGARD, The Utilization of Advanced Composites in Military Aircraft 13 p Apr. 1992
Copyright Avail: CASI HC A03/MF A03

NASA Langley and the U.S. Army have jointly sponsored programs to assess the effects of realistic flight environments and ground-based exposure on advanced composite materials and structures. Composite secondary structural components were initially installed on commercial transport aircraft in 1973; secondary and primary structural components were installed on commercial helicopters in 1979; and primary structural components were installed on commercial aircraft in the mid-to-late 1980's. Service performance, maintenance characteristics, and residual strength of numerous components are reported. In addition to data on flight components, 10 year ground exposure test results on material coupons are reported. Comparison between ground and flight environmental effects for several composite material systems are also presented. Test results indicate excellent in-service performance with the composite components during the 15 year period. Good correlation between ground-based material performance and operational structural performance has been achieved. Author

N92-33423*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ISOTHERMAL AGING OF IM7/8320 AND IM7/5260
RODERICK H. MARTIN (Analytical Services and Materials, Inc., Hampton, VA.), EMILIE J. SIOCHI (Lockheed Engineering and Sciences Co., Hampton, VA.), and THOMAS S. GATES Aug. 1992 34 p Proposed for presentation at the 7th Technical Conference on Composite Materials, University Park, PA, 13-15 Oct. 1992
(Contract RTOP 505-63-50-04)
(NASA-TM-107666; NAS 1.15:107666) Avail: CASI HC A03/MF A01

Isothermal aging was conducted on two composite systems being considered as possible candidates for the next generation supersonic transport. The composite systems were IM7/5260, a carbon/thermoset, and IM7/8320, a carbon/amorphous thermoplastic. The materials were isothermally aged for a total of 5000 hours at 125 C and 175 C. These temperatures are approximately equivalent to the upper skin temperatures of an aircraft flying at Mach 2.0 and Mach 2.4, respectively. The variations of the following properties were determined as a function of aging time: weight loss, moduli, glass transition temperature, microcracking, and modulus and strength of a +/- 45 laminate. The difficulties and accuracy of strain measurements are also discussed. Author

N92-33613*# Delaware Univ., Newark. Dept. of Mechanical Engineering.
CONTINUATION OF TAILORED COMPOSITE STRUCTURES OF ORDERED STAPLE THERMOPLASTIC MATERIAL Final Report
MICHAEL H. SANTARE and R. BYRON PIPES Sep. 1992 87 p
(Contract NAS1-18758; RTOP 510-02-12-01)
(NASA-CR-189671; NAS 1.26:189671) Avail: CASI HC A05/MF A01

The search for the cost effective composite structure has motivated the investigation of several approaches to develop composite structure from innovative material forms. Among the promising approaches is the conversion of a planar sheet to components of complex curvature through sheet forming or stretch forming. In both cases, the potential for material stretch in the fiber direction appears to offer a clear advantage in formability over continuous fiber systems. A framework was established which allows the simulation of the anisotropic mechanisms of deformation of long discontinuous fiber laminates wherein the matrix phase is a viscous fluid. Predictions for the effective viscosities of a hyper-anisotropic medium consisting of collimated, discontinuous fibers suspended in viscous matrix were extended to capture the characteristics of typical polymers including non-Newtonian behavior and temperature dependence. In addition, the influence of fiber misorientation was also modeled by compliance averaging to determine ensemble properties for a given orientation distribution. A design tool is presented for predicting the effect of material heterogeneity on the performance of curved composite beams such as those used in aircraft fuselage structures. Material heterogeneity can be induced during manufacturing processes such as sheet forming and stretch forming of thermoplastic composites. This heterogeneity can be introduced in the form of fiber realignment and spreading during the manufacturing process

causing radial and tangential gradients in material properties. Two analysis procedures are used to solve the beam problems. The first method uses separate two-dimensional elasticity solutions for the stresses in the flange and web sections of the beam. The separate solutions are coupled by requiring that forces and displacements match section boundaries. The second method uses an approximate Rayleigh-Ritz technique to find the solutions for more complex beams. Analyses are performed for curved beams of various cross-sections loaded in pure bending and with a uniform distributed load. Preliminary results show that the geometry of the beam dictates the effect of heterogeneity on performance. The role of heterogeneity is larger in beams with a small average radius-to-depth ration, R/t, where R is the average radius of the beam and t is the difference between the inside and outside radii. Results of the anlysis are in the form of stresses and displacements and are compared to both mechanics of materials and numerical solutions obtained using finite element analysis. Author

N92-33624# California Univ., San Diego, La Jolla.
THEORIES OF TURBULENT COMBUSTION IN HIGH SPEED FLOWS Final Report, Apr. 1989 - Apr. 1992
P. A. LIBBY and F. A. WILLIAMS 20 Apr. 1992 10 p
(Contract AF-AFOSR-0310-89)
(AD-A253032; AFOSR-92-0673TR) Avail: CASI HC A02/MF A01

Since the Damkohler and Reynolds numbers, over the range of conditions relevant to supersonic hydrogen-air combustion, were found to be consistent with the combustion occurring in the reaction-sheet regime, detailed numerical integrations were performed on the structures of counterflow hydrogen-air diffusion flames, for pressures from 0.5 to 10 atm and air temperatures from 300 - 1200 K, at a hydrogen temperature of 300 K. The results showed extinction to occur at high enough rates of strain in most cases, but no extinction for air temperatures above about 1000 K. Reduced chemical-kinetic mechanisms were developed for simplifying the computations. The computed extinction strain rates were found to be in excellent agreement with experiments. Compressibility effects were taken into account, and the results are being worked into methods for describing turbulent combustion in high-speed flows. GRA

N92-33994# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany).
STABILITY FAILURE OF SANDWICH STRUCTURES
G. DREHER (Eurocopter Hubschrauber G.m.b.H., Munich, Germany, F.R.) 1992 16 p Presented at the 2nd International Conference Construction, Gainesville, FL, 9-12 Mar. 1992
(MBB-UD-0613-92-PUB; ETN-92-92108) Avail: CASI HC A03/MF A01

Results of a theoretical and experimental study on different stability failure modes of plane sandwich structures subjected to compressive respectively flexural loading are presented. Depending on geometry and material properties of the structure different stability failure modes occur. In the theoretical studies several calculation methods capable of determining the critical linear buckling load are summarized and verified by FE (Finite Element) analysis. The experimental results are compared with the theoretical predictions (analytical methods and FE analysis). The comparison revealed a reasonably good correlation between theory and experiment. ESA

N92-34019# Rolls-Royce Ltd., Derby (England).
FATIGUE CRACK GROWTH OF SMALL CORNER DEFECTS FROM BLUNT NOTCHES IN AN AEROENGINE ALLOY
I. W. HUSSEY, J. BYRNE (Portsmouth Polytechnic, England), and W. LOCKE (Aerostructures Hamble, Portsmouth, England) 1 Dec. 1991 22 p
(PNR-90860; ETN-92-92181) Copyright Avail: CASI HC A03/MF A01

The study of the fatigue crack gorwth behavior of physically small cracks within notch elastic stress fields, previously applied to through cracks, is extended to corner cracks. The fatigue growth rate of small corner defects from the bore extremities of blunt keyhole notches (k(sub T) = 1.74 to 2.4) in CT specimens was studied for Waspaloy at room temperature. Variation in crack shape was determined by beach marking to establish an aspect ratio calibration with increasing crack length. Both surface and inferred bore results were compared with an approximate analysis, according to Chell, which determines the stress intensity factor for part-through cracks in regions of varying stress. The experimental results demonstrate that the theoretical predictions based on this analysis provide conservative estimates of the stress intensity factor on the absence of microstructural short crack effects and crack interactions. ESA

12

ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A92-53550
DETAILED NUMERICAL ANALYSIS OF STANDING OBLIQUE DETONATION
AKIKO MATSUO (Recruit Co., Ltd., Institute for Supercomputing Research, Tokyo, Japan) and TOSHI FUJIWARA (Nagoya University, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, AGNE Publishing, Inc., 1990, p. 735-740. refs
Copyright

In an attempt to understand the characteristics of supersonic combustion for the development of supersonic combustor ramjet engines, a detailed analysis is presented of the 3D standing oblique detonation (SOD) in a realistic oxyhydrogen mixture in front of a blunt obstacle. It is found that the SODs are decoupled for any incoming Mach number and that the diameter of the flying object is an important factor in establishing a perfectly coupled SOD. No large-amplitude periodic instability is found. C.D.

A92-53755
EXPERIMENTAL STUDY OF CONVECTION EFFECTS AROUND THE PHASE CHARGE INTERFACE
AKIRA IWASAKI (Electrotechnical Laboratory, Tsukuba, Japan), SHUNSUKE HOSOKAWA, MITSUMORI TANIMOTO, and ISAO KUDO IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 2. Tokyo, AGNE Publishing, Inc., 1990, p. 2153-2158. Research supported by Space Technology Research and Development Group of Japan. refs
Copyright

An experimental apparatus was developed for observation of the transport phenomena in liquid together with the interface phenomena during unidirectional solidification processes of transparent material. An incoherent moire interferometric technique, which eliminated wavefront deformation by the interference of two interferograms at different times, made it possible to visualize the temperature profile in liquid. A time-dependent temperature profile in liquid was taken, and the growth rate of the solid-liquid interface was measured. It was found that when supercooled liquid was solidified quickly, the temperature reversed layer appeared due to the released latent heat, which was conducted not only to the solid but also to the liquid. The effect of thermal convection in an unstable system was also observed. Author

A92-53758
FUNDAMENTAL STUDIES ON MARANGONI CONVECTION RELATED TO BRIDGMAN CRYSTAL GROWTH
KEIICHI KUWAHARA, SHINTARO ENYA, RYO AKIYOSHI, JUN-ICHI OCHIAI, and HIROYUKI UCHIDA (Ishikawajima-Harima

Heavy Industries Co., Ltd., Yokohama, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 2. Tokyo, AGNE Publishing, Inc., 1990, p. 2171-2178. Research supported by Science and Technology Agency of Japan. refs
Copyright

Transient flow in liquid column during Bridgman crystal growth was visualized in a simulation on aircraft in parabolic flight. The observed flow field revealed the free liquid surface to be subjected to strong Marangoni effect. The value obtained in the present experiment under low gravity on thermal Peclet number and on Marangoni number proved to agree quite well with the relation between these numbers determined from ground experiment and from approximate numerical solution. And the effect of Prandtl number on the flow field in the melting liquid under microgravity was investigated with visualization experiments and with numerical analysis. Application of these results to semiconductor melt suggested the possibility that the flow velocity exceeds the diffusion velocity. Author

A92-53786
EFFECT OF POROSITY IN TRANSPIRATION COOLING SYSTEM
SHIRO YAMAMOTO (Tokyo, University, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 2. Tokyo, AGNE Publishing, Inc., 1990, p. 2355-2360. refs
Copyright

Transpiration cooling is a candidate thermal protection system against aerodynamic heating. Porous matrices may have many characteristics which affect the efficiency of this system. In the present experiment, porosity effects were evaluated in a relatively low radiative heating environment. CO2 and helium were used as cooling gas. The evaluation was performed by measuring the surface and the inner temperature. In the range of porosity, flow rate and cooling gas type, in this experiment, the surface temperature is scarcely affected by porosity. This is temperature difference between fluid flow and no fluid flow casses. CO2 is more effective. The inner temperature, is affected by porosity, flow rate and cooling gas type. Author

A92-54029#
THE ENHANCEMENT OF THE MIXING AND COMBUSTION PROCESSES IN SUPERSONIC FLOW APPLIED TO SCRAMJET ENGINE
V. I. KOPCHENOV and K. E. LOMKOV (Tsentral'nyi NII Aviatsionnogo Motorostroeniia, Moscow, Russia) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 9 p. refs
(AIAA PAPER 92-3428) Copyright

The Reynolds averaged parabolized Navier-Stokes equations are employed for the numerical study of turbulent mixing and combustion of a supersonic hydrogen jet in a supersonic airflow. A one-equation differential turbulence model is utilized. The simplified flame sheet model is employed for the numerical simulation of the supersonic combustion. R.E.P.

A92-54036*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MODAL SIMULATION OF GEARBOX VIBRATION WITH EXPERIMENTAL CORRELATION
FRED K. CHOY, YEEFENG F. RUAN (Akron, University, OH), JAMES J. ZAKRAJSEK, and FRED B. OSWALD (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 16 p. Previously announced in STAR as N92-31485. refs
(AIAA PAPER 92-3494) Copyright

A newly developed global dynamic model was used to simulate the dynamics of a gear noise rig at NASA Lewis Research Center. Experimental results from the test rig were used to verify the analytical model. In this global dynamic model, the number of degrees of freedom of the system are reduced by transforming the system equations of motion into modal coordinates. The vibration of the individual gear-shaft system are coupled through the gear mesh forces. A three-dimensional, axial-lateral coupled, bearing model was used to couple the casing structural vibration to the gear-rotor dynamics. The coupled system of modal equations is solved to predict the resulting vibration at several locations on the test rig. Experimental vibration data was compared to the predicitions of the global dynamic model. There is excellent agreement between the vibration results from analysis and experiment. Author

A92-54044#
HIGH-SPEED CINEMATOGRAPHY OF SUPERSONIC MIXING LAYERS
R. MAHADEVAN, JAMES J. GUGLIELMO, ROBERT S. FRANK, and ERIC LOTH (Illinois, University, Urbana) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 13 p. refs
(Contract NSF CTS-90-10594)
(AIAA PAPER 92-3545) Copyright

An experimental investigation of the fundamental physical mechanisms which control three-dimensional supersonic mixing has been conducted. Experiments are performed in a newly constructed supersonic wind tunnel using high-speed cinematography to capture the supersonic mixing layer structures on film. Results are presented that describe how large-scale structures evolve at a relative Mach number of 1.67, and the importance of their role in mixing. Nonintrusive optical diagnostic techniques include shadowgraph methods and a planar light sheet visualization technique based on the scalar transport of ethyl alcohol. Product formation studies have also been completed but have been limited to single shot results. The time-dependent shadowgraph and Mie scattering data are documented with a Beckman-Whitley Model 192 rotating mirror camera run at between 195,000 and 500,000 frames per second. The results thus far have demonstrated both the technique's feasibility and the compressibility and mixing dynamics of the supersonic shear layer. Author

A92-54057#
COMPUTATIONAL AND EXPERIMENTAL STUDIES OF FLOW IN MULTI-LOBED FORCED MIXERS
J. K. ELLIOTT, T. A. MANNING, Y. J. QIU, E. M. GREITZER, C. S. TAN (MIT, Cambridge, MA), and T. G. TILLMAN (United Technologies Research Center, East Hartford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 16 p. refs
(Contract N00019-88-C-0029; AF-AFOSR-85-0288)
(AIAA PAPER 92-3568) Copyright

This paper presents a summary of research conducted at MIT during the past four years on flow in multilobed force mixers. The work, which involves experiment, computation, and analytical studies, addresses several specific fluid dynamic issues underlying the engineering basis of the design of forced mixers. The details of the investigations are reported elsewhere; this document focuses on describing the main results that have been obtained relevant to these issues. It is shown that the computational and analytical models that have been developed appear to capture much of the essential fluid dynamics associated with lobed mixer flows as well as to be useful in providing insight into the behavior of a broad class of these devices. Author

A92-54075#
TURBULENT COMBUSTION MODELLING IN A SIDE DUMP RAMJET COMBUSTOR
X. MONTAZEL (Aerospatiale, Centre des Gatines, Verrieres-le-Buisson, France), J. M. SAMANIEGO, F. LACAS, T. POINSOT, and S. CANDEL (Laboratoire d'Energetique Moleculaire et Macroscopique-Combustion, Chatenay-Malabry, France) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 12 p. Research supported by Aerospatiale. refs
(AIAA PAPER 92-3599) Copyright

Experimental and theoretical studies are reported on the

turbulent flow in a side dump rectangular combustor. Hot wire velocimetry was used to measure the axial and transverse mean velocity and turbulence intensity components in the nonreacting case. Flow oscillations in nonreacting case are determined from spectral analysis of the signal. In the presence of combustion, gas analysis (CO, CO2) was carried out in the chamber to obtain the temperature field. Light emission from CH radicals provides additional information which is interpreted as mean rate of heat release per unit volume. Regions where combustion takes place are identified. Measurements are compared with calculations performed with a combustion model relying on the flamelet concept and using a transport equation for the surface density. Good agreement is achieved between the model predictions and experimental results. Author

A92-54093#
THERMAL PAINTS FOR SHOCK/BOUNDARY LAYER INTERACTION IN INLET FLOWS
T. LIU, B. T. CAMPBELL, and J. P. SULLIVAN (Purdue University, West Lafayette, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 11 p. Research sponsored by U.S. Navy. refs
(AIAA PAPER 92-3626) Copyright

A fluorescent paint technique with high spatial resolution is applied to the measurement of the heat transfer rate and visualization of the flow separation in the three-dimensional shock wave/turbulent boundary layer interaction in an inlet flow. The temperature dependence of the fluorescence of several compounds and some related aspects to the technique are discussed in detail. Author

A92-54105#
STRUCTURE AND PENETRATION OF A TRANSVERSE FLUID JET INJECTED AT SUPERCRITICAL PRESSURE IN SUPERSONIC FLOW
J. C. HERMANSON, P. PAPAS, and I. W. KAY (United Technologies Research Center, East Hartford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 19 p. Research supported by United Technologies Corp. refs
(AIAA PAPER 92-3652) Copyright

The structure and penetration of a transverse nitrogen jet injected at supercritical pressure into supersonic flow was examined experimentally. The supercritical nitrogen fluid rapidly vaporized in the relatively low static pressure environment of the supersonic stream. Spark shadowgraph imaging was employed to examine the penetration characteristics and turbulent structure of supercritical nitrogen and also subcooled ethanol liquid jets. For the conditions studied, the supercritical nitrogen jet penetrated significantly less than jets consisting of subcooled ethanol. The supercritical nitrogen jet was also characterized by large-scale structure not observed for the case of subcooled ethanol injection. Practical difficulties inherent in the use of liquid fuel simulants in unheated supersonic flow to simulate a supersonic combustion environment are briefly discussed. Author

A92-54108#
DEGENERATE FOUR-WAVE MIXING FOR MEASUREMENT OF NO2 AND SMOKE CONCENTRATION IN JET ENGINE EXHAUST
T. C. COLE, W. A. COLE, T. M. BROWN, and R. W. PITZ (Vanderbilt University, Nashville, TN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 7 p. Research supported by Tennessee Valley Aerospace Consortium. refs
(Contract NSF CTS-86-57130)
(AIAA PAPER 92-3658) Copyright

Degenerate four-wave mixing (DFWM) was successfully used to monitor a wide range of concentration levels of NO2 and smoke in static test cells. Both species were resonantly pumped at 500 nm using an excimer-pumped dye laser having an average power level of 2.5 mJ/pulse. The DFWM signal from both the NO2 and smoke showed a squared dependence on concentration. The signal beam's dependence on laser power was also investigated in order to determine the degree of saturation. The signal was found to be saturated at energy levels greater than 1.8 mJ/pulse. For laser powers below this value, the signal's dependence on laser power became approximately cubic as expected. Single-pulse measurements of NO2 and smoke in the static cell indicate that temporally and spatially resolved in situ DFWM measurements are feasible for engine exhausts. Author

A92-54132*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A FINITE-VOLUME NUMERICAL METHOD TO CALCULATE FLUID FORCES AND ROTORDYNAMIC COEFFICIENTS IN SEALS
M. M. ATHAVALE, A. J. PRZEKWAS (CFD Research Corp., Huntsville, AL), and R. C. HENDRICKS (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 12 p. refs
(Contract NAS3-25644)
(AIAA PAPER 92-3712) Copyright

A numerical method to calculate rotordynamic coefficients of seals is presented. The flow in a seal is solved by using a finite-volume formulation of the full Navier-Stokes equations with appropriate turbulence models. The seal rotor is perturbed along a diameter such that the position of the rotor is a sinusoidal function of time. The resulting flow domain changes with time, and the time-dependent flow in the seal is solved using a space conserving moving grid formulation. The time-varying fluid pressure reaction forces are then linked with the rotor center displacement, velocity and acceleration to yield the rotordynamic coefficients. Results for an annular seal are presented, and compared with experimental data and other more simplified numerical methods. Author

A92-54198#
SUPERSONIC FLOW MIXING AND COMBUSTION USING RAMP NOZZLE
K. YU, K. KRAEUTLE, K. WILSON, T. PARR, R. SMITH, E. GUTMARK, and K. SCHADOW (U.S. Navy, Naval Air Warfare Center, China Lake, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 12 p. Research supported by American Society for Engineering Education and U.S. Navy. refs
(AIAA PAPER 92-3840)

Initial shear layer growth in coaxial supersonic jets is experimentally studied using a special supersonic nozzle which features five swept ramps on its expansion side. The development of this RAMP-expanded supersonic jet is compared to that of a conical expansion circular supersonic jet with Mach 2.0 at the exit. The jets discharge into either an open surrounding of air at rest or a coaxial supersonic jet stream at Mach 1.3. The resulting total pressure fields of the supersonic jets are measured using a pressure transducer, and the initial shear layer growth rates are deduced from the measurements. The results show that the growth rate is significantly increased when the RAMP nozzle is used. The jets are visualized using a planar Mie scattering technique. The flow images show large-scale structures appearing in the shear layers of the RAMP-expanded jets. The appearance of these structures is linked to the increase in the initial shear layer growth rate. In reacting shear layers, the overall reaction rate is shown to be also affected by the change. Author

A92-54199# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN ASSUMED JOINT-BETA PDF APPROACH FOR SUPERSONIC TURBULENT COMBUSTION
R. A. BAURLE, G. A. ALEXOPOULOS, H. A. HASSAN (North Carolina State University, Raleigh), and J. P. DRUMMOND (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 12 p. refs

(Contract NAG1-244; NAGW-1331)
(AIAA PAPER 92-3844) Copyright

In a recent experiment, Cheng et al. (1991) used ultraviolet spontaneous vibrational Raman scattering and laser-induced predissociative fluorescence techniques for simultaneous measurements of temperature and concentrations of O2, H2, H2O, OH, and N2 (and their rms) in supersonic turbulent reacting shear layers. Because present computational techniques are not suited for prediction of all of the above measurements, a new approach has been developed and is being used to predict all relevant flow properties and their rms (where appropriate). The approach explores the use of a joint-Beta PDF for concentrations. It was found that the general expression of this PDF was impractical because of decoding problems resulting from determining the various parameters of the PDF. Thus, a special case of this general expression was considered. Calculations using this simplified version of the joint-Beta PDF were not consistent with the available data from the experiment. Author

A92-54223
EXPERIMENTAL INVESTIGATION OF THE STABILITY OF A CLEARANCE-EXCITED ROTOR SYSTEM WITH OPTIMAL PARAMETERS
JHY-HORNG WANG and MING-DAH KING (National Tsing Hua University, Hsinchu, Taiwan) Chinese Institute of Engineers, Journal (ISSN 0253-3839), vol. 15, no. 3, May 1992, p. 245-254. refs
(Contract NSCRC-77-0401-E007-17)

An optimization technique has been proposed in previous work to improve the stability of a rotor-bearing system. In this work, the validity and the practical procedure of the optimization technique are experimentally verified and demonstrated using a rotor-bearing system. The experimental results verify the important theoretical conclusion that the threshold of stability of a rotor-bearing system can be significantly increased by slight modification of the rotor diameters. Two examples are given to show the detailed procedure when the proposed optimization technique is used to increase the threshold of stability of an existing rotor-bearing system. Author

A92-54301
ICIASF '91 - INTERNATIONAL CONGRESS ON INSTRUMENTATION IN AEROSPACE SIMULATION FACILITIES, 14TH, ROCKVILLE, MD, OCT. 27-31, 1991, RECORD
Congress sponsored by U.S. Navy and IEEE. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, 471 p. For individual items see A92-54302 to A92-54351.
(ISBN 0-0783-0123-4) Copyright

The present volume on instrumentation in aerospace simulation facilities discusses pressure measurement technology, optical diagnostics, flowfield measurements, and laser Doppler velocimetry techniques. Attention is given to temperature measurement technology, IR imaging, wind tunnel calibration, skin friction techniques, hot-wire/film technology, and ground test facilities. Topics addressed include optimizing the design process of multihole pressure probes for transonic flow with panel methods, the detection of 3D turbulent separation regions using unsteady thermographic technique, the response of turbulent jet flow to rapid compression, and correction analysis for a supersonic water-cooled total temperature probe tested to 1370 K. Also discussed are problems and solutions for transition detection in cryogenic wind tunnels by IR imaging, important factors in turbulence in flight measurement, Rayleigh imaging and flow tagging in ground test facilities, and signal processing schemes for Doppler global velocimetry. P.D.

A92-54304
AERODYNAMIC ASSESSMENT OF AN OPTICAL PRESSURE MEASUREMENT SYSTEM (OPMS) BY COMPARISON WITH CONVENTIONAL PRESSURE MEASUREMENTS IN A HIGH SPEED WIND TUNNEL
R. H. ENGLER, K. HARTMANN (DLR, Goettingen, Germany), and B. SCHULZE (MBB GmbH, Ottobrunn, Germany) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 17-24. refs
Copyright

The authors present an assessment of a novel optical pressure measurement system (OPMS). For this purpose experiments were carried out in a high-speed wind tunnel on a cropped delta wing model to demonstrate and assess this technique. Pressure distributions were measured separately as well as simultaneously with both the OPMS and a conventional technique via pressure taps for comparison. Temperature variations on the model surface were determined by means of an infrared camera and thermocouples to assess a possible error caused by temperature changes. Surface oil flow visualizations were performed to get additional information on boundary layer transition, separation, and reattachment lines as well as vortex positions. I.E.

A92-54314* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPARISON OF FREQUENCY DOMAIN AND TIME DOMAIN LASER VELOCIMETER SIGNAL PROCESSORS
W. D. MACE, JR. (Lockheed Engineering & Sciences Co., Hampton, VA), JOE W. ELLIOTT (NASA, Langley Research Center, Hampton, VA), BARRY BLANCHA, and JAY MURPHY (Macrodyne, Inc., Clifton Park, NY) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 103-112. refs
Copyright

An experimental investigation was conducted in the 14- by 22-foot subsonic tunnel at NASA-Langley Research Center to measure the inflow into a scale model helicopter rotor in forward flight. These inflow measurements were acquired utilizing a two-component laser velocimeter, and the data were processed by a frequency-domain processor (FDP). As a subset of the experiment, a time-domain counter processor was utilized simultaneously with an FDP to make a comparison of the two processors possible. The results indicate that the FDP had a marked improvement in processing capability in conditions of low signal-to-noise ratios and had a reduction in the number of erroneous data points acquired. However, the FDP yielded a lower data rate in comparison to the counter when signal-to-noise ratios were high. Comparison of the data sets shows that the FDP consistantly measures velocities which are 0.7 percent higher than those measured by the counter processor. I.E.

A92-54317* National Aeronautics and Space Administration, Washington, DC.
A FINE-WIRE THERMOCOUPLE PROBE FOR MEASUREMENT OF STAGNATION TEMPERATURES IN REAL GAS HYPERSONIC FLOWS OF NITROGEN
BRIAN R. HOLLIS, WAYLAND C. GRIFFITH (North Carolina State University, Raleigh), and WILLIAM J. YANTA (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 136-145. Research supported by U.S. Navy and USAF. refs
(Contract NAGW-1072)
Copyright

A fine-wire thermocouple probe was used to determine freestream stagnation temperatures in hypersonic flows. Data were gathered in a N2 blowdown wind tunnel with runtimes of 1-5 s. Tests were made at supply pressures between 30 and 1400 atm and supply temperatures between 700 and 1900 K, with Mach numbers of 14 to 16. An iterative procedure requiring thermocouple data, pilot pressure measurements, and supply conditions was used to determine test cell stagnation temperatures. Probe conduction and radiation losses, as well as real gas behavior of N2, were accounted for during analysis. Temperature measurement error was found to be 5 to 10 percent. A correlation was drawn between

thermocouple diameter Reynolds number and temperature recovery ratio. Transient probe behavior was studied and was found to be adequate in temperature gradients up to 1000 K/s. I.E.

A92-54321
QUANTITATIVE HEAT TRANSFER MEASUREMENTS IN HYPERSONIC WIND TUNNELS BY MEANS OF INFRARED THERMOGRAPHY
G. SIMEONIDES, J. P. VERMEULEN, H. L. BOERRIGTER, and J. F. WENDT (Von Karman Institute for Fluid Dynamics, Rhode-Saint-Genese, Belgium) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 178-189.
Copyright

A description of infrared thermography as this is employed in a hypersonic blowdown wind tunnel for the acquisition of high quality '2-D' heat transfer data over aerodynamic surfaces is given. It is shown that the availability of an infrared scanning radiometer and a standard digital image processing system in the laboratory may provide the means for the performance of highly efficient (in terms of time and cost) heat transfer measurements, which exhibit accuracy levels comparable to those achieved by classical discrete point gauges such as thin film surface resistance thermometers and thermocouples. Author

A92-54330
RAYLEIGH IMAGING AND FLOW TAGGING IN GROUND TEST FACILITIES
R. MILES, W. R. LEMPERT, B. ZHANG, J. FORKEY, and I. GLESK (Princeton University, NJ) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 255-261. Research supported by USAF. refs
Copyright

The authors present preliminary results on the application of ultraviolet Rayleigh imaging and RELIEF flow tagging to a high Reynolds number, Mach 3 blow-down air facility at Princeton University's Gas Dynamics Laboratory. RELIEF tagging was accomplished using stimulated Raman scattering to vibrationally excite oxygen molecules. Examples include instantaneous images of boundary-layer structure and shock-wave/boundary-layer interactions, as well as very recent results of flow tagging velocity measurements in the free-stream and boundary-layer regions of this facility. The future implementation of filtered Rayleigh scattering is also discussed. I.E.

A92-54333
A SIMPLE THREE COMPONENT VELOCITY MEASUREMENT METHOD USING A ROTATED SPLIT-FILM SENSOR
L. S. MILLER and K. YANO (Wichita State University, KS) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 277-283. refs
Copyright

A rotated split-film anemometry method which can be used to obtain three-component average flow velocities is reviewed and evaluated. The related theory, apparatus, calibration procedure, and results of the new technique are discussed. The new technique utilizes a single split-film probe in combination with a mechanical rotating probe holder. The basic procedure is to make a plane or two-component velocity measurement with the probe in one orientation and then to rotate the probe 90 deg and make another measurement. The two pairs of velocity and flow angle data are correlated, for yawed flow effects, and resolved to identify three (steady-flow) speed and direction components. Measurements in an axisymmetric jet at various flow speeds and angles indicate that the method has, under most circumstances, errors of about 5 percent. Slightly greater errors were encountered at extreme test flow speeds and at large sensor yaw and pitch angles. I.E.

A92-54334
SHOCK DETECTION ON AIRFOILS BY MEANS OF PIEZO FOIL- AND HOT FILM ARRAYS
M. SWOBODA, W. NITSCHE, and J. SUTTAN (Berlin, Technische Universitaet, Germany) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 284-294. refs
Copyright

The authors describe comparative investigations concerning the detection of shock positions on a transonic airfoil model. A piezo foil array consisting of 24 separate sensors and a hot film array consisting of 8 separate sensors were used. While the piezo sensors detect increasing unsteady fluctuations of pressure, wall shear stress, and temperature in the region of a shock, the hot film sensors only register shear stress fluctuations qualitatively and, if calibrated, the mean wall shear stress too. Owing to their low total height, the two sensor arrays can be mounted on the airfoil model without causing disturbances, and they allow reliable detection of shock positions. I.E.

A92-54337
PARTICLE IMAGE VELOCIMETRY MEASUREMENTS OF THE AERODYNAMICS OF A WIND TURBINE
I. GRANT, G. H. SMITH, A. LIU (Heriot-Watt University, Edinburgh, United Kingdom), D. INFIELD (Rutherford Appleton Laboratory, Didcot, United Kingdom), and T. EICH (Universitaet Essen-Gesamthochschule, Germany) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 314-320. refs
Copyright

The authors describe an aerodynamic study of flow over a simple commercial wind turbine in wind tunnel experiments using the particle image velocity (PIV) technique. In particular the use of the PIV technique was demonstrated for determining both the characteristics of the tip vortices trailing from consecutive blades of the wind turbine and circulation around the individual blade. These factors are of interest to both helicopter and wind turbine blade design. The experimental apparatus is described as it pertains to the sampling of the periodic but unsteady flow found behind the rotor. Also described are the data processing techniques used to extract velocity, vorticity and circulation measurements from the PIV images. I.E.

A92-54338* *National Aeronautics and Space Administration.* Langley Research Center, Hampton, VA.
SIGNAL PROCESSING SCHEMES FOR DOPPLER GLOBAL VELOCIMETRY
JAMES F. MEYERS, JOSEPH W. LEE (NASA, Langley Research Center, Hampton, VA), and ANGELO A. CAVONE (Vigyan, Inc., Hampton, VA) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 321-328. refs
Copyright

Two schemes for processing signals obtained from the Doppler global velocimeter are described. The analog approach is a simple, real-time method for obtaining an RS-170 video signal containing the normalized intensity image. Pseudocolors are added using a monochromatic frame grabber producing a standard NTSC video signal that can be monitored and/or recorded. The digital approach is more complicated, but maintains the full resolution of the acquisition cameras with the ability to correct the signal image for pixel sensitivity variations and to remove background light. Prototype circuits for each scheme are described, and example results from the investigation of the vortical flow field above a 75-deg delta wing are presented. I.E.

A92-54344* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EVALUATION OF ELECTROLYTIC TILT SENSORS FOR WIND TUNNEL MODEL ANGLE-OF-ATTACK (AOA) MEASUREMENTS
DOUGLAS T. WONG (NASA, Langley Research Center, Hampton, VA) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 382-391. refs

The results of a laboratory evaluation of three types of electrolytic tilt sensors as potential candidates for model attitude or angle of attack (AOA) measurements in wind tunnel tests are presented. Their performance was also compared with that from typical servo accelerometers used for AOA measurements. Model RG-37 electrolytic tilt sensors were found to have the highest overall accuracy among the three types. Compared with the servo accelerometer, their accuracies are about one order of magnitude worse and each of them cost about two-thirds less. Therefore, the sensors are unsuitable for AOA measurements although they are less expensive. However, the potential for other applications exists where the errors resulting from roll interaction, vibration, and response time are less, and sensor temperature can be controlled. I.E.

A92-54345
FAULT DIAGNOSTICS ON JET ENGINE STARTING
H. Z. LIU, H. M. WANG, and X. Q. NI (Beijing University of Aeronautics and Astronautics, China) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 392-396. refs
Copyright

To investigate jet engine starting, a series of engine parameters must be evaluated. The measurements of rotor speed, fuel flow rate, fuel combustion, and gas temperature must be taken in real time. A dynamic measurement system was used to evaluate the starting performance, and to diagnose faults during starting. The dynamic measurement system contained a photoelectric system and a fast thermocouple used to detect and inspect the fault symptoms during starting. As a result, the starting operation quality to be assessed can be determined and improved. The experiment was completed on a sea-level test bench for a small single spool jet engine. I.E.

A92-54348* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE USE OF SILICON MICROSENSORS IN SMART SKINS FOR AERODYNAMIC RESEARCH
DEBRA L. CARRAWAY (NASA, Langley Research Center, Hampton, VA) IN: ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 413-422. refs

A futuristic look at what should be pursued in terms of measurement instrumentation for aerodynamic research is presented. A cursory method is given for incorporating silicon microsensors, signal conditioning, and signal processing into a thin skin which will ultimately become the surface of an airfoil. Polyimide is the candidate material suggested for use as the skin because of its flexibility and IC processing compatibility. Specifications are given for the detection of boundary layer phenomena of current interest. I.E.

A92-54496
MONITORING FATIGUE CRACKS IN GEARS
G. DALPIAZ and U. MENEGHETTI (Bologna, University, Italy) (Condition Monitoring '91, Meeting, Erding, Germany, May 14-16, 1991) NDT & E International (ISSN 0963-8695), vol. 24, no. 6, Dec. 1991, p. 303-306. Research supported by MURST. refs
Copyright

Vibration analysis is the most common means of gear monitoring and diagnostics. Gear vibration is affected by faults but the signal is usually picked up at the case, where it is also affected by the structural response. An appropriate filtering function is therefore proposed to recover the torsional gear vibration from the case vibration signal. The restored gear vibration can then be used with greater confidence than case vibration both for particular diagnostics purposes like crack detection and for more general objectives. This technique and its possible advantages in fatigue crack detection are illustrated in the paper. Author

A92-54563
AN ANALYSIS OF BOUNDARY LAYER FOR DROPLET AERODYNAMIC STRIPPED IN HIGH SPEED GAS FLOW
MENG ZHOU and F. C. ZHUANG (National University of Defense Technology, Changsha, China) National University of Defense Technology, Journal (ISSN 1001-2486), vol. 13, no. 3, Sept. 1991, p. 29-33. In Chinese. refs

Based on boundary-layer theory a theoretical model for the coupling problem of a two-phase boundary layer of gas and droplet is established. A formula to calculate the minimum velocity of gas flow needed to start the aerodynamic stripping is obtained for the problem of the aerodynamic stripping, which is a result from the interaction between gas and a droplet surface when the droplet is in a high-speed gas flow. This paper could be useful for the investigation of atomizing mechanisms of liquid fuel in high-speed gas flow. Author

A92-54650
EFFECTS OF MATERIAL CHOICES ON BRUSH SEAL PERFORMANCE
EDWARD ATKINSON and BRENT BRISTOL (General Electric Co., Cincinnati, OH) (STLE, Annual Meeting, 46th, Montreal, Canada, Apr. 29-May 2, 1991) Lubrication Engineering (ISSN 0024-7154), vol. 48, no. 9, Sept. 1992, p. 740-746. refs
Copyright

This paper discusses some of the initial hot and cold material testing undertaken in a brush seal development program. It describes the effects of material selection on relative wear and leakage of brush seals. Criteria for ranking wear couples are addressed. Author

A92-54678
MECHANISMS OF HIGH-CURRENT PULSES IN LIGHTNING AND LONG-SPARK STEPPED LEADERS
S. LARIGALDIE (ONERA, Chatillon, France), A. ROUSSAUD, and B. JECKO (Limoges, Universite, France) Journal of Applied Physics (ISSN 0021-8979), vol. 72, no. 5, Sept. 1, 1992, p. 1729-1739. Research supported by DRET. refs
Copyright

The mechanisms of high-current transients in lightning stepped leaders and in long laboratory sparks at negative polarity are analyzed both from improved time resolution measurements and from systematic identifications of the various elements of the discharge during a pulse. A qualitative model was first constructed when the observations made were correlated with some previously known basic phenomena. Then the model was made quantitative by means of a computer simulation of spark formation, carried out from a modified program in electromagnetics. The relevance of the proposed model was checked for long sparks at negative polarity when computed and recorded current pulse wave forms were compared. Finally, the model of stepped-leader development was applied to a full scale event: an in-flight lightning strike on an instrumented aircraft. Slight discrepancies between computed and recorded current pulse wave forms may indicate possible underestimation of the electromagnetic high-frequency threat to sensitive airborne equipment due to the frequency limitations of the transient recorders used for lightning characterization on aircraft. Author

A92-54867
JOINING A NI-BASED CREEP-RESISTANT (ODS) ALLOY BY BRAZING
I. A. BUCKLOW (Welding Institute, Abington, United Kingdom) IN: Advances in joining newer structural materials; Proceedings of the

International Conference, Montreal, Canada, July 23-25, 1990. Oxford and Elmsford, NY, Pergamon Press, 1990, p. 293-298. refs
Copyright

Joints are produced in a fine-grained Ni oxide-dispersion-strengthened (ODS) alloy by means of brazing alloys with and without boron, and the resulting joints are studied mechanographically. The brazing alloys employed are either sputtered coatings or foils, and brazing is conducted in a vacuum for approximately two hours. The resulting joints are examined during the process by mass spectrometry and afterwards by means of metallographic observation following etching in glyceregia. Premature and uncontrolled recrystallization of the parent metal is noted in the samples brazed with alloys obtaining boron. The 2-micron braze coating used minimize second-phase formation and dispersoid agglomerations, and the 25-micron brazing foils lead to high porosity and dispersoid aggregation due to excessive melting. Recrystallization of the parent metal near brazing zones is concluded to be undesirable although is does not necessarily influence the quality of the joint. C.C.S.

A92-54868
DIFFUSION BONDING A CREEP-RESISTANT FE-ODS ALLOY
I. A. BUCKLOW (Welding Institute, Abington, United Kingdom) IN: Advances in joining newer structural materials; Proceedings of the International Conference, Montreal, Canada, July 23-25, 1990. Oxford and Elmsford, NY, Pergamon Press, 1990, p. 299-304. refs
Copyright

A method is described for diffusion bonding iron-based alloys in which the grain structure is continuous along the interface. The method is based on oxide-dispersion-strengthened (ODS) alloying for producing fine-grained materials with highly directional strain. Samples of the Fe-based MA956 alloy are rapidly diffusion bonded at about 1200 C and 200-300 MPa with either one or two induction heat treatments, and secondary recrystallization is seeded epitaxially. Sections are etched in glyceregia and studied by means of micrographs, and the diffusion rates of the ferritic alloys are found to be high enough to allow bonding at temperatures below the recrystallization level. Some mechanical damage to the specimens is noted that can lead to suboptimal grain directionality. The present results are of interest to the development of Fe-ODS alloys for turbine applications and for use in sulfurous atmospheres. C.C.S.

A92-54921* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AEROELASTIC MODAL CHARACTERISTICS OF MISTUNED BLADE ASSEMBLIES - MODE LOCALIZATION AND LOSS OF EIGENSTRUCTURE
CHRISTOPHE PIERRE (Michigan, University, Ann Arbor) and DURBHA V. MURTHY (NASA, Lewis Research Center, Cleveland, OH) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2483-2496. Previously cited in issue 12, p. 1977, Accession no. A91-32032. refs
(Contract NAG3-1163)
Copyright

A92-54931
INTERACTION BETWEEN CHEMICAL REACTION AND TURBULENCE IN SUPERSONIC NONPREMIXED H2-AIR COMBUSTION
R. VILLASENOR (Vanderbilt University, Nashville, TN), J.-Y. CHEN (California, University, Berkeley), and R. W. PITZ (Vanderbilt University, Nashville, TN) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2552-2554. Abridged. Research supported by Sandia National Laboratories. Previously cited in issue 06, p. 848, Accession no. A91-19264. refs
(Contract NSF CTS-86-57130)
Copyright

A92-54932
DYNAMICAL SCALING OF A MODEL UNSTEADY SEPARATING FLOW
MUKUND ACHARYA and ANWAR RAMIZ (Illinois Institute of Technology, Chicago) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2554-2556. refs
(Contract F49620-86-C-0133)
Copyright

Unsteady separation flow generated by deployment at constant pitch rate of a spoilerlike flap into initially attached flow over a flat plate is studied for Re between 1.5 x 10 exp 5 and 2.6 x 10 exp 6 and rise times between 0.06 and 2 sec. The formation and growth of the separated region were examined using a combination of unsteady wall static pressure and flow-direction measurements at several locations downstream of the flap. The results are consistent with the suggestion by Reynolds and Carr (1985) that the growth of the separation regions controlled by two different mechanisms that set a balance between the vorticity input and output to the separated region. C.D.

A92-54934* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPROXIMATE RIEMANN SOLVER FOR HYPERVELOCITY FLOWS
P. A. JACOBS (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2558-2561. Previously announced in STAR as N91-32463. refs
Copyright

We describe an approximate Riemann solver for the computation of hypervelocity flows in which there are strong shocks and viscous interactions. The scheme has three stages, the first of which computes the intermediate states assuming isentropic waves. A second stage, based on the strong shock relations, may then be invoked if the pressure jump across either wave is large. The third stage interpolates the interface state from the two initial states and the intermediate states. The solver is used as part of a finite-volume code and is demonstrated on two test cases. The first is a high Mach number flow over a sphere while the second is a flow over a flow over a slender cone with an adiabatic boundary layer. In both cases the solver performs well. Author

A92-54938
DOUBLE PISTON SHOCK-WAVE VALVE
H. ONODERA (Iwate University, Morioka, Japan) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2569-2571. refs
Copyright

A new concept for a shock-wave valve is introduced. The valve has a simple structure, is easy to operate, is suitable for large-scale shock tubes, and generates very little turbulence in the flowfield produced. C.D.

A92-55127 National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
GETTING UP TO SPEED IN HYPERSONIC STRUCTURES
MICHAEL W. KEHOE (NASA, Flight Research Center, Edwards, CA) and RODNEY H. RICKETTS (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 30, no. 9, Sept. 1992, p. 18-20, 29.
Copyright

An overview is presented of some of the hypersonic technology that will become the baseline for more advanced commercial aerospace systems and new military transportation systems for carrying astronauts and equipment into space. Attention is given to the X-15 aeronautical research program, the X-20 DYNA-SOAR, and the current X-30 National Aerospace Plane. Consideration is given to FEM analysis methods, modal testing conducted to measure the structure's resonant frequencies, dampings, and mode shapes, and high-temperature, high-speed wind tunnel testing and in-flight measurement of steady and unsteady pressures at Mach 3 and above. R.E.P.

A92-55453
ENHANCEMENT OF LAMINAR BOUNDARY LAYER HEAT TRANSFER BY A VORTEX GENERATOR
JURANDIR I. YANAGIHARA (Sao Paulo, Universidade, Brazil) and KAHORU TORII (Yokohama National University, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 35, no. 3, Aug. 1992, p. 400-405. refs

The enhancement of heat transfer caused by the presence of a single vortex generator in a laminar boundary layer was experimentally investigated. The local heat transfer coefficients just downstream of the vortex generator and the mean and fluctuation components of velocity were measured. A substantial increase in the heat transfer was noted, with a maximum improvement of the heat transfer coefficient of 80 percent, even in regions where the laminar structure was clearly predominant. It was observed that the heat transfer coefficient presented two peaks in the spanwise direction. These peaks were found to be associated with the downward motion of the mean vortex and the corner vortex, which arose in the generator's front corner. The influence of the height, angle of attack and geometry of the vortex generator on heat transfer was also investigated. Author

A92-56024
STRUCTURAL OPTIMIZATION OF A CANTILEVERED BEAM SUBJECT TO COMBINED STATIC LOADINGS
TOSHIFUMI NEKOHASHI, NAOHIRO IBOSHI, and TOMOARI NAGASHIMA (National Defense Academy, Yokosuka, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 96-99. In Japanese. refs
A basic study concerning the structural optimization of a cantilevered beam subject to combined static loadings is conducted. The minimum deflection problem is formulated as an optimization problem involving inequality constraints and solution procedure using a conjugate gradient algorithm is presented. Optimum area distributions are determined numerically for various combinations of lateral and axial loadings including variable axial and lateral loadings both of which are simulated centrifugal force and air loadings for a rotor blade in hover. Effects of differences in applied loading conditions on the optimum solutions are discussed. Author

A92-56034
GUST RESPONSE AND CROSS WIND PERFORMANCE OF A HOVERCRAFT WITH VERTICAL WINGS
NAGAKATU KAWAHATA (Nihon University, Tokyo, Japan) and YOSIHIRO MIURA (Olympos Co., Ltd., Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 138-141. In Japanese.
The configurations of a radio-controlled hovercraft model with vertical wings are presented. The flight performance in cross wind is evaluated, and the difference between the target point and visual angular error is addressed. Y.P.Q.

A92-56035
ON THE MANEUVERING TESTS OF AN ACV MODEL
RINICHI MURAO (Aoyama Gakuin University, Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 142-145. In Japanese. refs
Results of an ACV simulation to investigate control response, ice surface friction, and wind direction and speed are presented. Test methods are given, and position and yaw measurements are addressed. Y.P.Q.

A92-56036
CONFIGURATION OF FLEXIBLE-SKIRTS FOR AN ACV AND ITS CAD
RINICHI MURAO and MINORU IWAI (Aoyama Gakuin University, Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 146-149. In Japanese. refs
An investigation of the flight performance and durability of an ACV is presented. Designs of various flexible skirts for ACV are examined. Geometric and dynamic conditions are given for the computer-aided design of an ACV. Y.P.Q.

A92-56038
PLANNING METHOD OF SKIRT SYSTEMS FOR SMALL ACVS
KENSUKE MATSUO (Kumamoto Institute of Technology, Japan) and HIDEO MATSUO (Kumamoto University, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 154-157. In Japanese. refs
A simple method to predict the static configuration of the skirt is proposed. Effects of the weight of skirt material and the pressure distribution in the nozzle region are considered. The nozzle region is the space between the ground and the skirt. The numerical results are shown and discussed. Both the effects of the weight of skirt material and the pressure distribution in the nozzle region are important for the initial design of a bag-type skirt. Author

A92-56039
A POTENTIAL FLOW THEORY OF TWO-DIMENSIONAL BIFURCATED CURTAIN JETS. II
SYUNRO NAKAMURA IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 162-165. In Japanese. refs
A calulation method for the potential theory of bifurcated curtain jets is presented. The velocity and pressure distribution of nozzle outlet flow are analyzed, and ground pressure distribution is examined. Y.P.Q.

A92-56084
APPLICATION OF X-RAY IMAGE RADIOGRAPHY SYSTEM FOR AIRCRAFT
KENJI TSUBAKI (Kawasaki Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 374-377. In Japanese.
Water entrapment in a honeycomb assembly is generally detected by means of X-ray film method in the maintenance phase. Nowadays, much improvement and lower cost of digital image processing systems accelerates wide use of them in NDI. The Kawasaki Image Radiography Inspection System (K-IRIS) consists of digital image processor, digital controlled X-ray equipment, and a 10-axis teaching playback mechanism. K-IRIS shows its remarkable ability to detect water entrapment and to reduce much inspection time compared with the ordinary film method. Author

A92-56094
FATIGUE CRACKING THRESHOLD PREDICTION OF TRANSPORT AIRPLANES
GENKICHI FUJIWARA (Japan Airlines Co., Ltd., Tokyo) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 428-431. In Japanese.
Current aging airplane service data have identified that there are more cracked airplanes with increasing fleet age, and possibly several fatigue cracks in some of the cracked airplanes. Moreover, multiple site damage in some of the cracked airplanes is not only an economic problem, but may also impact safety considerations. This paper discusses a method which will estimate the fatigue life thresholds of the aircraft structure's detail from fleet service experience, and also addresses the phenomena of multiple site damage from the operator's viewpoint. Author

A92-56107
DEVELOPMENT OF AN AUTOMATIC DRILLING SYSTEM. II
JUNICHI ITO and YUJI SHINAGAWA (SMIC, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 482-485. In Japanese.

An automatic drilling system used in the assembly of aircraft structures is presented. The configurations of the automatic drilling equipment are described. Y.P.Q.

A92-56109
APPLICATION OF AUTOMATION FOR STRUCTURAL-COMPOSITES PRODUCTION
TAKAHISA HASEGAWA and HIROYUKI ANDO (Fuji Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 490-493. In Japanese. refs

An outboard aileron has been developed using composite materials. The production automation and tool structure are described. C.D.

A92-56141#
EXPERIMENTAL MODELING OF FILM-COOLED AXIAL TURBINE TIP SEALS
C. D. EICK and D. E. METZGER (Arizona State University, Tempe) ASME, AIChE, ANS, and AIAA, National Heat Transfer Conference, 28th, San Diego, CA, Aug. 9-12, 1992. 9 p. refs
(AIAA PAPER 92-4058) Copyright

The convection heat transfer and the film cooling behavior on an axial turbine tip shroud were investigated using a stationary laboratory shroud surface model that simulates the clearance flow and its acceleration into the leakage gap. It is shown that a localized acceleration, placed in this study at the injection location, produces a nonmonotonic downstream convection coefficient distribution and causes a decrease in effectiveness. I.S.

A92-56143#
COMPUTATIONAL AND EXPERIMENTAL INVESTIGATION OF ANNULUS HEAT TRANSFER WITH SWIRL
JAY C. KIM (Pratt & Whitney Group, East Hartford, CT) and JOHN C. BENNETT (Connecticut, University, Storrs) ASME, AIChE, ANS, and AIAA, National Heat Transfer Conference, 28th, San Diego, CA, Aug. 9-12, 1992. 12 p. Research supported by Pratt & Whitney Group. refs
(AIAA PAPER 92-4060) Copyright

Computational and experimental investigations were conducted to evaluate the effect of swirl on annulus heat transfer. In the computational approach, Reynolds-averaged turbulent Navier-Stokes equations were solved numerically using a standard K-epsilon turbulence model. For the near-wall regions, where accurate velocity and temperature profiles were needed for heat transfer calculations, the equations were solved down to the wall with a fine grid instead of using a wall function. Average convective heat transfer coefficients were measured with heat-flux gauges mounted on a large scale model. Swirl was found to cause a substantial increase in annulus heat transfer. With 45-deg swirl, average heat transfer coefficients on the outer and inner annulus wall were measured 1.5 to 2.5 times those of nonswirling flow. The comparison of the numerical results with the experimental data showed reasonable agreements in nonswirling heat transfer. In swirling flow, the calculated heat transfer agreed well with the measured data on the outer annulus wall, but the calculation overpredicted the inner heat transfer. Author

A92-56181
DEMONSTRATION OF STRUCTURAL OPTIMIZATION APPLIED TO WIND-TUNNEL MODEL DESIGN
MARK FRENCH and RAYMOND M. KOLONAY (USAF, Wright Laboratory, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 966-968. refs

Results are presented which indicate that using structural optimization to design wind-tunnel models can result in a procedure that matches design stiffnesses well enough to be very useful in sizing the structures of aeroelastic models. The design procedure that is presented demonstrates that optimization can be useful in the design of aeroelastically scaled wind-tunnel models. The resulting structure effectively models an aeroelastically tailored composite wing with a simple aluminum beam structure, a structure that should be inexpensive to manufacture compared with a composite one. L.M.

A92-56201
ANNUAL RELIABILITY AND MAINTAINABILITY SYMPOSIUM, LAS VEGAS, NV, JAN. 21-23, 1992, PROCEEDINGS
Symposium sponsored by IEEE, AIAA, SAE, et al. New York, Institute of Electrical and Electronics Engineers, Inc., 1992, 605 p. For individual items see A92-56202 to A92-56258.
(ISBN 0-7803-0521-3) Copyright

Various papers on reliability and maintainability (R&M) are presented. The general topics addressed include: design practices for reliability, achieving cost effectiveness, R&M in the quality of life, cultivating cultural change, power plant R&M and safety, reliability of components and systems, maintenance, future role of R&M assurance in space flight exploration, real-life experiences, software R&M and safety, concepts and philosophies of reliability growth, failure modes and effects analysis and fault trees, fiberoptic systems, R&M and availability modeling, product assurance management, software tools for product assurance. C.D.

A92-56202
REDUNDANCY DESIGN PHILOSOPHY FOR CATASTROPHIC LOSS PROTECTION
KENNETH H. EAGLE and AJAY S. AGARWALA (Boeing Defense & Space Group, Philadelphia, PA) IN: Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1992, p. 1-4.
Copyright

To ensure high flight safety and mission reliability in flight-critical electronics of aerospace vehicles, a redundancy design technique named brick wall is discussed. Basically, the technique proposes triplex redundant, independent paths where each path can self-monitor its own health (by using a comparison scheme within each path). Upon a fault detection, the whole path is taken offline. The inherent high redundancy allows the achievement of stringent flight safety and mission reliability goals. The design also protects against hidden/unknown failure modes and sneak circuits. The design tradeoffs are made against higher maintenance rates, cost, and weight. I.E.

A92-56209
DESIGNING TO COST EFFECTIVENESS - ENHANCING QUALITY
JAMES R. BRENNAN (Texas Instruments, Inc., Dallas) and JERRELL T. STRACENER (LTV Aerospace and Defense Co., Dallas, TX) IN: Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1992, p. 44-52. refs
Copyright

The authors present a practical application of cost-effectiveness analysis techniques through the definition and solution of a representative design tradeoff study using cost-effectiveness as a figure of merit for quality. They also describe a decision process based on the results of tradeoff studies to provide a method of integrating the 'ilities' with design and manufacturing engineering to help accomplish integrated product development (IPD). While the approach is demonstrated in an aircraft application, the method is equally applicable in almost any product and any operational scenario, military or commercial. I.E.

A92-56215
EFFECTIVE MAINTENANCE PRACTICES TO MANAGE SYSTEM AGING
ALAN CHOCKIE and KENNETH BJORKELO (Battelle Seattle Research Center, WA) IN: Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1992, p. 166-170. refs
Copyright

A study for the Nuclear Regulatory Commission was recently undertaken to identify effective maintenance practices that could be adapted by the nuclear industry in the United States to assist in managing the aging degradation of plant systems and components. Four organizations were examined to assess the influence of maintenance programs on addressing the system and component aging degradation issues. An effective maintenance program was found to be essential to the management of system and component aging. Four key elements of an effective maintenance program that are important to an aging management were identified: (1) the selection of critical systems and components; (2) the development of an understanding of aging through the collection and analysis of equipment performance information; (3) the development of appropriate preventive and predictive maintenance tasks to manage equipment and system aging degradation; and (4) the use of feedback mechanisms to continuously improve the management of aging systems and components. These elements were found to be common to all four organizations. I.E.

A92-56222
A TESTABILITY-DEPENDENT MAINTAINABILITY-PREDICTION TECHNIQUE
JOSEPH A. CAROLI and GEORGE W. LYNE (USAF, Rome Laboratory, Griffiss AFB, NY) IN: Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1992, p. 223-227. refs

The authors outline a novel mean-time-to-repair (MTTR) prediction technique which is a modification of MIL-HDBK-472 procedure V. The modifications directly relate testability characteristics to maintainability parameters and introduce the influence that different maintenance and repair philosophies have on MTTR. A computerized version of this technique is also discussed. Future plans include proposing this technique for inclusion in one of the next revisions of MIL-HDBK-472. I.E.

A92-56225
NEW AIRCRAFT TECHNOLOGIES - CHALLENGES FOR DEPENDABILITY
TILAK C. SHARMA (Boeing Commercial Airplane Group, Seattle, WA) IN: Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1992, p. 243-248.
Copyright

Advances being planned in the commercial aircraft business, which include those in the areas of E-ETOPS, HSCT, fly-by-wire, and fly-by-light pose the question of their dependability. The paper defines the concept of dependability as it refers to aircraft equipment, the characteristics which a dependable aircraft equipment should possess, the use of the Dependable Computing techniques during the design and development of new equipment, and the new technology application to the current 777 program. Consideration is also given to the certification requirements for transport aircraft systems in terms of reliability, integrity, and availability. I.S.

A92-56241* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MODULAR TECHNIQUES FOR DYNAMIC FAULT-TREE ANALYSIS
F. A. PATTERSON-HINE (NASA, Ames Research Center, Moffett Field, CA) and JOANNE B. DUGAN (Duke University, Durham, NC) IN: Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1992, p. 363-369. refs (Contract NAC2-478)
Copyright

It is noted that current approaches used to assess the dependability of complex systems such as Space Station Freedom and the Air Traffic Control System are incapable of handling the size and complexity of these highly integrated designs. A novel technique for modeling such systems which is built upon current techniques in Markov theory and combinatorial analysis is described. It enables the development of a hierarchical representation of system behavior which is more flexible than either technique alone. A solution strategy which is based on an object-oriented approach to model representation and evaluation is discussed. The technique is virtually transparent to the user since the fault tree models can be built graphically and the objects defined automatically. The tree modularization procedure allows the two model types, Markov and combinatoric, to coexist and does not require that the entire fault tree be translated to a Markov chain for evaluation. This effectively reduces the size of the Markov chain required and enables solutions with less truncation, making analysis of longer mission times possible. Using the fault-tolerant parallel processor as an example, a model is built and solved for a specific mission scenario and the solution approach is illustrated in detail. I.E.

A92-56252
ELECTRONICS/AVIONICS INTEGRITY - DEFINITION, MEASUREMENT AND IMPROVEMENT
W. KOLARIK, J. RASTY, M. CHEN, and Y. KIM (Texas Tech University, Lubbock) IN: Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1992, p. 460-467. Research supported by General Dynamics, Corp. refs
Copyright

The authors report on the results obtained from an extensive, three-fold research project: (1) to search the open quality and reliability literature for documented information relative to electronics/avionics integrity; (2) to interpret and evaluate the literature as to significant concepts, strategies, and tools appropriate for use in electronics/avionics product and process integrity efforts; and (3) to develop a list of critical findings and recommendations that will lead to significant progress in product integrity definition, measurement, modeling, and improvements. The research consisted of examining a broad range of trade journals, scientific journals, and technical reports, as well as face-to-face discussions with reliability professionals. Ten significant recommendations have been supported by the research work. I.E.

A92-56254
ENGINEERING RELIABILITY AND MAINTAINABILITY REVIEW - A REGIMEN FOR DISCOVERING PRODUCTION DEFICIENCIES
MICHAEL H. MCKELVEY and ROBERT S. BABIN (Douglas Aircraft Co., Long Beach, CA) IN: Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1992, p. 475-477.
Copyright

An engineering reliability and maintainability review (ER&MR) is a methodical disassembly, visual inspection, and physical examination of a production unit of airborne equipment by a team of reviewers from reliability, maintainability, and other technical disciplines. Established at Douglas Aircraft for the DC-10 program and recently upgraded, ER&MR facilitates detection of unit design and assembly flaws and deficiencies that traditional design reviews and inspections may fail to discover. ER&MR also verifies required circuit separation and segregation in the unit and incorporation of unit design changes authorized by the critical design review team. I.E.

A92-56257* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HIREL - RELIABILITY/AVAILABILITY INTEGRATED WORKSTATION TOOL
SALVATORE J. BAVUSO (NASA, Langley Research Center, Hampton) and JOANNE B. DUGAN (Duke University, SC) IN: Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings. New York, Institute of Electrical

and Electronics Engineers, Inc., 1992, p. 491-500. refs
Copyright

The HiRel software tool is described and demonstrated by application to the mission avionics subsystem of the Advanced System Integration Demonstrations (ASID) system that utilizes the PAVE PILLAR approach. HiRel marks another accomplishment toward the goal of producing a totally integrated computer-aided design (CAD) workstation design capability. Since a reliability engineer generally represents a reliability model graphically before it can be solved, the use of a graphical input description language increases productivity and decreases the incidence of error. The graphical postprocessor module HARPO makes it possible for reliability engineers to quickly analyze huge amounts of reliability/availability data to observe trends due to exploratory design changes. The addition of several powerful HARP modeling engines provides the user with a reliability/availability modeling capability for a wide range of system applications all integrated under a common interactive graphical input-output capability. I.E.

A92-56276
COMPUTED TOMOGRAPHY (CT) AS A NONDESTRUCTIVE TEST METHOD USED FOR COMPOSITE HELICOPTER COMPONENTS
REINHOLD OSTER (MBB GmbH, Munich, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 8 p. Previously announced in STAR as N92-29873.

The first components of primary helicopter structures to be made of glass fiber reinforced plastics were the main and tail rotor blades of the Bo105 and BK 117 helicopters. These blades are now successfully produced in series. New developments in rotor components, e.g., the rotor blade technology of the Bo108 and PAH2 programs, make use of very complex fiber reinforced structures to achieve simplicity and strength. Computer tomography was found to be an outstanding nondestructive test method for examining the internal structure of components. A CT scanner generates x-ray attenuation measurements which are used to produce computer reconstructed images of any desired part of an object. The system images a range of flaws in composites in a number of views and planes. Several CT investigations and their results are reported taking composite helicopter components as an example. Author

A92-56296
TIME RESOLVED LIDAR FLUOROSENSOR OPERATING FROM HELICOPTER
ALFREDO BIANCHI, ALBERTO GALLOTTI (Agusta S.p.A., Tradate, Italy), CLAUDIO KOECHLER, and JEAN VERDEBOUT (CEC, Joint Research Centre, Ispra, Italy) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 12 p.

The design and the principles of operation of the Time Resolved Lidar Fluorosensor (TRLF) developed for environmental surveys from helicopters are described. Results are presented on validation tests showing that the TRLF is particularly suitable for obtaining data on the characteristics of oil spills on the sea surface and for the analysis of water column parameters. A diagram illustrating the conceptual layout of TRLF is presented. I.S.

A92-56320
INFLUENCE OF CROSS SECTION VARIATIONS ON THE STRUCTURAL BEHAVIOUR OF COMPOSITE ROTOR BLADES
HELMUT RAPP and RUDOLF WOERNDLE (MBB GmbH, Munich, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 9 p. refs

A highly sophisticated structural analysis is required for helicopter rotor blades with nonhomogeneous cross sections made from nonisotropic material. Combinations of suitable analytical techniques with FEM-based techniques permit a cost effective and sufficiently accurate analysis of these complicated structures. It is determined that in general the 1D engineering theory of bending combined with 2D theories for determining the cross section properties is sufficient to describe the structural blade behavior. R.E.P.

A92-56322
A FINITE ELEMENT METHOD FOR SHEAR STRESSES CALCULATION IN COMPOSITE BLADE MODELS
B. PALUCH (ONERA, Institut de Mecanique des Fluides de Lille, France) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 30 p. refs

A finite-element method is developed for accurately calculating shear stresses in helicopter blade models, induced by torsion and shearing forces. The method can also be used to compute the equivalent torsional stiffness of the section, their transverse shear coefficient, and the position of their center of torsion. A grid generator method which is a part of the calculation program is also described and used to discretize the sections quickly and to condition the grid data reliably. The finite-element method was validated on a few sections composed of isotropic materials and was then applied to a blade model sections made of composite materials. Good agreement was obtained between the calculated and experimental data. I.S.

A92-56324* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DETAILED ANALYSIS AND TEST CORRELATION OF A STIFFENED COMPOSITE WING PANEL
D. D. DAVIS, JR. (U.S. Army, Aerostructures Directorate; NASA, Langley Research Center, Hampton, VA) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 16 p. refs

New finite element analysis methods are examined by application to a complicated composite wing panel from the V-22 rotorcraft. A detailed FEM model with a relatively coarse mesh of 9-node elements was generated, and linear and nonlinear stress analyses, first-ply failure analyses, and buckling analyses were conducted. At low values of applied load, i.e., up to the design ultimate load of the panel, the linear stress analysis accurately predicted the strains and structural response characteristics of the panel. R.E.P.

A92-56371* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SURFACE HEAT TRANSFER AND FLOW PROPERTIES OF VORTEX ARRAYS INDUCED ARTIFICIALLY AND FROM CENTRIFUGAL INSTABILITIES
C. S. SUBRAMANIAN (Florida Institute of Technology, Melbourne), P. M. LIGRANI (Utah, University, Salt Lake City), and M. F. TUZZOLO (U.S. Naval Postgraduate School, Monterey, CA) International Journal of Heat and Fluid Flow (ISSN 0142-727X), vol. 13, no. 3, Sept. 1992, p. 210-223. Research sponsored by U.S. Navy and U.S. Army. refs
(Contract NASA ORDER C-30030-P)
Copyright

The paper presents and compares fluid-flow and heat transfer properties from artificially induced vortices in a flat-plate turbulent boundary layer and naturally occurring vortices due to centrifugal instabilities in a curved-channel laminar flow. Pairs and arrays of vortices are artificially induced by placing half-delta wings on the plate surface. With both arrays and pairs of vortices, streamwise velocities and total pressures are high, and surface heat transfer is locally augmented in vortex downwash regions. In contrast to vortices in the arrays vortices in the pairs tend to move in the streamwise direction with significant divergence (when the common flow between pair is toward the wall) or convergence (when the common flow between pair is away from the wall). The vortices in the arrays cause maximum peak-to-peak heat transfer variations of up to 12 percent of local spanwise-averaged values for initial vortex spacings between 1 to 2.5 generator heights. C.A.B.

A92-56374
ASSESSMENT OF CALCULATION METHODS FOR EFFICIENCY OF STRAIGHT FINS OF RECTANGULAR PROFILE
L. J. HUANG and R. K. SHAH (General Motors Corp., Harrison Div., Lockport, NY) International Journal of Heat and Fluid Flow

(ISSN 0142-727X), vol. 13, no. 3, Sept. 1992, p. 282-293. refs
Copyright

A critical assessment is presented of the accuracy of the conventional 1D fin efficiency formula when the following effects are included in the analysis: the effect of 2D heat flow (thick fin), temperature dependent fin thermal conductivity, nonuniform heat transfer coefficient over the fin surface, nonuniform temperature of the ambient fluid, finite longitudinal heat conduction in the fin in the fluid flow direction, and temperature depression at the fin base. It is found that the idealization of the uniform heat transfer coefficient may lead to gross errors in analyzing extended surface heat transfer. Nonuniform ambient temperature has a 1-percent effect on the fin efficiency for 1D fin efficiency of greater than 60 percent and hence can be neglected. The fin base temperature depression increases the total heat flow rate through the extended surface compared with that with no fin base temperature depression, and hence neglecting this effect provides a conservative approach for the extended surface heat transfer.
C.A.B.

A92-56607
TRANSVERSE SHEAR EFFECT ON FLUTTER OF COMPOSITE PANELS
LE-CHUNG SHIAU and JING-TANG CHANG (National Cheng Kung University, Tainan, Taiwan) Journal of Aerospace Engineering (ISSN 0893-1321), vol. 5, no. 4, Oct. 1992, p. 465-479. refs
Copyright

The effect of transverse shear deformation on the supersonic flutter of composite panels has been investigated using the finite element method. First-order shear-deformation laminated-plate theory and quasi-steady aerodynamic theory are employed for the analysis. The total displacement of the plate is expressed as the sum of the displacement due to bending and the displacement due to shear deformation. Thus, the aerodynamic pressure induced by the plate motion is also the sum of the pressure induced by bending deformation and the pressure induced by shear deformation. Numerical results show that the transverse shear deformation may have a significant effect on the flutter boundary if aerodynamic damping were small or neglected in the determination of flutter boundary.
Author

A92-56735#
DEVELOPMENT OF LOCAL NONINTRUSIVE MEASUREMENTS OF INLET AND EXHAUST FLOWS FOR THE GROUND TESTING OF AIR-BREATHING ENGINES
RONALD H. KOHL (Sverdrup Technology, Inc., AEDC Group, Arnold AFB, TN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 14 p. refs
(AIAA PAPER 92-3899)

Requirements for nonintrusive diagnostics and measurements of gas flows in the ground testing of propulsion systems are examined with particular reference to turbine and hydrogen engine testing. The discussion focuses on test conditions, test parameter requirements, time and space requirements, and test and measurement parameter uncertainties. Attention is then given to development directions, general development path, laboratory demonstration for application, and development of nonintrusive techniques.
V.L.

A92-56765#
HOLOGRAPHIC AND PLIF MEASUREMENTS OF FREE-FLIGHT HYPERVELOCITY FLOWS IN THE AEDC RANGE G FACILITY
GEORGE HAVENER and MICHAEL S. SMITH (Calspan Corp., Arnold AFB, TN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 13 p. Research supported by USAF. refs
(AIAA PAPER 92-3935)

A laser diagnostics approach to investigating hypervelocity flows is presented which is based on pulsed laser holography (PLH) and planar laser-induced fluorescence (PLIF). PLH is used to visualize projectiles and near-wake flow fields, and holographic interferometry provides optical phase maps that are reducible to flow density. PLIF is used to visualize the distribtion of nitric oxide and to quantify number densities in planes across the wake.
O.G.

A92-56788#
TURBINE ENGINE HOT-PART TEMPERATURE MEASUREMENT TECHNIQUES
A. G. JACKSON and M. B. PRUFERT (Sverdrup Technology, Inc., Arnold AFB, TN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 12 p. refs
(AIAA PAPER 92-3960)

The paper identifies altitude test facility techniques for nonintrusive acquisition of hot-part temperatures using IR radiance measurements. The techniques discussed are applicable for turbojet and low-bypass turbofan engines. Constraints limiting IR measurements in the altitude ground test facility are discussed. Methods for evaluating altitude ground test data are outlined including review of predictive capabilities which enable the determination of the influence of turbine engine hot-part temperatures on IR emissions.
Author

A92-56824#
THE CRYOGENIC BALANCE DESIGN AND BALANCE CALIBRATION METHODS
B. EWALD (Darmstadt, Technische Universitaet, Germany), L. POLANSKI (Carl Schenck AG, Darmstadt, Germany), and E. GRAEWE (Deutsche Airbus GmbH, Bremen, Germany) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 13 p. refs
(AIAA PAPER 92-4001) Copyright

The current status of a program aimed at the development of a cryogenic balance for the European Transonic Wind Tunnel is reviewed. In particular, attention is given to the cryogenic balance design philosophy, mechanical balance design, reliability and accuracy, cryogenic balance calibration concept, and the concept of an automatic calibration machine. It is shown that the use of the automatic calibration machine will improve the accuracy of calibration while reducing the man power and time required for balance calibration.
V.L.

A92-56826#
APPLICATION OF ELECTRONICALLY SCANNED PRESSURE MEASUREMENT SYSTEM FOR ENGINE SIMULATION TESTS IN THE GERMAN-DUTCH WIND TUNNEL
J. W. KOOI (DNW German-Dutch Wind Tunnel, Emmeloord, Netherlands), W. BURGSMUELLER (Deutsche Airbus GmbH, Bremen, Germany), G. H. HEGEN, and J. F. SLAUERHOFF (National Aerospace Laboratory, Emmeloord, Netherlands) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 18 p. refs
(AIAA PAPER 92-4003) Copyright

The accuracy of an electronic scanning system is assessed for the calibration of turbofan powered simulators (TPS) with mechanical and electronic systems measuring in parallel. Pressure and temperature fluctuations were investigated. The test data was analyzed using the measurement uncertainty methodology applied for full-scale gas-turbine testing. This method was also used to calculate the propagation of TPS calibration and pressure measurement errors to the wind-tunnel results. It was found that the accuracy of mechanical and electronic results is comparable. The electronic scanning system has a much higher scanning rate and it is expected that the wind-tunnel test time can be reduced by about 10 to 20 percent or equivalent increases in data rates.
Author

A92-56828*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CALIBRATION OF HEMISPHERICAL-HEAD FLOW ANGULARITY PROBES
EDWARD L. CLARK, JOHN F. HENFLING, and DANIEL P. AESCHLIMAN (Sandia National Laboratories, Albuquerque, NM) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN,

July 6-8, 1992. 10 p. refs
(Contract DE-AC04-76DP-00789; NASA ORDER C-22955-P)
(AIAA PAPER 92-4005)

The hemisphere-cylinder flow angularity probes were calibrated over a Mach number range of 0.5 to 2.0 at pitch and yaw angles of -5 to +5 deg. Each probe had five pressure orifices in the hemispherical head - one on the axis and four located 45 deg from the axis and equally spaced circumferentially. The probes were identical within fabrication tolerances. Details of probe design, test procedures and data analysis are described and selected test results are presented. Author

A92-56829# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DESCRIPTION OF A PRESSURE MEASUREMENT TECHNIQUE FOR OBTAINING SURFACE STATIC PRESSURES OF A RADIAL TURBINE
L. D. DICICCO, BRENT C. NOWLIN (NASA, Lewis Research Center, Cleveland, OH), and LIZET TIRRES (Sverdrup Technology, Inc., Brook Park) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 10 p. Previously announced in STAR as N92-24959. refs
(Contract RTOP 535-05-10)
(AIAA PAPER 92-4006)

The aerodynamic performance of a solid uncooled version of a cooled radial turbine was evaluated in the Small Engine Components Test Facility Turbine rig at the NASA Lewis Research Center. Specifically, an experiment was conducted to rotor surface static pressures. This was the first time surface static pressures had been measured on a radial turbine at NASA Lewis. These pressures were measured by a modified Rotating Data Package (RDP), a standard product manufactured by Scanivalve, Inc. Described here are the RDP, and the modifications that were made, as well as the checkout, installation, and testing procedures. The data presented are compared to analytical results obtained from NASA's MERIDL TSONIC BLAYER (MTSB) code. Author

A92-56860#
DAMAGE TOLERANT DESIGN OF CRITICAL AIRCRAFT STRUCTURAL COMPONENTS
DAVID A. BEARDEN and BRUCE B. STARLEY (Utah, University, Salt Lake City) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 17 p. refs
(AIAA PAPER 92-4041) Copyright

A study of damage tolerant design as applied to the design, manufacture and inspection of critical aircraft components was performed. Damage tolerant methods of design assume that all materials possess discontinuities and heterogeneities, and therefore 'infinite life methods' cannot be applicable in 'real life' cases. In this study it was shown that fracture mechanics can be used to determine a failure criteria for a given stress and crack length as a function of fracture toughness. Also discussed was how material degradation and crack propagation can be affected by other factors such as thermal behavior, chemical behavior, and metallurgical changes. The research indicates the importance of inspection techniques that contribute significantly in detecting cracks for further analysis as well as crack growth rates for components under fatigue and residual stresses. In this manner, failure in critical components can be identified before catastrophic failure occurs through repair or replacement of the damaged part. The application of damage tolerant techniques and design approaches contributes to the safe and reliable design of aircraft structural components both before and after they reach the field. This knowledge, if correctly applied, could greatly improve current verification and certification testing procedures. Author

A92-56866
A DYNAMIC STIFFNESS TECHNIQUE FOR THE VIBRATION ANALYSIS OF STIFFENED SHELL STRUCTURES
R. S. LANGLEY (Cranfield Institute of Technology, United Kingdom) Journal of Sound and Vibration (ISSN 0022-460X), vol. 156, no. 3, Aug. 8, 1992, p. 521-540. refs
Copyright

A dynamic stiffness method is presented for the analysis of stiffened shell structures. The method is based on a singly curved orthogonally stiffened shell element which has a constant radius of curvature and which is simply supported along the curved edges. The stiffeners are taken to be smeared over the surface of the element, and Hamilton's principle is used to derive the appropriate modifications which must be made to the shell differential equations and boundary conditions. The resulting differential equations are solved exactly to yield the dynamic stiffness matrix and the loading vector for the element. Any number of elements may be assembled to model the cross-section of a built-up structure such as an aircraft fuselage. A discrete stringer element is also derived which enables the detailed analysis of smaller structural components such as an array of stiffened panels. The method is applied to a range of stiffened circular cylinders, a cylinder with an internal floor, and a five-panel/six-stringer array. Author

A92-57039
STAINLESS STEEL WELDING SHINES THROUGH ON WIND TUNNEL PROJECT
Welding Journal (ISSN 0043-2296), vol. 71, no. 9, Sept. 1992, p. 65-67.
Copyright

The European transonic wind (ETW) tunnel designed by Babcock Energy at Renfrew, Scotland, and erected in Cologne, Germany, is described which is scheduled to be operational in 1994. This cryogenic tunnel is capable of operating under pressures from 1.25 to 4.5 bar in a temperature range from 183 to 40 C through the use of liquid nitrogen injection. Topics discussed include selection of welding consumables, metallurgy, ETW fabrication, and welding processes and techniques. O.G.

A92-57288
STOKES FLOWS IN SUPERPOSED IMMISCIBLE LIQUIDS WITH HORIZONTAL HEATING
A. VIVIANI and C. GOLIA (Napoli, Universita, Naples, Italy) IAF, International Astronautical Congress, 43rd, Washington, Aug. 28-Sept. 5, 1992. 17 p. refs
(IAF PAPER 92-0909) Copyright

Attention is given to surface tension and buoyancy driven free convection within two superposed immiscible fluids enclosed in rectangular cavities with differentially heated end walls. For small nondimensional transport numbers and crispation number, the field variables are expressed as power series of the small parameters, by obtaining a series of successive linear approximations to the field equations. The zeroth order approximation for the velocity field is the Stokes problem, which is reformulated in terms of the stream function and analytically solved via separation of variables by means of infinite series of the Papkovitch-Fadle complex biorthogonal functions. The pressure field is computed as well as the first order interface shape. The flowfield structure, velocity profiles, interface velocity, and interface deformation are analyzed in terms of the aspect ratios of the upper and lower fluids and of their viscosity ratio, for Marangoni, natural, and combined convection. P.D.

A92-57399
EFFECTS OF SPECTRUM VARIATIONS ON FATIGUE CRACK GROWTH
A. LANCIOTTI and L. LAZZERI (Pisa, University, Italy) International Journal of Fatigue (ISSN 0142-1123), vol. 14, no. 5, Sept. 1992, p. 319-324. Research supported by Rinaldo Piaggio S.p.A. refs
Copyright

Results are presented of an experimental program carried out in support of the certification of the Piaggio P.180 aircraft. In these tests, particular attention was given to the effects of truncating high loads and of omitting small cycles on fatigue-crack propagation. The results of tests are compared to analytical predictions, obtained by using a simple closure model, and with published experimental results. I.S.

N92-32265*# United Technologies Research Center, East Hartford, CT.
TURBINE DISK CAVITY AERODYNAMICS AND HEAT TRANSFER
B. V. JOHNSON and W. A. DANIELS *In* NASA. Goddard Space Flight Center, Tenth Workshop for Computational Fluid Dynamic Applications in Rocket Propulsion, Part 2 p 1163-1179 Jul. 1992
(Contract NAS8-37462)
Avail: CASI HC A03/MF A05

Experiments were conducted to define the nature of the aerodynamics and heat transfer for the flow within the disk cavities and blade attachments of a large-scale model, simulating the Space Shuttle Main Engine (SSME) turbopump drive turbines. These experiments of the aerodynamic driving mechanisms explored the following: (1) flow between the main gas path and the disk cavities; (2) coolant flow injected into the disk cavities; (3) coolant density; (4) leakage flows through the seal between blades; and (5) the role that each of these various flows has in determining the adiabatic recovery temperature at all of the critical locations within the cavities. The model and the test apparatus provide close geometrical and aerodynamic simulation of all the two-stage cavity flow regions for the SSME High Pressure Fuel Turbopump and the ability to simulate the sources and sinks for each cavity flow. Author

N92-32268*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A CRITICAL EVALUATION OF A THREE-DIMENSIONAL NAVIER-STOKES CFD AS A TOOL TO DESIGN SUPERSONIC TURBINE STAGES
C. HAH, O. KWON, and M. SHOEMAKER *In* NASA. Goddard Space Flight Center, Tenth Workshop for Computational Fluid Dynamic Applications in Rocket Propulsion, Part 2 p 1227-1241 Jul. 1992
Avail: CASI HC A03/MF A05

Three-dimensional flow phenomena in a supersonic turbine blade row were studied numerically to evaluate CFD as a tool to design supersonic turbine stages. The details of the three-dimensional flow structure inside the supersonic turbine blade row and the overall aerodynamic performance at design and off-design conditions are analyzed and the results are compared between the experimental data and the numerical results. Author

N92-32270*# Pennsylvania State Univ., University Park.
NUMERICAL SIMULATION OF TURBOMACHINERY FLOWS WITH ADVANCED TURBULENCE MODELS
B. LAKSHMINARAYANA, R. KUNZ, J. LUO, and S. FAN *In* NASA. Goddard Space Flight Center, Tenth Workshop for Computational Fluid Dynamic Applications in Rocket Propulsion, Part 2 p 1275-1306 Jul. 1992
Avail: CASI HC A03/MF A05

A three dimensional full Navier-Stokes (FNS) code is used to simulate complex turbomachinery flows. The code incorporates an explicit multistep scheme and solves a conservative form of the density averaged continuity, momentum, and energy equations. A compressible low Reynolds number form of the k-epsilon turbulence model, and a q-omega model and an algebraic Reynolds stress model have been incorporated in a fully coupled manner to approximate Reynolds stresses. The code is used to predict the viscous flow field in a backswept transonic centrifugal compressor for which laser two focus data is available. The code is also used to simulate the tip clearance flow in a cascade. The code has been extended to include unsteady Euler solutions for predicting the unsteady flow through a cascade due to incoming wakes, simulating rotor-stator interactions. Author

N92-32292*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Mechanical Engineering.
EFFECTS OF CURVATURE AND ROTATION ON TURBULENCE IN THE NASA LOW-SPEED CENTRIFUGAL COMPRESSOR IMPELLER
JOAN G. MOORE and JOHN MOORE *In* NASA. Goddard Space Flight Center, Tenth Workshop for Computational Fluid Dynamic Applications in Rocket Propulsion, Part 1 p 315-338 Jul. 1992
Avail: CASI HC A03/MF A05

The flow in the NASA Low-Speed Impeller is affected by both curvature and rotation. The flow curves due to the following: (1) geometric curvature, e.g. the curvature of the hub and shroud profiles in the meridional plane and the curvature of the backswept impeller blades; and (2) secondary flow vortices, e.g. the tip leakage vortex. Changes in the turbulence and effective turbulent viscosity in the impeller are investigated. The effects of these changes on three-dimensional flow development are discussed. Two predictions of the flow in the impeller, one with, and one without modification to the turbulent viscosity due to rotation and curvature, are compared. Some experimental and theoretical background for the modified mixing length model of turbulent viscosity will also be presented. Author

N92-32632# Wright Lab., Wright-Patterson AFB, OH.
AN EXAMINATION OF SEVERAL HIGH RESOLUTION SCHEMES APPLIED TO COMPLEX PROBLEMS IN HIGH SPEED FLOWS Final Report, Jun - Dec. 1991
NORBERT KROLL, MICHAEL AFTOSMIS, and DATTA GAITONDE 2 Feb. 1992 63 p
(Contract AF PROJ. 2307)
(AD-A250814; WL-TR-91-3089) Avail: CASI HC A04/MF A01

A comparative study of five upwind schemes was performed to evaluate their ability to accurately model the convective fluxes of the Euler equations for problems containing complex shock structure. The schemes investigated used a variety of Reimann solvers and obtained higher order accuracy using either a MUSCL or non-MUSCL approach. The MUSCL-type schemes included the flux vector split formulations of Steiger-Warming and van Leer and the flux difference split approach of Roe. The Non-MUSCL schemes included the Symmetric and Upwind TVD methods of Yee, and Harten and Yee. Two central difference schemes provide a basis for the evaluation of these upwind methods. The comparison was performed using identical meshes and convergence criteria. In a supersonic blunt body flow, all the upwind schemes displayed comparably resolved bow shocks, independent of free stream Mach number. However, a complex type IV shock on cowl lip example pointed out significant differences in the accuracy and convergence behavior of the schemes. A comparison of the flow structure shown by the various algorithms on identical grids indicated that the discrete solutions obtained with Upwind TVD and Roe flux difference splitting were the least diffusive of the upwind methods considered. GRA

N92-32686# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
AIRPORT SURVEILLANCE RADAR (ASR-9) WIND SHEAR PROCESSOR: 1991 TEST AT ORLANDO, FLORIDA
M. E. WEBER 1 Jun. 1992 44 p
(Contract DTFA01-89-Z-02030)
(AD-A252246; ATC-189; DOT/FAA/NR-92/7) Avail: CASI HC A03/MF A01

An operational test of a Wind Shear Processor (WSP) add-on to the Federal Aviation Administration's airport surveillance radar (ASR-9) took place at Orlando International Airport during July and August 1991. The test allowed for both quantitative assessment of the WSP's signal processing and wind shear detection algorithms and for feedback from air traffic controllers and their supervisors on the strengths and weaknesses of the system. Thunderstorm activity during the test period was intense; low-altitude wind shear impacted the runways or approach/departure corridors on 40 of the 53 test days. As in previous evaluations of the WSP in the southeastern United States, microburst detection performance was very reliable. Over 95 percent of the strong microbursts that affected the Orlando airport during the test period were detected by the system. Gust front detection during the test, while operationally useful, was not as reliable as it should have been, given the quality of gust front signatures in the base reflectivity and radial velocity data from the WSP. Subsequent development

of a Machine Intelligent Gust Front Algorithm has resulted in significantly improved detection capability. Results from the operational test are being utilized in ongoing refinement of the WSP. GRA

N92-32742# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany).
EXAMPLES OF ADVANCED NEAR-NET SHAPE MANUFACTURING TECHNIQUES FOR AEROSPACE
P.-J. WINKLER and H.-E. FRIEDRICH 1991 29 p Presented at the 1991 Advanced Aerospace Material/Processes Conference, Long Beach, CA, 20-24 May 1991 Submitted for publication
(MBB-Z-0399-91-PUB; ETN-92-92118) Avail: CASI HC A03/MF A01

Aerospace industry manufacturing technology is reviewed. The following are described: development principles for materials and construction methods; influence of valuable materials; present and future requirements for metallic structural components in aircraft building; near-net shape technologies and typical applications; design and manufacturing principles for superelastic forming and the combination with diffusion bonding; the incremental forcing process; further developments in investment casting. The need to rationalize manufacturing processes and the wish to obtain improved performance in aircraft will continue to provide the necessary impulse to develop innovative manufacturing methods. The development of suitable 'near-net shape' technologies will play an important part in the design of the aircraft of the future. ESA

N92-32776# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction des Structures.
STRONG COUPLING BETWEEN INVISCID FLUID AND BOUNDARY LAYER OF SHARP LEADING EDGES: TWO-DIMENSIONAL STATIONARY AND TURBULENT CASES FOR ISOLATED PROFILES AND GUARD VANES [DOUPLAGE FORT FLUIDE PARFAIT COUCHE LIMITE POUR DES PROFILES A BORD D'ATTAQUE AIGU. CAS 2D STATIONNAIRE ET INSTATIONNAIRE POUR DES PROFILS ISOLES ET POUR LES GRILLES D'AUBES]
C. SOIZE Dec. 1991 75 p In FRENCH
(Contract DRET-89-34-001)
(ONERA-RT-44/1621-RY-016-R; ETN-92-91675) Avail: CASI HC A04/MF A01

The theory and the numerical model concerning the strong coupling between the inviscid fluid and the upper boundary layer are presented. The calculations are performed for two dimensional turbulent and stationary conditions. The results were compared to those obtained from wind tunnel tests, and a good agreement between them is obtained. A quasi-stationary simplified method to approximately calculate, at low costs, the turbulent aerodynamic forces for guard vanes, is given. ESA

N92-32856 British Petroleum Co. Ltd., London (England).
SPRAY NOZZLE FOR FIRE CONTROL Patent Application
PANAYIOTIS G. PAPAVERGOS, inventor 14 Sep. 1990 15 p
(CA-PATENT-APPL-SN-2-011-945;
INT-PATENT-CLASS-B05B-1/00; CTN-92-60391) Avail: Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC/MF

The design of a spray nozzle for fire control is described. It produces a spray of gas and liquid having an oval transverse cross section and it comprises a mixing chamber with an oval transverse cross section adapted to induce a toroidal mixing pattern in pressurized gas and liquid introduced to the mixing chamber through a plurality of inlets. In a preferred embodiment the mixing chamber is toroidal. The spray nozzle produces an oval spray pattern for more efficient wetting of narrow passages and is suitable for fire control systems in vehicles or other confined spaces. Vehicles to which this invention may be applied include trains, armoured vehicles, ships, hovercraft, submarines, oil rigs, and most preferably, aircraft. CISTI

N92-32964*# Applied Acoustic Research, State College, PA.
A LIGHTWEIGHT LOUDSPEAKER FOR AIRCRAFT COMMUNICATIONS AND ACTIVE NOISE CONTROL
GLENN E. WARNAKA, MARK KLEINLE (Oxford Speaker Co., Chicago, IL.), PARRY TSANGARIS (Oxford Speaker Co., Chicago, IL.), MICHAEL J. OSLAC (Oxford Speaker Co., Chicago, IL.), and HARRY J. MOSKOW (Oxford Speaker Co., Chicago, IL.) *In* NASA. Langley Research Center, Fourth Aircraft Interior Noise Workshop p 316-327 Jul. 1992
Avail: CASI HC A03/MF A03

A series of new, lightweight loudspeakers for use on commercial aircraft has been developed. The loudspeakers use NdFeB magnets and aluminum alloy frames to reduce the weight. The NdFeB magnet is virtually encapsulated by steel in the new speaker designs. Active noise reduction using internal loudspeakers was demonstrated to be effective in 1983. A weight, space, and cost efficient method for creating the active sound attenuating fields is to use the existing cabin loudspeakers for both communication and sound attenuation. This will require some additional loudspeaker design considerations. Author

N92-33066# Universiteit Twente, Enschede (Netherlands). Fluid Mechanics and Heat Transfer Group.
ON THE ORIGIN AND ACOUSTICAL BEHAVIOUR OF CLOUD CAVITATION Ph.D. Thesis
JAKOB BUIST 1991 139 p Sponsored by Maritime Research Inst., Netherlands
(Contract TTN77-1038)
(ISBN-90-9004317-9; ETN-92-92041) Copyright Avail: CASI HC A07/MF A02

Cavitation noise, produced by ship propellers, is addressed. Here, cavitation is defined as the occurrence and physical behavior of vapor filled voids in a fluid flow. These cavities, which arise in low pressure areas, are carried with the flow and implode in high pressure regions. The subsequent oscillations produce high noise levels both on-board the ship concerned and in the far field. In particular, an investigation into the problem of how to provide rules for the prediction of cavitation noise, based upon measurements on model scale, is made. On model scale, all similarity conditions cannot be satisfied simultaneously, and hence, scaling rules are needed. Up to now the scaling rules, which are given in the literature, are obtained by considering the behavior of individual bubbles. In practical situations, however, bubble clouds are observed, in which interactions between bubbles are of utmost importance. The issues addressed cover: the prediction of cloud cavitation noise; the relative importance of cluster formation in bubble mixtures; and the origin of bubble clouds. ESA

N92-33104*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL METHODS FOR GLOBAL/LOCAL ANALYSIS
JONATHAN B. RANSOM, SUSAN L. MCCLEARY (Lockheed Engineering and Sciences Co., Hampton, VA.), MOHAMMAD A. AMINPOUR (Analytical Services and Materials, Inc., Hampton, VA.), and NORMAN F. KNIGHT, JR. (Clemson Univ., SC.) Aug. 1992 24 p
(Contract RTOP 505-63-53-01)
(NASA-TM-107591; NAS 1.15:107591) Avail: CASI HC A03/MF A01

Computational methods for global/local analysis of structures which include both uncoupled and coupled methods are described. In addition, global/local analysis methodology for automatic refinement of incompatible global and local finite element models is developed. Representative structural analysis problems are presented to demonstrate the global/local analysis methods. Author

N92-33139*# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
GLOBAL/LOCAL INTERLAMINAR STRESS ANALYSIS OF A GRID-STIFFENED COMPOSITE PANEL
J. F. M. WIGGENRAAD and N. R. BAULD, JR. (Clemson Univ.,

SC.) 30 May 1991 21 p Presented at the 6th American Society for Composites Technical Conference, Albany, NY, 6-9 Oct. 1991
(Contract NAS1-17925)
(NASA-CR-190822; NAS 1.26:190822; NLR-TP-91052-U; ETN-92-91996) Avail: CASI HC A03/MF A01

A global/local procedure for the computation of the interlaminar stress components at the skin wrap, skin core, and wrap core interfaces for an advanced concept stiffened panel, is described. The procedure consists of a global model of two dimensional shell elements that is used to design a grid stiffened panel with blade type stiffeners, a local model of three dimensional solid elements that is used to compute interlaminar stress components, and a scheme devised to assign displacement boundary conditions for a local model that are based on displacement and rotation data of a few nodes of the global model. A global panel was designed according to strength, stiffness, and stability criteria associated with the design of traditional aircraft wing panels. Interlaminar normal and shearing stress components, computed via the local model, were found to be well below typical tensile normal and shearing strengths of a graphite epoxy material.
ESA

N92-33307*# Michigan Univ., Ann Arbor. Radiation Lab.
DEVELOPMENT OF 3D ELECTROMAGNETIC MODELING TOOLS FOR AIRBORNE VEHICLES Semiannual Progress Report, Feb. - Sep. 1992
JOHN L. VOLAKIS Sep. 1992 44 p
(Contract NAG2-541)
(NASA-CR-190810; NAS 1.26:190810; UMICH-025921-32-T)
Avail: CASI HC A03/MF A01

The main goal of this project is to develop methodologies for scattering by airborne composite vehicles. Although our primary focus continues to be the development of a general purpose code for analyzing the entire structure as a single unit, a number of other tasks are also pursued in parallel with this effort. These tasks are important in testing the overall approach and in developing suitable models for materials coatings, junctions and, more generally, in assessing the effectiveness of the various parts comprising the final code. Here, we briefly discuss our progress on the five different tasks which were pursued during this period. Our progress on each of these tasks is described in the detailed reports (listed at the end of this report) and the memoranda included. The first task described below is, of course, the core of this project and deals with the development of the overall code. Undoubtedly, it is the outcome of the research which was funded by NASA-Ames and the Navy over the past three years. During this year we developed the first finite element code for scattering by structures of arbitrary shape and composition. The code employs a new absorbing boundary condition which allows termination of the finite element mesh only 0.3 lambda from the outer surface of the target. This leads to a remarkable reduction of the mesh size and is a unique feature of the code. Other unique features of this code include capabilities to model resistive sheets, impedance sheets and anisotropic materials. This last capability is the latest feature of the code and is still under development. The code has been extensively validated for a number of composite geometries and some examples are given. The validation of the code is still in progress for anisotropic and larger non-metallic geometries and cavities. The developed finite element code is based on a Galerkin's formulation and employs edge-based tetrahedral elements for discretizing the dielectric sections and the region between the target and the outer mesh termination boundary (ATB). This boundary is placed in conformity with the target's outer surface, thus resulting in additional reduction of the unknown count.
Author

N92-33440 McMaster Univ., Hamilton (Ontario).
RADAR CLUTTER CLASSIFICATION Ph.D. Thesis
WOLFGANG STEHWIEN Nov. 1989 373 p
(ISBN-0-315-57981-1; CTN-92-60565) Copyright Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC/MF

The problem of classifying radar clutter as found on air traffic control radar systems is studied. An algorithm based on Bayes decision theory and the parametric maximum a posteriori probability classifier is developed to perform this classification automatically. This classifier employs a quadratic discriminant function and is optimum for feature vectors that are distributed according to the multivariate normal density. Separable clutter classes are most likely to arise from the analysis of the Doppler spectrum. Specifically, a feature set based on the complex reflection coefficients of the lattice prediction error filter is proposed. The classifier is tested using data recorded from L-band air traffic control radars. The Doppler spectra of these data are examined; the properties of the feature set computed using these data are studied in terms of both the marginal and multivariate statistics. Several strategies involving different numbers of features, class assignments, and data set pretesting according to Doppler frequency and signal to noise ratio were evaluated before settling on a workable algorithm. Final results are presented in terms of experimental misclassification rates and simulated and classified plane position indicator displays. Author (CISTI)

N92-33480# Galaxy Scientific Corp., Mays Landing, NJ.
CURRENT NONDESTRUCTIVE INSPECTION METHODS FOR AGING AIRCRAFT Final Report
GEORGE ANSLEY, STEPHEN BAKANAS, MAURICE CASTRONUOVA, TED GRANT, and FRANK VICHI Jun. 1992 134 p
(Contract DTFA03-89-C-00043)
(DOT/FAA/CT-91/5) Avail: CASI HC A07/MF A02

This report identifies and describes current methods used during the nondestructive inspection (NDI) of commercial transport aircraft for structural damage. The six most prevalent NDI methods identified are visual, eddy current, radiography, ultrasonic, penetrant, and magnetic particle. The physical principles, generalized performance characteristics, and typical applications associated with each method are described. In addition, descriptions of specific airframe and engine inspection practices are also presented. Author

N92-33498# Massachusetts Inst. of Tech., Cambridge. Gas Turbine Lab.
ACTIVE CONTROL OF COMPRESSOR SURGE AND STALL Progress Report, 1991-1992
C. BOUSSIOS, A. H. EPSTEIN, E. M. GREITZER, G. HENDRICKS, and J. PADUANO 1992 10 p Sponsored by Naval Ocean Systems Center
(AD-A252771) Avail: CASI HC A02/MF A01

Having demonstrated in previous years the ability to model, identify, and control rotating stall, our research has concentrated in the past year on refinements and extensions to the compressor modeling developed for active control research. The areas in which progress has been made are: (1) refinement of the basic fluid mechanics based on identification results, (2) understanding the effects of distortion on wave detection, and (3) using the nonlinear form of the rotating stall model to simulate short-circumferential extent waves. Three-stage actively stabilized compressor experiments supported this work, and further verified that rotating stall stabilization is a viable concept. GRA

N92-33501# National Inst. of Standards and Technology, Gaithersburg, MD.
PRELIMINARY SCREENING PROCEDURES AND CRITERIA FOR REPLACEMENTS FOR HALONS 1211 AND 1301 Final Report, Oct. 1989 - Sep. 1990
R. G. GANN, J. D. BARNES, S. DAVIS, J. S. HARRIS, and R. H. HARRIS Jul. 1991 326 p Sponsored by AFESC
(AD-A252912; NIST-TN-1278; ESL-TR-90-24) Avail: CASI HC A15/MF A03

Halons 1301 and 1211 are being restricted by the Montreal Protocol of 1987. This project facilitates identification of alternative chemicals by developing quick, inexpensive screening procedures for nine critical properties: fire suppression efficiency, ozone depletion potential, global warming potential, residue level, toxicity,

long-term storage stability, metals corrosion, electrical conductivity, and compatibility with plastics. The procedures are straight forward to conduct, require about 5 moles of chemical, and can be performed in about 8 days for less than $15k. Concurrent testing of many chemicals would cost less. Sample purity is critical. The test results are reported in classes that relate to the performance of Halons 1211 and 1301. Examples of testing sequences are provided. Interpretation of the results requires expert judgment since weak performance in a test may not be the basis for rejecting a chemical. These methods and performance classes have been developed for screening purposes only and should not be used for final selection procurement regulation without more extensive evaluation. GRA

N92-33538# Cranfield Inst. of Tech., Bedford (England). School of Mechanical Engineering.
RADIAL INFLOW TURBINE STUDY Interim Report No. 7
S. HAMID and R. L. ELDER Mar. 1992 11 p
(Contract DAJA45-89-C-0006)
(AD-A252783; R/D-5824-AN-01) Avail: CASI HC A03/MF A01

The radial inflow turbine is a primary component used both in small gas turbines and turbochargers. Better understanding of the flow processes occurring within the small passages of the machine could well result in the improved design of units. As most of the detailed aerodynamics is still ill-defined, a joint research project with the objective of improving our understanding has been instigated by Cranfield, the US Army and Turbomach (San Diego). This document gives the seventh report on the project and describes progress and measurements taken. GRA

N92-33627# Laser Technology, Inc., Norristown, PA
INSPECTION OF FABRICATED FUSELAGE PANELS USING ELECTRONIC SHEAROGRAPHY
JOHN TYSON, II and BEN FEFERMAN Jul. 1992 42 p
(Contract DTRS57-90-P-80922)
(DOT/FAA/CT-TN92/26) Avail: CASI HC A03/MF A01

The results of a proof of principle demonstration of using electronic shearography to detect induced damage in fabricated aircraft panels are presented. The demonstration was performed at the FAA's Aircraft Panel Test Facility in Waltham, Massachusetts and all shearography equipment and its operational support was provided by Laser Technology, Inc. (LTI) under a separate contract from the Volpe National Transportation Systems Center. The test panels that were inspected using the electronic shearography were constructed to closely simulate the fuselage and skin structure of Boeing 727 and 737 aircraft. These panels contained programmed flaws intended to simulate two major types of defects associated with aging aircraft, namely cracks along fastener rows, and disbonded tear strap doublers and lap joints. The proof of principle consisted of a series of inspections that demonstrated shearography's capability to detect cracks and disbonds in the fuselage panel specimens. The sensitivity of shearography to detect short, simulated fatigue cracks that would correspond to a multiple site damage situation was too low to provide sufficient confidence that the method could economically replace existing eddy current surface methods. The sensitivity of the method to detect panel disbonding, however, is sufficient to encourage further development of the technique. Author

N92-33696*# Illinois Inst. of Tech., Chicago. Dept. of Mechanical and Aerospace Engineering.
ELECTRO OPTICAL SYSTEM TO MEASURE STRAINS AT HIGH TEMPERATURE Final Report, 16 Jul. 1990 - 31 Dec. 1991
CESAR A. SCIAMMARELLA 31 Dec. 1991 58 p
(Contract NAG2-547)
(NASA-CR-190450; NAS 1.26:190450) Avail: CASI HC A04/MF A01

The measurement of strains at temperatures of the order of 1000 C has become a very important field of research. Technological advances in areas such as the analysis of high speed aircraft structures and high efficiency thermal engines require operational temperatures of this order of magnitude. Current techniques for the measurement of strains, such as electrical strain gages, are at the limit of their useful range and new methods need to be developed. Optical techniques are very attractive in this type of application because of their noncontacting nature. Holography is of particular interest because a minimal preparation of the surfaces is required. Optoelectronics holography is specially suited for this type of application, from the point of view of industrial use. There are a number of technical problems that need to be overcome to measure strains using holographic interferometry at high temperatures. Some of these problems are discussed, and solutions are given. A specimen instrumented with high temperature strains gages is used to compare the results of both technologies. Author

N92-33916# Ruhr Univ., Bochum (Germany). Fakultaet fuer Maschinenbau.
INFLUENCE OF THE SWIRL PRODUCING CONSTRUCTION IN THE FLOW AND REACTION FIELD OF TURBULENT DIFFUSION FLAMES Ph.D. Thesis [UEBER DEN EINFLUSS DER DRALLERZEUGERKONSTRUKTION AUF DAS STROEMUNGS- UND REAKTIONSFELD TURBULENTER DIFFUSIONSFLAMMEN]
BERNHARD MUNDUS 1990 181 p In GERMAN
(ETN-92-92103) Avail: CASI HC A09/MF A02

Data relating to the influences of single constructions on the aerodynamic properties of turbulent free jet and on the flow and reaction field of free burning turbulent diffusion flames were experimentally obtained and compared. The theoretical swirl number and the swirl number obtained from measuring data were used to describe the swirl power. It was shown that radial positions, and the rates of maximum turbulence degree depend on the swirl producing construction and on the swirl power. Swirl jets and flames were modelized using an integral process based on the analogy between unstationary heat conduction and impulse spreading for free turbulent flows. ESA

N92-33968 Old Dominion Univ., Norfolk, VA.
PREDICTION AND CONTROL OF ASYMMETRIC VORTICAL FLOWS AROUND SLENDER BODIES USING NAVIER-STOKES EQUATIONS Ph.D. Thesis
TIN-CHEE WONG 1991 245 p
Avail: Univ. Microfilms Order No. DA9130686

Steady and unsteady vortex-dominated flows around slender bodies at high angles of attack are solved by using the unsteady, compressible Navier-Stokes equations. An implicit upwind, finite-volume scheme is used for numerical computations. For supersonic flows past pointed bodies, the locally-conical flow assumption was used. Asymmetric flows past five-degree semi-apex cones using the thin-layer Navier-Stokes equations at different angles of attack, freestream Mach numbers, Reynolds numbers, grid fineness, computational domain size, sources of disturbances, and cross-section shapes were studied. The onset of flow asymmetry occurs when the relative incidence of pointed forebodies exceeds certain critical values. At these critical values of relative incidence, asymmetric flow develops irrespective of the sources of disturbances. The results of unsteady asymmetric flows show that periodic vortex shedding exists at larger angles of attack and it is independent of the numerical schemes used. Passive control of steady and unsteady asymmetric vortical flows around cones using vertical fins and side-strakes were also studied. Side-strikes control of flow asymmetry over a wide range of angles of attack requires shorter strake heights than those of the vertical-fin control and produces higher lift for the same cone. Three-dimensional, incompressible flows past a prolate spheroid and a tangent-ogive cylinder are solved and compared with experimental data for validation of the numerical scheme. Three-dimensional supersonic asymmetric flows around a five degree semi-apex angle circular cone at different angles of attack and Reynolds numbers are presented. Flow asymmetry was obtained using short-duration disturbances. The flow asymmetry becomes stronger as the Reynolds number and angle of attack are increased. The asymmetric solutions show spatial vortex shedding which is

qualitatively similar to the temporal vortex shedding of the unsteady locally-conical flow. Dissert. Abstr.

N92-34017*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FINITE DIFFERENCE TIME DOMAIN GRID GENERATION FROM AMC HELICOPTER MODELS
ROBIN L. CRAVEY Sep. 1992 12 p
(Contract RTOP 505-64-70-01)
(NASA-TM-107679; NAS 1.15:107679) Avail: CASI HC A03/MF A01

A simple technique is presented which forms a cubic grid model of a helicopter from an Aircraft Modeling Code (AMC) input file. The AMC input file defines the helicopter fuselage as a series of polygonal cross sections. The cubic grid model is used as an input to a Finite Difference Time Domain (FDTD) code to obtain predictions of antenna performance on a generic helicopter model. The predictions compare reasonably well with measured data. Author

N92-34036 Cincinnati Univ., OH.
THE DYNAMICS OF FLEXIBLE MULTIBODY SYSTEMS: A FINITE SEGMENT APPROACH Ph.D. Thesis
JOHN DAVID CONNELLY 1991 121 p
Avail: Univ. Microfilms Order No. DA9124223

The dynamics of rotating beams such as turbine or rotorcraft blades was studied. This was done using a dynamic formulation modified by incorporating flexibility effects. Springs and dampers were added to the end of rigid elements. These springs and dampers simulated the flexibility of the structure. The first goal was to develop these springs and dampers and to implement them into the equations of motion of the system. The second goal was to try to better understand the motion of rotating beams. Hopefully, this type of analysis offers advantages over other methods that arenow being used. Dissert. Abstr.

N92-34043*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
INVESTIGATION OF ADVANCING FRONT METHOD FOR GENERATING UNSTRUCTURED GRID Progress Report, period ending 31 May 1992
A. M. THOMAS and S. N. TIWARI Jun. 1992 74 p
(Contract NCC1-68)
(NASA-CR-190902; NAS 1.26:190902) Avail: CASI HC A04/MF A01

The advancing front technique is used to generate an unstructured grid about simple aerodynamic geometries. Unstructured grids are generated using VGRID2D and VGRID3D software. Specific problems considered are a NACA 0012 airfoil, a bi-plane consisting of two NACA 0012 airfoil, a four element airfoil in its landing configuration, and an ONERA M6 wing. Inviscid time dependent solutions are computed on these geometries using USM3D and the results are compared with standard test results obtained by other investigators. A grid convergence study is conducted for the NACA 0012 airfoil and compared with a structured grid. A structured grid is generated using GRIDGEN software and inviscid solutions computed using CFL3D flow solver. The results obtained by unstructured grid for NACA 0012 airfoil showed an asymmetric distribution of flow quantities, and a fine distribution of grid was required to remove this asymmetry. On the other hand, the structured grid predicted a very symmetric distribution, but when the total number of points were compared to obtain the same results it was seen that structured grid required more grid points. Author

N92-34112*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
APPLICATION OF COMPUTATIONAL FLUID DYNAMICS TO THE STUDY OF VORTEX FLOW CONTROL FOR THE MANAGEMENT OF INLET DISTORTION
BERNHARD H. ANDERSON and JAMES GIBB (Defence Research Agency, Bedford, England) Jul. 1992 12 p Presented at the 28th Joint Propulsion Conference and Exhibit, Nashville, TN, 6-8 Jul. 1992; sponsored by AIAA, SAE, ASME, and ASEE
(Contract RTOP 505-62-52)
(NASA-TM-105672; E-7039; NAS 1.15:105672; AIAA PAPER 92-3177) Copyright Avail: CASI HC A03/MF A01

The present study demonstrates that the Reduced Navier-Stokes code RNS3D can be used very effectively to develop a vortex generator installation for the purpose of minimizing the engine face circumferential distortion by controlling the development of secondary flow. The computing times required are small enough that studies such as this are feasible within an analysis-design environment with all its constraints of time and costs. This research study also established the nature of the performance improvements that can be realized with vortex flow control, and suggests a set of aerodynamic properties (called observations) that can be used to arrive at a successful vortex generator installation design. The ultimate aim of this research is to manage inlet distortion by controlling secondary flow through an arrangements of vortex generators configurations tailored to the specific aerodynamic characteristics of the inlet duct. This study also indicated that scaling between flight and typical wind tunnel test conditions is possible only within a very narrow range of generator configurations close to an optimum installation. This paper also suggests a possible law that can be used to scale generator blade height for experimental testing, but further research in this area is needed before it can be effectively applied to practical problems. Lastly, this study indicated that vortex generator installation design for inlet ducts is more complex than simply satisfying the requirement of attached flow, it must satisfy the requirement of minimum engine face distortion. Author

N92-34178*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECTS OF CONSTRAINT ON CRACK GROWTH UNDER AIRCRAFT SPECTRUM LOADING
J. C. NEWMAN, JR. Sep. 1992 49 p
(Contract RTOP 538-02-10-01)
(NASA-TM-107677; NAS 1.15:107677) Avail: CASI HC A03/MF A01

The objective is to study the effects of constraint on fatigue crack growth under aircraft spectrum loading. A plasticity-induced crack-closure model that accounts for constraint variations during the transition from flat-to-slant crack growth was used to correlate crack-growth rate data under constant-amplitude loading and to calculate crack growth under simulated aircraft spectrum loading. The model was applied to several thin-sheet aluminum alloy materials. Under laboratory air conditions, the transition was shown to be related to the size of the cyclic plastic zone based on the effective stress-intensity factor range for several sheet materials and thicknesses. Results from three-dimensional, elastic-plastic, finite-element analyses of a flat, straight-through crack in a thin-sheet aluminum alloy specimen showed a constraint loss similar to that assumed in the model. Using test data and the closure model, the location of the constraint-loss regime in terms of growth rate and the value of the constraint factor at these rates were determined by trial and error. The model was then used to calculate crack growth under the TWIST spectrum. The calculated results agreed reasonably well with test data. In general, the model predicted shorter crack-growth lives than tests under the TWIST spectrum by about 40 percent. For the TWIST spectrum clipped at Level 3, the calculated lives were within about 20 percent. The results demonstrated that constraint variations, especially for thin-sheet alloys, should be accounted for to predict crack growth under typical aircraft spectra. Author

N92-34207*# Case Western Reserve Univ., Cleveland, OH.
THERMAL MECHANICAL ANALYSIS OF SPRAG CLUTCHES Final Report
ROBERT L. MULLEN, RONALD JOSEPH ZAB, and ANTONIUS S. KURNIAWAN 7 Jul. 1992 236 p
(Contract NAG3-653)
(NASA-CR-190686; NAS 1.26:190686) Avail: CASI HC A11/MF A03

Work done at Case Western Reserve University on the Thermal

Mechanical analysis of sprag helicopter clutches is reported. The report is presented in two parts. The first part is a description of a test rig for the measurement of the heat generated by high speed sprag clutch assemblies during cyclic torsional loading. The second part describes a finite element modeling procedure for sliding contact. The test rig provides a cyclic torsional load of 756 inch-pounds at 5000 rpm using a four-square arrangement. The sprag clutch test unit was placed between the high speed pinions of the circulating power loop. The test unit was designed to have replaceable inner ad outer races, which contain the instrumentation to monitor the sprag clutch. The torque loading device was chosen to be a water cooled magnetic clutch, which is controlled either manually or through a computer. In the second part, a Generalized Eulerian-Lagrangian formulation for non-linear dynamic problems is developed for solid materials. This formulation is derived from the basic laws and axioms of continuum mechanics. The novel aspect of this method is that we are able to investigate the physics in the spatial region of interest as material flows through it without having to follow material points. A finite element approximation to the governing equations is developed. Iterative Methods for the solution of the discrete finite element equations are explored. A FORTRAN program to implement this formulation is developed and a number of solutions to problems of sliding contact are presented. Author

13

GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A92-54630* National Aeronautics and Space Administration, Washington, DC.
MEASURED AND CALCULATED OPTICAL PROPERTY PROFILES IN THE MIXED LAYER AND FREE TROPOSPHERE
JAMES M. ROSEN (Wyoming, University, Laramie), BARRY A. BODHAINE, JOE F. BOATMAN, JOHN J. DELUISI, M. J. POST (NOAA, Boulder, CO), YOUNG KIM (Cooperative Institute for Research in Environmental Sciences, Boulder, CO), RUSSELL C. SCHNELL (Mauna Loa Observatory, Hilo, HI), PATRICK J. SHERIDAN (Cooperative Institute for Research in Environmental Sciences, Boulder, CO), and DENNIS M. GARVEY (U.S. Army, Atmospheric Sciences Laboratory, White Sands Missile Range, NM) Journal of Geophysical Research (ISSN 0148-0227), vol. 97, no. D12, Aug. 20, 1992, p. 12,837-12,850. Research supported by NOAA, U.S. Army, and NASA. refs
Copyright
Nearly simultaneous measurements of the physical and optical properties of mixed layer and free tropospheric aerosols near Boulder, Colorado, were made on several occasions using aircraft, balloon, and ground-based sensors. This effort (Front Range Lidar, Aircraft, and Balloon experiment (FRLAB)) was conducted with the purpose of obtaining a diverse, self-consistent data set that could be used for testing optical model calculations based on measured physical characteristics such as apparent size distribution, composition, and shape. It was found that even with the uncertainties involved, the model predictions are in good agreement with the measurements in the visible and near infrared wavelength regions. At CO2 lidar wavelengths there is considerably more uncertainty in both the calculated and measured values; however, within the estimated errors there appears to be satisfactory agreement except for the highest free tropospheric layer studied. The results also indicate that during FRLAB the aerosol in the boundary layer and free troposphere behaved as spherical particles for optical modeling purposes. The utility of the observations for determining the extinction-to-backscatter ratio relevant to aerosols in the boundary layer and free troposphere is described with typical measured values being in the 20 to 30 sr range. Author

N92-33220# Naval Ocean Systems Center, San Diego, CA.
FEASIBILITY OF MEASURING TRANSVERSE ELECTRIC NOISE AT VLF AND LF ON AN ICE CAP Final Report
C. H. SHELLMAN Dec. 1991 25 p
(Contract NR PROJ. RR0-3308)
(AD-A252280; NOSC/TR-1492) Avail: CASI HC A03/MF A01
There is an existing need for very low frequency (VLF) and low frequency (LF) transverse electric (TE) air-to-air communications. However, TE noise cannot be measured at ground level on highly conducting or even moderately conducting ground, and routine measurements from an aircraft would be prohibitively expensive. The amplitudes of TE waves at the surface of an ice cap are evidently strong enough to be measured at LF when the ice cap is about 1000 meters thick and at VLF when the ice cap is about 2000 meters thick. Amplitudes are stronger over colder ice. Measurements of temperature in a drill hole would be needed for extrapolating fields to higher heights. GRA

N92-33271# Oak Ridge National Lab., TN.
PROOF OF CONCEPT OF A MAGNETICALLY COUPLED STIRLING ENGINE-DRIVEN HEAT PUMP
J. A. SHONDER, GONG CHEN (Sunpower, Inc., Athens, OH.), and J. MCENTEE (Sunpower, Inc., Athens, OH.) 1992 7 p Presented at the 27th Intersociety Energy Conversion Engineering Conference, San Diego, CA, 3-7 Aug. 1992
(Contract DE-AC05-84OR-21400)
(DE92-017129; CONF-920801-15) Avail: CASI HC A02/MF A01
A prototype magnetically-coupled Stirling engine-driven heat pump module has been designed and fabricated by Sunpower, Inc. under sponsorship of the US Department of Energy and the Oak Ridge National Laboratory (ORNL). Preliminary testing indicates that the magnetic coupling is an effective means for transmitting power from a free-piston Stirling engine to a refrigerant compressor. Compared with other power transmission concepts, the magnetic coupling has relatively low cost, and will help make commercial development of Stirling-driven heat pumps more likely in the future. DOE

N92-33751# Rolls-Royce Ltd., Derby (England).
THE IMPACT OF AIR TRANSPORT ON THE ENVIRONMENT
M. T. METCALFE, R. A. EATON, and D. M. SNAPE 1 Oct. 1991 9 p
(PNR-90876; ETN-92-92186) Copyright Avail: CASI HC A02/MF A01
The impact of atmospheric emissions upon the environment and the understanding of the contribution made by aircraft engines to pollution globally, in the vicinity of airports and at high altitudes, are considered. The technical status and future improvements in combustor technology, now under development, are addressed generally. The often conflicting requirements of emissions reduction and the other established combustor performance factors are examined. Particular stress is placed on safety aspects. The concept of an Environmental Impact Parameter (EIP), which would allow the optimization of engine cycle, and combustor design, to minimize the environmental consequences throughout the flight cycle, is introduced. The EIP could take into account the relative environmental importance of each emission species. ESA

N92-33794# Power Reactor and Nuclear Fuel Development Corp., Oarai (Japan).
STUDY OF POTASSIUM TURBINE ELECTRIC GENERATOR SYSTEM [KARIUMU TABIN HATSUDEN SHISUTEMU NO KENTOU]
HIROSHI SEINO, KAZUO HAGA, HAJIME KATAOKA, and AKIRA OOTSUBO *In* NASDA, Future Space Activities Workshop: Lunar Base Workshop 1991 31 p 17 Jul. 1991 In JAPANESE
Avail: CASI HC A03/MF A10
Structures and weight of the heat radiator panels (including heat pipes) and condensers as major constituent elements of the potassium Rankine cycle electric power generator systems of 300

kW output are reviewed and evaluated. An overall circuit diagram, major specifications, structure, weight, and heat transfer performance of the potassium Rankine cycle electric power generator system are estimated. Protection of radiator panels (including radiator fins and heat pipes) from meteoroids, structure and weight estimate of the potassium condensers are also described. Physical property trade-off of radiator fin materials, compatibility between metallic and alkaline materials, and potassium Rankine cycle circuit diagram are presented. The problems to be solved in the future are: (1) detailed examination of material strength to reduce structure weight; (2) methods of melting potassium or sodium for starting the system; (3) methods of supporting equipment taking into consideration the absorption of thermal expansion and acceleration (max. 8 g); (4) ensuring flow stability in the condenser; and (5) verification of relationship between heat transfer and pressure loss used in the design.
Author (NASDA)

15

MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A92-53596
INTEGRATED SYSTEM TO SUPPORT COMPUTER ANALYSIS IN CONCEPTUAL AEROSPACE DESIGN
H. YAMAMOTO, K. MATSUSHIMA, M. NAKA, K. MATSUMOTO (National Aerospace Laboratory, Chofu, Japan), Y. SATO, K. HARADA (Fujitsu Laboratories, Ltd., Kawasaki, Japan), and M. KAWAI (Facom-Hitac, Ltd., Tokyo, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 1. Tokyo, ACNE Publishing, Inc., 1990, p. 1039-1043. refs
Copyright

This paper describes a knowledge-based system to support designers and improve the efficiency of design analysis. The system provides designers with information to analyze a problem and extract desired output by using the expertise accumulated in the system. Knowledge base, engineering database, and program library are all combined in an object-oriented expert shell. This system has been constructed based on the three concepts: I/O data and programs are separated and can be registered in the separate tree-structured databases. Macrocommands are provided to form a large-scale compound program with component programs semiautomatically. A frame structure is introduced to categorize the I/O arguments of each engineering program and arrange them in a domain-specific hierarchical database. The system is flexible and evolutional. Programs and data can be registered, maintained, and developed with little labor, thereby providing a systematic framework for constructing and developing hierarchical databases of programs and data. Author

A92-53785
IMPROVEMENT OF ATMOSPHERIC FLIGHT PERFORMANCE OF A SPACE VEHICLE THROUGH H INFINITY-CONTROL THEORY
YUKINOBU NAKAMURA (Kyoto University, Japan) IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 2. Tokyo, AGNE Publishing, Inc., 1990, p. 2349-2354. refs
Copyright

This paper considers a problem of improving controlled atmospheric flight performance of a winged space vehicle, and seeks simplicity of procedure in controller synthesis. It is shown that the problem is reduced to that of trading off between robustness of stability and sensitivity. Then, the reduced problem is shown to be solved through the H infinity optimal control theory. A new class of weighting functions used in optimization procedure is proposed. Using a weighting function in the class, an appropriate tradeoff is obtained for considering the sensitivity optimization problem. Some numerical simulations using data of a winged space vehicle, support the value of the class of the weighting functions.
Author

A92-54006*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FREPS - A FORCED RESPONSE PREDICTION SYSTEM FOR TURBOMACHINERY BLADE ROWS
DURBHA V. MURTHY (Toledo, University, OH) and GEORGE L. STEFKO (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 9 p. refs
(AIAA PAPER 92-3072)

FREPS (Forced REsponse Predicition System) is a software system that integrates structural dynamic, steady and unsteady aerodynamic analyses to efficiently predict the forced dynamic stresses of turbomachinery blades to aerodynamic and mechanical excitations. The program performs flutter analysis also. The FREPS system uses a modal approach for aeroelastic analysis. The structural dynamic analysis is based on MSC/NASTRAN, the steady aerodynamic analysis is based on potential theory and the unsteady aerodynamic analysis is based on a linearization of the non-uniform potential mean flow. The capabilities of the program are described and illustrated by application to the High Pressure Oxygen Turbopump turbine of the Space Shuttle Main Engine. Author

A92-54285*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
IMPROVING DESIGNER PRODUCTIVITY
GARY C. HILL (NASA, Ames Research Center, Moffett Field, CA) AIAA, 1992 Aerospace Design Conference, Irvine, CA, Feb. 3-6, 1992. 11 p. refs
(AIAA PAPER 92-1187) Copyright

Designer and design team productivity improves with skill, experience, and the tools available. The design process involves numerous trials and errors, analyses, refinements, and addition of details. Computerized tools have greatly speeded the analysis, and now new theories and methods, emerging under the label Artificial Intelligence (AI), are being used to automate skill and experience. These tools improve designer productivity by capturing experience, emulating recognized skillful designers, and making the essence of complex programs easier to grasp. This paper outlines the aircraft design process in today's technology and business climate, presenting some of the challenges ahead and some of the promising AI methods for meeting those challenges.
Author

A92-55151
AIAA GUIDANCE, NAVIGATION AND CONTROL CONFERENCE, HILTON HEAD ISLAND, SC, AUG. 10-12, 1992, TECHNICAL PAPERS. PTS. 1-3
Washington, American Institute of Aeronautics and Astronautics, 1992, p. Pt. 1, 600 p.; pt. 2, 613 p.; pt. 3, 551 p. For individual items see A92-55152 to A92-55314.
Copyright

The present conference on guidance, navigation, and control encompasses space robotics, control-system designs, computational dynamics, spacecraft control, optimal control theory, flexible structure system identification, applications of neural networks and fuzzy logic, robustness analysis and eigenstructure assignment, and aircraft navigation. Also addressed are flexible structure slew-maneuver control, applications of genetic algorithms, H(infinity) and H(2) control theory, attitude control for the Space Station Freedom, optimization, robust fault accommodation, optimal control for nonlinear systems, and estimation theory. Specific issues addressed include capture-control responses with variable gains, robust dynamic-inversion control laws for aircraft control, applications of neural networks to control systems, a

fuzzy-logic-based F/A-18 automatic carrier landing system, and an adaptive controller for aerospace vehicles. C.C.S.

A92-55182#
A GENERAL APPROACH TO OPTIMAL REAL-TIME GUIDANCE OF DYNAMIC SYSTEMS BASED ON NONLINEAR PROGRAMMING
M. PAUS (Stuttgart, Universitaet, Germany) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 297-305. Research sponsored by Dornier GmbH. refs
(AIAA PAPER 92-4378) Copyright

A general approach to optimal real-time guidance of dynamic systems, based on a special shooting method and nonlinear programming, is presented and validated with some examples. The main focus lies on the reduction of the computing time as well as the improvements of the convergence behavior and the implicit generation of startup solutions. The described approach can be used for a wide variety of different systems. Its validity will be demonstrated here on the example of medium-range aircraft intercept maneuvers. Author

A92-55237#
AN ALGORITHM FOR ROBUST EIGENSTRUCTURE ASSIGNMENT USING THE LINEAR QUADRATIC REGULATOR
BRAD S. LIEBST (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 896-909. refs
(AIAA PAPER 92-4478)

The Linear Quadratic Regulator (LQR) can guarantee a robust closed loop eigenstructure for full state feedback. The algorithm developed here takes advantage of the stability guarantees of LQR to achieve an eigenstructure close to desired but within the allowable region of LQR. The algorithm selects the LQR weighting matrices, Q and R, that minimize the distance between the elements of the desired and LQR achievable eigenstructures. The minimization is accomplished by using a simplex based optimization routine. Specific weightings placed on the elements of the desired eigenstructure define the relative importance of each element. The algorithm is programmed in FORTRAN and is designed to be run from the software package MATLAB. Two examples are examined to illustrate the use of the program, including a helicopter flight control system. The results show that this algorithm is a valid technique for achieving robust eigenstructure assignment with full state feedback. Author

A92-55262*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONSTRAINED CONTROL ALLOCATION
WAYNE C. DURHAM (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1147-1155. refs
(Contract NCC1-158)
(AIAA PAPER 92-4550) Copyright

This paper addresses the problem of the allocation of several flight controls to the generation of specified body-axis moments. The number of controls is greater than the number of moments being controlled, and the ranges of the controls are constrained to certain limits. The controls are assumed to be individually linear in their effect throughout their ranges of motion, and independent of one another in their effects. The geometries of the subset of the constrained controls and of its image in moment space are examined. A direct method of allocating these several controls is presented, that guarantees the maximum possible moment is generated within the constraints of the controls. The results are illustrated by an example problem involving three controls and two moments. Author

A92-55265#
A ROBUST GAIN SCHEDULER INTERPOLATED INTO MULTIPLE MODELS BY MEMBERSHIP FUNCTIONS
TOSHIYUKI TANAKA and YASUTAKA AIZAWA (Japan Defense Agency, Technical Research and Development Institute, Tokyo) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1169-1185. refs
(AIAA PAPER 92-4553) Copyright

An approach to the design of a robust gain scheduler for multiple-input multiple-output plant depending on time-varying parameters is presented. The design procedure involves defining membership functions, designing the gain scheduler components, and integrating the components into a gain scheduler. As an example, robust gain scheduled autopilots are designed for the F-8 aircraft using the LQG/LTR technique, frequency shaping, and H-infinity control theory. V.L.

A92-55267#
G-FIELD CONTROL OF NONLINEAR SYSTEMS
J. W. ROLFGEN (McDonnell Douglas Missile Systems Co., Saint Louis, MO) and C. I. BYRNES (Washington University, Saint Louis, MO) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1196-1210. Research supported by USAF and NSF. refs
(AIAA PAPER 92-4555) Copyright

The G-Field Control design approach for nonlinear systems is described, and its performance is demonstrated using the problem of controlling a planar model of VTOL aircraft (based on the AV-8B Harrier II aircraft) as an example. The G-Field Controller is shown to provide transient performance comparable to that of linear controllers but has a much larger domain of convergence for the PVTOL problem. Preliminary stability results for the G-Field Control method are presented V.L.

A92-55271*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATIONS OF ROBUST CONTROL THEORY - EDUCATIONAL IMPLICATIONS
P. DORATO (New Mexico, University, Albuquerque) and R. K. YEDAVLLI (Ohio State University, Columbus) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1232-1238. refs
(Contract NSF INT-90-16501; NAG1-1164)
(AIAA PAPER 92-4559) Copyright

A survey is made of applications of robust control theory to problems of flight control, control of flexible space structures, and engine control which have appeared in recent conferences and journals. An analysis is made of which theoretical techniques are most commonly used and what implications this has for graduate and undergraduate education in aerospace engineering. Author

A92-55282*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN FRAMEWORK FOR ROBUST FLIGHT CONTROL DESIGN USING CONSTRAINED OPTIMIZATION
A. PALAZOGLU, M. YOUSEFPOR, and R. A. HESS (California, University, Davis) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1324-1333. refs
(Contract NAG2-654)
(AIAA PAPER 92-4603) Copyright

An analytical framework is described for the design of feedback control systems to meet specified performance criteria in the presence of structured and unstructured uncertainty. Attention is focused upon the linear time invariant, single-input, single-output

problem for the purposes of exposition. The framework provides for control of the degree of the stabilizing compensator or controller. Author

A92-55306#
INTELLIGENT CONTROL LAW TUNING FOR AIAA CONTROLS DESIGN CHALLENGE
YING-JYI P. WEI (General Dynamics Corp., Fort Worth, TX) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1569-1580. refs
(AIAA PAPER 92-4631) Copyright

Constrained optimization is used as the basis of the intelligent control law tuning to be applied to the American Institute of Aeronautics and Astronautics (AIAA) Controls Design Challenge. A tuning rule is formulated by translating multiple control system design requirements into a cost function and a set of constraints. During the tuning process, constrained optimization is employed to search for control laws for minimizing the cost function subject to the constraints. Simulation results are presented to demonstrate the successful applications of the method. Author

A92-55376*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PAYCOS, A MULTIDISCIPLINARY SIZING CODE FOR HYPERSONIC VEHICLES
LARRY EDINGTON and R. M. WILLIAMS (Lockheed Missiles & Space Co., Inc., Sunnyvale, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 2. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 517-541. refs
(Contract NAG1-1341)
(AIAA PAPER 92-4564) Copyright

PAYCOS is a computer code developed to rapidly perform concept sizing, concept evaluation, and associated trade studies for supersonic and hypersonic maneuvering vehicles. PAYCOS is a multidisciplinary analysis code that allows the engineer to determine the best geometric configuration for each design through parametric studies and mathematical optimization. This paper presents a general overview of the code, including a brief discussion of the approach used to develop it. The modular structure of the code is reviewed, and a brief discussion of each module is presented. Input data needed to run the code and output data supplied by it are discussed. The role of mathematical optimization in the solution process is discussed in some detail and examples of this process are presented. Finally, current modifications to the code are described along with potential future modifications and applications. Author

A92-55426
AN IDENTIFICATION PROCEDURE FOR A SYSTEM WITH A CHOICE OF FEEDBACK STRUCTURES
NORIHIRO GOTO (Kyushu University, Fukuoka, Japan), KAZUO MORIYAMA (Japan Air Lines Co., Ltd., Tokyo), and TOSHIKAZU MOTODA (NEC Corp., Tokyo, Japan) Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160), vol. 52, no. 2, June 1992, p. 171-185. refs

The paper proposes an identification procedure capable of selecting a proper feedback structure from two types of probable feedback structures, a direct output feedback single loop and a feedback system with an inner loop. Utilizing the autoregressive scheme, the procedure makes the singular value analysis of the transfer function matrix from the innovations to the outputs in addition to the correlation analysis of the innovations. A validation work using digital simulation data shows that the procedure makes clear distinction between the two types of feedback structures. The paper also discusses the cases where the procedure does not work successfully. Author

A92-56067
DESIGN OF A FLIGHT CONTROL SYSTEM USING A FEEDBACK-ERROR-LEARNING-TYPE NEURAL NETWORK
KIMIO KANAI, YOSHIMASA OCHI, and KAZUNOBU KATOU (National Defense Academy, Yokosuka, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 294-297. In Japanese. refs

The structure of an artificial neural network (ANN) of feedback-error-learning type is presented. Simulation results are presented, and the effectiveness of the ANN is compared with that of a proportional control system. Y.P.Q.

A92-56113
A DEVELOPMENT OF HYPERMEDIA TYPE DATABASE SYSTEM FOR INSTRUCTION OF AIRCRAFT CONCEPTUAL DESIGN
YOSHISADA MUROTSU, SHOWZOW TSUJIO, and CHOONG S. PARK (Osaka Prefecture, University, Sakai, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 506-510. In Japanese. refs

A database system is developed for instruction in aircraft conceptual design. The system is a hypermedia type database which stores and manages various kinds of design information, i.e., numerical data, documents, graphs, drawings, and so on. The system is programmed based on an object-oriented approach. Author

A92-56278
REAL-TIME HELICOPTER SIMULATION USING THE BLADE ELEMENT METHOD
L. MEERWIJK and W. BROUWER (National Aerospace Laboratory, Amsterdam, Netherlands) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 18 p. refs

The background of a program initiated by the National Aerospace Laboratory NLR to extend its moving-base research flight simulator facility with real-time helicopter simulation is discussed. The program's objective and the approach to accomplish them are also examined. Software modules which are typical for helicopters have been developed, tested, and finally implemented within the existing simulation program. The level of sophistication of the modules is such that with the resulting helicopter simulation program, research in the field of handling qualities, man-machine interface, etc. should be possible. The modularity of the flight simulation program and the application of a software package called Common-Data Quality Assurance System resulted in the smooth implementation of the modules. The resulting comprehensive flight simulation program, which provides the means for moving-base pilot-in-the-loop simulation, is characterized by a high degree of flexibility and maintainability due to its modular set-up and the use of the data-file structure. C.A.B.

A92-56293
A MODULE-LEVEL TESTING ENVIRONMENT FOR SAFETY-CRITICAL SOFTWARE SYSTEMS
A. SILVA, L. MARCOCCI, and M. DIDONE (Agusta S.p.A., Tradate, Italy) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 7 p.

A computer-aided test approach for safety-critical software systems which focuses on the software aspects rather than system aspects in the conduct of formal unitary testing is presented. A strategy is developed to achieve most of the coverage during module testing in isolation. A testing environment making it possible to describe the test cases in an understandable and formal language, and to execute them on the target machine is discussed. It automatically produces a detailed set of test reports covering the module's functionality as well as structure and execution threads down to the machine's elementary instructions. The testing phase of the software development life cycle is formalized in much the same way as the application software development, introducing a standard approach, a set of rules, and configuration management of the module test sets, along with a substantial advantage in terms of efficiency and use of human and machine resources. C.A.B.

A92-56339* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FIRST LEVEL RELEASE OF 2GCHAS FOR COMPREHENSIVE HELICOPTER ANALYSIS
ROBERT A. ORMISTON, GENE C. RUZICKA, CARINA M. TAN, and MICHAEL J. RUTKOWSKI (U.S. Army, Aeroflightdynamics Directorate; NASA, Ames Research Center, Moffett Field, CA) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 17 p. refs

Consideration is given to the Second Generation Comprehensive Helicopter Analysis System (2GCHAS) under development by the Aeroflightdynamics Directorate of the U.S. Army Aviation Systems Command to provide a significant advance in rotorcraft analysis capability. The recent progress that led to the completion of the first-level release in December 1990 is described. The project management approach, 2GCHAS engineering capabilities and features, documentation, and the user interface are also examined. The spanwise bound circulation distribution of the fixed wing calculated with the vortex wake system, and ground resonance frequency and damping results are illustrated in graphic form. C.A.B.

A92-56754#
ROLES OF WIND TUNNEL TESTS AND CFD ANALYSES IN THE DESIGN OF ENERGY-EFFICIENT SST
KOICHI HIRAOKA (Kawasaki Heavy Industries, Ltd., Gifu, Japan), HIDEKI NAKANISHI (Mitsubishi Heavy Industries, Ltd., Aichi, Japan), and TAKASHI TSUJIMOTO (Society of Japanese Aerospace Companies, Inc., Tokyo, Japan) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 7 p. refs
(AIAA PAPER 92-3923) Copyright

The dependence of aerodynamic design of the next generation SST on the wind tunnel tests and CFD analyses is discussed. Available CFD codes are assessed in reference to the expected attainable computer power at the early design phase of the next generation SST, which is assumed in this paper to be around the turn of the century. International cooperative facility concept is proposed consisting of new wind tunnel which simulates full flight Reynolds numbers in M = 1.5 - 3.0 utilizing all the available advanced technologies, and simulation facility which consists of the most advanced supercomputer and the fully validated CFD softwares. Author

A92-56781#
DEVELOPMENT OF AN UNCERTAINTY METHODOLOGY FOR MULTIPLE-CHANNEL INSTRUMENTATION SYSTEMS
DAVID M. CAHILL (Calspan Corp., Arnold AFB, TN) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 13 p. refs
(AIAA PAPER 92-3953)

An uncertainty methodology is presented that can be used to determine a single set, uncertainty components for uncertainty evaluation point that is valid for the entire multiple channel instrumentation system. The methodology also provides uncertainty components which accurately represent the actual uncertainty of the measured data. The methodology was developed and verified using electronically scanned pressure instrumentation systems, but it can also be applied to any multiple channel instrumentation system. It is based on the uncertainty components from a limited number of randomly selected individual instrumentation channels to calculate system uncertainty components that adequately represent the entire instrumentation system. O.G.

A92-57444
USING THE SIMULATION MODELING METHOD TO ESTIMATE THE RELIABILITY OF THE CREW-FLIGHT VEHICLE SYSTEM [PRIMENENIE METODA IMITATSIONNOGO MODELIROVANIIA DLIA OTSENKI NADEZHNOSTI SISTEMY EKIPAZH-LETATEL'NYI APPARAT]
V. A. KONDRATENKOV and G. A. TERESHKIN (Kievskoe Vysshee Voennoe Aviatsionnoe Inzhenernoe Uchilishche, Kiev, Ukraine) Kibernetika i Vychislitel'naia Tekhnika (ISSN 0454-9910), no. 92, 1991, p. 15-18. In Russian. refs
Copyright

A mathematical model of the crew-flight vehicle system is developed using the principles of simulation modeling. The model is suitable for the evaluation of the reliability of a crew involved in compensation tracking. It is shown that the approach proposed here is more accurate than an analytical method for evaluating the reliability of the crew-vehicle system. V.L.

A92-57445
AN APPROACH TO THE ORGANIZATION OF AN ADAPTIVE MAN-MACHINE SYSTEM FOR FLIGHT VEHICLE CONTROL [OB ODNOM PODKHODE K ORGANIZATSII ADAPTIVNOI ERGATICHESKOI SISTEMY UPRAVLENIIA LETATEL'NYM APPARATOM]
A. V. KHARCHENKO (Kievskoe Vysshee Voennoe Aviatsionnoe Inzhenernoe Uchilishche, Kiev, Ukraine) Kibernetika i Vychislitel'naia Tekhnika (ISSN 0454-9910), no. 92, 1991, p. 21-23. In Russian. refs
Copyright

A bioengineering approach to the organization of an adaptive man-machine system for flight vehicle control is examined which is based on a rational combination of the adaptive capacity of the pilot and automation. The proposed combination of biological and technological adaptation within a single system makes it possible to maximize the advantages of the two types of adaptation while minimizing their disadvantages. The approach proposed here provides for flexible distribution of control functions between the pilot and the automatic control system. V.L.

A92-57446
AN EXPERIMENTAL STUDY OF ORGANISMIC PRINCIPLES OF THE FUNCTIONING OF THE CREW-TRANSPORT AIRCRAFT SYSTEM [EKSPERIMENTAL'NYE ISSLEDOVANIIA ORGANIZMICHESKIKH PRINTSIPOV FUNKTSIONIROVANIIA SISTEMY EKIPAZH-TRANSPORTNYI SAMOLET]
A. A. TERESHKIN (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukraine) Kibernetika i Vychislitel'naia Tekhnika (ISSN 0454-9910), no. 92, 1991, p. 37-43. In Russian. refs
Copyright

The efficiency of the crew-transport aircraft (C-TA) system is examined from the standpoint of the implementation of the most important principles of the functioning of man-machine systems. The behavior of the C-TA system is described in terms of piloting precision criteria, pilot stress level, and control strategy. The main principles governing the behavior of the C-TA system under normal flight conditions and in the case of system failures are described. V.L.

N92-32507*# *National Aeronautics and Space Administration.* Hugh L. Dryden Flight Research Facility, Edwards, CA.
USER'S MANUAL FOR AEROFCN: A FORTRAN PROGRAM TO COMPUTE AERODYNAMIC PARAMETERS
JOSEPH L. CONLEY May 1992 24 p
(Contract RTOP 533-02-36)
(NASA-TM-104237; H-1675; NAS 1.15:104237) Avail: CASI HC A03/MF A01

The computer program AeroFcn is discussed. AeroFcn is a utility program that computes the following aerodynamic parameters: geopotential altitude, Mach number, true velocity, dynamic pressure, calibrated airspeed, equivalent airspeed, impact pressure, total pressure, total temperature, Reynolds number, speed of sound, static density, static pressure, static temperature, coefficient of dynamic viscosity, kinematic viscosity, geometric altitude, and specific energy for a standard- or a modified standard-day atmosphere using compressible flow and normal shock relations. Any two parameters that define a unique flight condition are selected, and their values are entered interactively. The remaining parameters are computed, and the solutions are stored in an output file. Multiple cases can be run, and the multiple case solutions can be stored in another output file for plotting.

Parameter units, the output format, and primary constants in the atmospheric and aerodynamic equations can also be changed. Author

N92-32851# National Research Council of Canada, Ottawa (Ontario). Flight Research Lab.
THE DESIGN AND DEVELOPMENT OF A PORTABLE, DSP MICRO-PROCESSOR BASED, HIGH-ACCURACY DATA ACQUISITION SYSTEM
GARY M. BEAUCHAMP and K. K. LUM 1989 24 p Presented at the CASI Flight Test Symposium, Cold Lake, Alberta, Mar. 1989
(NRC-32146; CTN-92-60372) Avail: CASI HC A03/MF A01

A self contained strapdown data acquisition system which combines portability with accuracy and which is suitable for aircraft parameter estimation is described. This system was designed to be transferrable from one aircraft to another with minimal effort. This system involves the application of state of the art thermally modelled instrumentation, modern computer hardware, temperature compensation and carefully selected low temperature sensitivity, and minimum power consumption electronic components. Much of this technology was unavailable until the 1980s, including the Digital Signal Processing (DSP) microprocessor, FACT low power consumption devices, and portable large capacity hard disc drives. Thermally modelled instrumentation is a relatively recent advance which not only increases accuracy, but reduces system complexity, size, and weight, while increasing flexibility and portability. Combining these modern technologies has produced a very capable data acquisition system which is expected to encounter a wide range of uses over and above its intended parameter estimation applications. CISTI

N92-32865*# Research Inst. for Computing and Information Systems, Houston, TX.
ADVANCED SOFTWARE DEVELOPMENT WORKSTATION: EFFECTIVENESS OF CONSTRAINT-CHECKING Interim Report
MICHEL IZYGON (Barrios Technology, Inc., Houston, TX.) 1 Jul. 1992 21 p
(Contract NCC9-16; RICIS PROJ. SR-02)
(NASA-CR-190712; NAS 1.26:190712) Avail: CASI HC A03/MF A01

This report summarizes the findings and lessons learned from the development of an intelligent user interface for a space flight planning simulation program, in the specific area related to constraint-checking. The different functionalities of the Graphical User Interface part and of the rule-based part of the system have been identified. Their respective domain of applicability for error prevention and error checking have been specified. Author

N92-32880*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ANALYSIS OF DATA FROM A DO-178A SOFTWARE DEVELOPMENT PROCESS
KELLY J. HAYHURST and GEORGE B. FINELLI *In* NASA. Goddard Space Flight Center, Proceedings of the Sixteenth Annual Software Engineering Workshop p 209-226 Dec. 1991
Avail: CASI HC A03/MF A03; NASA Goddard Space Flight Center, Code 552, Greenbelt, MD 20771 HC

A clear understanding of the software development process is essential to defining more accurate software reliability models and more effective software development procedures that will yield reliable software. The Guidance and Control Software Project (GCS) experiment establishes an environment for investigating the effectiveness of various development and verification methods for avionics software, such as those prescribed by the FAA. The data collected during the development cycle of the GCS implementations will be used to assess the effectiveness of the DO-178A guidelines. Since adequate models for dependable reliability estimation of mission critical, real time software do not currently exist, the data from the GCS experiment will also provide an indispensable basis for improving methods for assessing reliability and safety. Analysis of faults found during the development cycle of one GCS implementation has already yielded interesting results that will be useful in characterizing the software failure process. Author

N92-33339*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SATWG NETWORKED QUALITY FUNCTION DEPLOYMENT
DON BROWN *In its* Third SEI Technical Interchange: Proceedings p 483-488 1992
Avail: CASI HC A02/MF A05

The initiative of this work is to develop a cooperative process for continual evolution of an integrated, time phased avionics technology plan that involves customers, technologists, developers, and managers. This will be accomplished by demonstrating a computer network technology to augment the Quality Function Deployment (QFD). All results are presented in viewgraph format. H.A.

N92-33483*# *National Aeronautics and Space Administration.* Langley Research Center, Hampton, VA.
ADVANCED TECHNIQUES IN RELIABILITY MODEL REPRESENTATION AND SOLUTION
DANIEL L. PALUMBO and DAVID M. NICOL (College of William and Mary, Williamsburg, VA.) Oct. 1992 18 p
(Contract RTOP 505-64-10-07)
(NASA-TP-3242; L-17048; NAS 1.60:3242) Avail: CASI HC A03/MF A01

The current tendency of flight control system designs is towards increased integration of applications and increased distribution of computational elements. The reliability analysis of such systems is difficult because subsystem interactions are increasingly interdependent. Researchers at NASA Langley Research Center have been working for several years to extend the capability of Markov modeling techniques to address these problems. This effort has been focused in the areas of increased model abstraction and increased computational capability. The reliability model generator (RMG) is a software tool that uses as input a graphical object-oriented block diagram of the system. RMG uses a failure-effects algorithm to produce the reliability model from the graphical description. The ASSURE software tool is a parallel processing program that uses the semi-Markov unreliability range evaluator (SURE) solution technique and the abstract semi-Markov specification interface to the SURE tool (ASSIST) modeling language. A failure modes-effects simulation is used by ASSURE. These tools were used to analyze a significant portion of a complex flight control system. The successful combination of the power of graphical representation, automated model generation, and parallel computation leads to the conclusion that distributed fault-tolerant system architectures can now be analyzed. Author

N92-33894*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A GRAPHICAL USER-INTERFACE FOR PROPULSION SYSTEM ANALYSIS
BRIAN P. CURLETT and KATHLEEN RYALL (Harvard Univ., Cambridge, MA.) Aug. 1992 28 p
(Contract RTOP 505-69-50)
(NASA-TM-105696; E-7158; NAS 1.15:105696) Avail: CASI HC A03/MF A01

NASA LeRC uses a series of computer codes to calculate installed propulsion system performance and weight. The need to evaluate more advanced engine concepts with a greater degree of accuracy has resulted in an increase in complexity of this analysis system. Therefore, a graphical user interface was developed to allow the analyst to more quickly and easily apply these codes. The development of this interface and the rationale for the approach taken are described. The interface consists of a method of pictorially representing and editing the propulsion system configuration, forms for entering numerical data, on-line help and documentation, post processing of data, and a menu system to control execution. Author

N92-33920# Maryland Univ., College Park. Dept. of Computer Science.
DISTRIBUTED SYSTEMS: INTERCONNECTION AND FAULT TOLERANCE STUDIES Final Report
ASHOK AGAWALA and SATISH TRIPATHI Jan. 1992 23 p
(Contract DASG60-87-C-0066)
(AD-A252869) Avail: CASI HC A03/MF A01

The goal of this project was to study the primary design and implementation issues in distributed implementation of hard real-time systems. We organized the effort under a project named MARUTI and defined the goal as the creation of an environment for the development and deployment of applications with hard real-time, fault tolerance, and security requirements. Good examples of such embedded systems are found in signal processing and avionics applications. Such applications must be able to execute on a distributed, heterogeneous hardware base. During the past three years we have created a framework for such an environment and have demonstrated the feasibility of the design through initial implementations of the prototype components of the MARUTI Environment. In this proposal, we outline the research effort that we propose to undertake over the next three years. The design of the MARUTI Environment is motivated by the requirements of the next generation of applications. In the rest of this section we present some details of these requirements. GRA

16

PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A92-54484
THE INTERACTION BETWEEN A HIGH-FREQUENCY GUST AND A BLADE ROW
N. PEAKE (Cambridge, University, United Kingdom) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 241, Aug. 1992, p. 261-289. Research supported by SERC and Rolls-Royce, PLC. refs
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An asymptotic method for predicting the unsteady lift on a blade row due to the interaction with a convected vorticity wave was developed using the Wiener-Hopf technique for the case when the reduced frequency, Omega, is large. This allowed the application of asymptotic analysis in the formal limit Omega approaching infinity, with a result of considerable simplification. It is shown that the formulas developed can be easily incorporated into existing noise prediction codes. The advantage of the asymptotic approach lies in the fact that it can handle high-frequency regimes for which conventional numerical approaches may become unwieldy, but for which cascade effects can still be highly significant. The approach can be used for modeling other effects such as rotor blockage. I.S.

A92-54660* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
H-N2 INTERACTION ENERGIES, TRANSPORT CROSS SECTIONS, AND COLLISION INTEGRALS
JAMES R. STALLCOP, HARRY PARTRIDGE (NASA, Ames Research Center, Moffett Field, CA), STEPHEN P. WALCH (Eloret Institute, Sunnyvale, CA), and EUGENE LEVIN (NASA, Ames Research Center, Moffett Field, CA) Journal of Chemical Physics (ISSN 0021-9606), vol. 97, no. 5, Sept. 1, 1992, p. 3431-3436. refs
(Contract NCC2-478; NCC2-387)
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The energies for the interaction of a hydrogen atom with a nitrogen molecule have been calculated for large separation distances using a complete-active-space self-consistent-field/externally contracted configuration interaction method. H-N2 transport cross sections and collision integrals have been calculated using sudden approximations and a semiclassical description of the scattering. The values of these quantities are found to be close to the corresponding values determined from the average (isotropic) potential energy. The collision integrals are applied to determine diffusion and viscosity coefficients; the theoretical diffusion agrees well with the measured data available from experiments at low temperatures. Author

A92-54908
EXPERIMENTAL OBSERVATIONS OF INSTABILITY MODES IN A RECTANGULAR JET
CHIANG SHIH, ANJANEYULU KROTHAPALLI, and SIVARAM GOGINENI (Florida Agricultural and Mechanical University; Florida State University, Tallahassee) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2388-2394. Previously cited in issue 02, p. 230, Accession no. A91-12476. refs
Copyright

A92-54909* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BROADBAND SHOCK ASSOCIATED NOISE FROM SUPERSONIC JETS MEASURED BY A GROUND OBSERVER
CHRISTOPHER K. W. TAM (Florida State University, Tallahassee) AIAA Journal (ISSN 0001-1452), vol. 30, no. 10, Oct. 1992, p. 2395-2401. Previously cited in issue 10, p. 1676, Accession no. A92-26931. refs
(Contract NAG1-421)
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A92-56055
NOISE TEST OF HIGH-SPEED COUNTERROTATION PROPELLER IN LOW-SPEED WIND TUNNEL
S. BABA, N. HASHIDATE, N. KUWANO (National Aerospace Laboratory, Chofu, Japan), K. AMANO, S. NAKAMURA, Y. WATANABE (Japan Aircraft Development Corp., Tokyo), A. KANEKO, K. SAITO (Kawasaki Heavy Industries, Ltd., Tokyo, Japan), and K. OKURA (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 246-249. In Japanese.

A noise test of a high-speed advanced counterrotation propeller was conducted in the NAL 5.5m x 6.5m low-speed wind tunnel. The propeller was run over a range of blade setting angles from 30 deg/28 deg to 30 deg/30 deg, rotor speed from 5000 to 13000 rpm and wind speed from 0 to 60 m/s. The test results confirm the following characteristics. (1) The noise level was found to have maximum peak at 3 BPF. (2) The over-all value increased with rotor speed and decreased with advance ratio. Author

A92-56074
A CALCULATION METHOD TO PREDICT HELICOPTER NOISE AND ITS VERIFICATION
KEIJI KAWACHI and YASUMICHI HASEGAWA (Tokyo, University, Japan) IN: Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings. Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, p. 322-325. In Japanese. refs

A numerical calculation method was developed to predict helicopter noise. This method is composed of two codes, aerodynamic code and acoustic code. The aerodynamic code utilizes the local momentum theory and the acoustic code utilizes the equation by Williams and Hawkings. The acoustic source of quadrupole is omitted. The noise from tail rotor as well as main rotor is included in the calculation. The calculated results are compared with flight tests near heliports, and the good agreement between the calculation and measurement was obtained. The effective methods to reduce the noise level of civil helicopter are also discussed. Author

A92-56162
FORCING LEVEL EFFECTS OF INTERNAL ACOUSTIC EXCITATION ON THE IMPROVEMENT OF AIRFOIL PERFORMANCE
R. C. CHANG (CSIST, Aeronautical Research Laboratory, Taichung, Taiwan), F.-B. HSIAO, and R.-N. SHYU (National Cheng Kung University, Tainan, Taiwan) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 823-829. Previously cited in issue 02, p. 234, Accession no. A91-12522. refs
(Contract NSCRC-79-0210-D006-03)
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A92-56169
EXPERIMENTAL STUDY OF NOISE GENERATION AND PROPAGATION IN A TURBOFAN MODEL
S. LEWY, S. CANARD-CARUANA (ONERA, Chatillon, France), and J. JULLIARD (SNECMA, Moissy-Cramayel, France) Journal of Aircraft (ISSN 0021-8669), vol. 29, no. 5, Sept.-Oct. 1992, p. 892-898. Research supported by Service Technique des Programmes Aeronautiques and Direction Generale de l'Aviation Civile. Previously cited in issue 02, p. 230, Accession no. A91-12466. refs
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A92-56344* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BVI IMPULSIVE NOISE REDUCTION BY HIGHER HARMONIC PITCH CONTROL - RESULTS OF A SCALED MODEL ROTOR EXPERIMENT IN THE DNW
WOLF R. SPLETTSTOESSER, KLAUS-J. SCHULTZ, ROLAND KUBE (DLR, Braunschweig, Germany), THOMAS F. BROOKS, EARL R. BOOTH, JR. (NASA, Langley Research Center, Hampton, VA), GEORG NIESL (MBB GmbH, Ottobrunn, Germany), and OLIVIER STREBY (Aerospatiale, Marignane, France) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 14 p. refs

Results are presented of a model rotor acoustics test performed to examine the benefit of higher harmonic control (HHC) of blade pitch to reduce blade-vortex interaction (BVI) impulsive noise. A dynamically scaled, four-bladed, rigid rotor model, a 40-percent replica of the B0-105 main rotor, was tested in the German Dutch Wind Tunnel. Noise characteristics and noise directivity patterns as well as vibratory loads were measured and used to demonstrate the changes when different HHC schedules were applied. Dramatic changes of the acoustic signatures and the noise radiation directivity with the HHC phase variations are found. Compared to the baseline conditions (without HHC), significant mid-frequency noise reductions of locally 6 dB are obtained for low-speed descent conditions where GVI is most intense. For other rotor operating conditions with less intense BVI there is less or no benefit from the use of HHC. LF noise and vibratory loads, especially at optimum noise reduction control settings, are found to increase. C.A.B.

A92-56345
SOUND PRODUCED BY VORTEX-AIRFOIL INTERACTION
K. EHRENFRIED (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, Germany), G. E. A. MEIER (DLR, Institut fuer Experimentelle Stroemungsmechanik, Goettingen, Germany), and F. OBERMEIER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, Germany) European Rotorcraft Forum, 17th, Berlin, Germany, Sept. 24-26, 1991, Paper. 13 p. refs

Transonic vortex-airfoil interactions are numerically investigated. The numerical calculations are done by solving the unsteady 2D Euler equations on an unstructured grid surrounding a NACA 0012 airfoil. The simulations show that several mechanisms of sound generation are effective during the vortex-airfoil interaction. From the numerical results an overview of the processes which occur is given. Additionally, the numerical results are compared with experiments, and the influence of the Mach number and other parameters on the sound production is discussed. Author

N92-32595# Washington Univ., Seattle.
FORMATION AND SUSTAINMENT OF A VERY LOW ASPECT RATIO TOKAMAK USING COAXIAL HELICITY INJECTION: HELICITY INJECTED TORUS (HIT) EXPERIMENT
T. R. JARBOE and B. A. NELSON 1992 52 p
(Contract DE-FG06-90ER-54095)
(DE92-014311; DOE/ER-54095/2; UWAERP-35) Avail: CASI HC A04/MF A01

In the paper, we will discuss the progress of the HIT experiment construction, including the following components: preliminary data and interpretation; diagnostic systems; vacuum vessel and pumping system; helicity source and power supplies; toroidal field coil and power supply; data acquisition system; and our collaboration with General Atomics. A brief summary of each topic will be given.
DOE

N92-32697# Federal Aviation Administration, Washington, DC. Office of Aviation Medicine.
EXPOSURES FROM HEADSET INTERFERENCE TONES Final Report
NOAL D. MAY Jan. 1992 16 p
(AD-A247175; DOT/FAA/AM-92/4) Avail: CASI HC A03/MF A01

This study evaluated the acoustic characteristics of interference tones as experienced by FAA Air Traffic Control Specialists (ATCS's) and pilots who wear headsets with insert type ear pieces. The sound pressure levels (SPL's) of generated tones were measured through the headset at five randomly selected ATCS positions in each of seven Air Route Traffic Control Centers (ARTCC's). The SPL's were compared within and between four frequencies (.5, 1, 2, and 3 KHz) over ten discrete signal power levels. The comparisons demonstrated that SPL's of tones could not be predicted for ARTCC's or for positions within an ARTCC, and that the durations of exposure were brief, i.e., limited to the time needed to remove the headset earpiece from the ear canal. Potential amounts of temporary threshold shifts (TTS's) also were evaluated in a laboratory by checking hearing levels following exposures to tones played with ATCS/pilot communication through the same headset. Audiometric checks of 20 volunteer subjects indicated TTS could be detected following 1 KHz/114 dB/60 and 145 seconds, 2 KHz/108 dB/60 and 145 seconds, and 3 KHz/99 dB/145 seconds exposures, when hearing checks were made within the first 15 minutes. Such extended durations are highly unlikely for pilots and ATCS's and no TTS was detectable following exposures to shorter durations or to other frequencies with equivalent durations. GRA

N92-32948*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FOURTH AIRCRAFT INTERIOR NOISE WORKSHOP
DAVID G. STEPHENS, comp. Jul. 1992 335 p Workshop held in Friedrichshafen, Fed. Republic of Germany, 19-20 May 1992; sponsored by NASA, Society of Automotive Engineers, and the German Aerospace Research Establishment
(Contract RTOP 535-03-11-03)
(NASA-CP-10103; NAS 1.55:10103) Avail: CASI HC A15/MF A03

The fourth in a series of NASA/SAE Interior Noise Workshops was held on May 19 and 20, 1992. The theme of the workshop was new technology and applications for aircraft noise with emphasis on source noise prediction; cabin noise prediction; cabin noise control, including active and passive methods; and cabin interior noise procedures. This report is a compilation of the presentations made at the meeting which addressed the above issues.

N92-32949*# Lockheed Aeronautical Systems Co., Marietta, GA.
ACOUSTIC LOADS PREDICTION ON JET AIRCRAFT
N. N. REDDY *In* NASA. Langley Research Center, Fourth Aircraft Interior Noise Workshop p 1-12 Jul. 1992
Avail: CASI HC A03/MF A03

A nearfield aircraft noise prediction computer program is

presented for the F-22 aircraft. The dominant sources of noise are jet turbulent mixing noise, jet broadband shock noise, and fluctuating pressure under the turbulent boundary layer. All results from this investigation are presented in viewgraph format. H.A.

N92-32950*# Douglas Aircraft Co., Inc., Long Beach, CA.
MD-80 AFT CABIN NOISE CONTROL: A CASE HISTORY
M. A. LANG, D. R. LORCH, D. N. MAY, and M. A. SIMPSON *In* NASA. Langley Research Center, Fourth Aircraft Interior Noise Workshop p 13-33 Jul. 1992
Avail: CASI HC A03/MF A03

The interior noise technology program to improve the noise environment in the aft cabin of the MD-80 twin jet aircraft is discussed. Two potential noise control treatments were identified: vibration absorber devices for the airframe and for the engine. A series of ground and flight tests using in-service aircraft was then conducted. These tests showed that the vibration absorbers for the airframe and engine decreased aircraft noise significantly. H.A.

N92-32951*# Dornier Luftfahrt G.m.b.H., Friedrichshafen (Germany).
THE DORNIER 328 ACOUSTIC TEST CELL (ATC) FOR INTERIOR NOISE TESTS AND SELECTED TEST RESULTS
H. JOSEF HACKSTEIN, INGO U. BORCHERS, KLAUS RENGER, and KONRAD VOGT *In* NASA. Langley Research Center, Fourth Aircraft Interior Noise Workshop p 34-43 Jul. 1992
(AIAA PAPER 92-2164) Avail: CASI HC A02/MF A03

To perform acoustic studies for achieving low noise levels for the Dornier 328, an acoustic test cell (ATC) of the Dornier 328 has been built. The ATC consists of a fuselage section, a realistic fuselage suspension system, and three exterior noise simulation rings. A complex digital 60 channel computer/amplifier noise generation system as well as multichannel digital data acquisition and evaluation system have been used. The noise control tests started with vibration measurements for supporting acoustic data interpretation. In addition, experiments have been carried out on dynamic vibration absorbers, the most important passive noise reduction measure for low frequency propeller noise. The design and arrangement of the current ATC are presented. Furthermore, exterior noise simulation as well as data acquisition are explained. The most promising results show noise reduction due to synchrophasing and dynamic vibration absorbers. Author

N92-32952*# Saab Aircraft Co., Linkoping (Sweden).
VIBRO-ACOUSTIC FE ANALYSES OF THE SAAB 2000 AIRCRAFT
INGE S. GREEN *In* NASA. Langley Research Center, Fourth Aircraft Interior Noise Workshop p 44-69 Jul. 1992
Avail: CASI HC A03/MF A03

A finite element model of the Saab 2000 fuselage structure and interior cavity has been created in order to compute the noise level in the passenger cabin due to propeller noise. Areas covered in viewgraph format include the following: coupled acoustic/structural noise; data base creation; frequency response analysis; model validation; and planned analyses. H.A.

N92-32955*# Cambridge Collaborative, Inc., MA.
USE OF SEA TO PREDICT STRUCTURE-BORNE NOISE IN AIRCRAFT
JEROME E. MANNING *In* NASA. Langley Research Center, Fourth Aircraft Interior Noise Workshop p 112-128 Jul. 1992
Avail: CASI HC A03/MF A03

A Statistical Energy Analysis is used to predict aircraft noise from the structural components. Structural-borne noise is vibration: (1) generated at one location; (2) transmitted by the structure to other locations; and (3) radiated into the cabin as noise. All results are presented in viewgraph format. H.A.

N92-32956*# Dornier Luftfahrt G.m.b.H., Friedrichshafen (Germany).
ADVANCED STUDY FOR ACTIVE NOISE CONTROL IN AIRCRAFT (ASANCA)
INGO U. BORCHERS, URBAN EMBORG (Saab Aircraft Co., Linkoping, Sweden), ANTONIO SOLLO (Alenia Spazio S.p.A., Naples, Italy), ELLY H. WATERMAN (Fokker B.V., Schipol-Oost, Netherlands), JACQUES PAILLARD (MATRA Sep Imagerie et Informatique, Saint Quentin en Yvelines, France), PETER N. LARSEN (Reson System A/S, Slangerup, Denmark), GERARD VENET (METRAVIB, Ecully, France), PETER GOERANSSON (Aeronautical Research Inst. of Sweden, Bromma.), and VINCENT MARTIN (Centre National de la Recherche Scientifique, Marseilles, France) *In* NASA. Langley Research Center, Fourth Aircraft Interior Noise Workshop p 129-141 Jul. 1992
(Contract EEC-AERO-0028-C)
(AIAA PAPER 92-2092) Avail: CASI HC A03/MF A03

Aircraft interior noise and vibration measurements are included in this paper from ground and flight tests. In addition, related initial noise calculations with and without active noise control are conducted. The results obtained to date indicate that active noise control may be an effective means for reducing the critical low frequency aircraft noise. Author

N92-32957*# Southampton Univ. (England). Inst. of Sound and Vibration Research.
ACTIVE CONTROL OF SOUND TRANSMISSION THROUGH STIFF LIGHTWEIGHT COMPOSITE FUSELAGE CONSTRUCTIONS
D. R. THOMAS, P. A. NELSON, R. J. PINNINGTON, and S. J. ELLIOTT *In* NASA. Langley Research Center, Fourth Aircraft Interior Noise Workshop p 142-172 Jul. 1992
Avail: CASI HC A03/MF A03

Work was performed on the active control of sound transmission in composite structures. First, a model was outlined of a vibrating plate with arbitrary boundary conditions. Second, the far field was minimized to radiate acoustic power using secondary force inputs. Third, a model of a simple case of freely mounted stiff lightweight panels was used. Fourth, experimental results for aluminum honeycomb composite panels is presented. Fifth, experimental results are presented for the combination of a clamped steel plate and an aluminum honeycomb panel with secondary forces acting between the partitions. Finally, experimental results for the combination of a clamped steel plate with four secondary aluminum honeycomb panels is presented. All materials are shown in viewgraph format. H.A.

N92-32958*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACTIVE CONTROL OF INTERIOR NOISE IN A LARGE SCALE CYLINDER USING PIEZOELECTRIC ACTUATORS
H. C. LESTER and R. J. SILCOX *In its* Fourth Aircraft Interior Noise Workshop p 173-190 Jul. 1992
Avail: CASI HC A03/MF A03

The noise reduction effectiveness of two types of control force actuator models has been analytically investigated: (1) a point actuator, and (2) an in-plane, piezoelectric actuator. The actuators were attached to the wall of a simply supported, elastic cylinder closed with rigid end caps. Control inputs to the actuators were determined such that the integrated square of the pressure over the interior of the vibrating cylinder was a minimum. Significant interior noise reductions were achieved for all actuator configurations, but especially for the structurally dominated response. Noise reduction of 9 dB to 26 dB were achieved using point force actuators, as well as localized and extended piezoelectric actuators. Control spillover was found to limit overall performance for all cases. However, the use of extended piezoelectric actuators was effective in reducing control spillover, without increasing the number of control degrees of freedom. Author

N92-32960*# Deutsche Lufthansa A.G., Frankfurt am Main (Germany).
PILOTS NOISE EXPOSURE DURING A BOEING 747-400 ROUND TRIP: AMBIENT NOISE AND ACOUSTIC-HEAD RECORDING AND ANALYSIS OF DATA

KNUT HOFFMAN *In* NASA. Langley Research Center, Fourth Aircraft Interior Noise Workshop p 211-227 Jul. 1992
Avail: CASI HC A03/MF A03

Pilot noise exposure is examined during the round trip flight of a Boeing 747-400 aircraft. Although the sound power origin is the aircraft, this paper examines the effects of this noise on the human occupants within the airplane. Data is acquired and analyzed to determine the noise exposure of pilots on long flights, in this case, a flight of 12 hours and 20 minutes. All results are presented in viewgraph format. H.A.

N92-32961*# Deutsche Insurance Germany (F.R.).
PILOT NOISE EXPOSURE DURING A BOEING 747-400 ROUND TRIP: JUDGEMENT OF NOISE AND ANALYSIS IN RESPECT TO HEARING IMPAIRMENT OF PILOTS
HANS JUERGEN HOOMAN *In* NASA. Langley Research Center, Fourth Aircraft Interior Noise Workshop p 228-251 Jul. 1992
Avail: CASI HC A03/MF A03

Noise level measurements are made on Boeing 747 aircraft to determine the potential hazards to airline pilots. Measuring results have shown that most pilots work under conditions that where noise constitutes a health hazard. Long and short term effects of noise exposure in pilots is examined as well as the legal ramifications of this potential hazard. H.A.

N92-32962*# Alenia Aeronautica, Naples (Italy).
ACTIVE VIBRATIONS AND NOISE CONTROL FOR TURBOPROP APPLICATION RESEARCH PROGRAM ACTIVITIES
A. PAONESSA, A. CONCILIO (Italian Aerospace Research Center, Naples.), and LEONARDO V. LECCE (Istituto Progetto Velivoli, Naples, Italy) *In* NASA. Langley Research Center, Fourth Aircraft Interior Noise Workshop p 252-294 Jul. 1992
Avail: CASI HC A03/MF A03

The objectives of this work include the following: (1) development of active noise control techniques to alleviate inefficiencies and drawbacks of passive noise control approach especially at low frequencies; (2) reduction of structurally radiated noise applying external forces to the vibrating structure by means of force actuators made of piezoelectric material; and (3) reduction of fuselage vibration levels in propeller driven aircraft by means of distributed piezoelectric actuators that are actively controlled. H.A.

N92-32963*# Fokker B.V., Schipol-Oost (Netherlands).
ACTIVE SYNCHROPHASING OF PROPELLER UNBALANCE
DICK KAPTEIN *In* NASA. Langley Research Center, Fourth Aircraft Interior Noise Workshop p 295-315 Jul. 1992
Avail: CASI HC A03/MF A03

The results of a survey are presented to reduce the inflight propeller unbalance vibrations in the cabin of the Fokker 50 airplanes. Several approaches have been investigated. Active synchrophasing of the unbalance vibrations of both propellers appears to be successful. Author

N92-33160*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BUILDING VIBRATIONS INDUCED BY NOISE FROM ROTORCRAFT AND PROPELLER AIRCRAFT FLYOVERS
KEVIN P. SHEPHERD and HARVEY H. HUBBARD (Lockheed Engineering and Sciences Co., Hampton, VA.) Jun. 1992 29 p
(Contract RTOP 535-03-11-03)
(NASA-TM-104170; NAS 1.15:104170) Avail: CASI HC A03/MF A01

Noise and building vibrations were measured for a series of helicopter and propeller-driven aircraft flyovers at WFF during May 1978. The building response data are compared with similar data acquired earlier at sites near Dulles and Kennedy Airports for operation of commercial jet transports, including the Concorde supersonic transport. Results show that noise-induced vibration levels in windows and walls are directly proportional to sound pressure level and that for a given noise level, the acceleration levels induced by a helicopter or a propeller-driven aircraft flyover cannot be distinguished from the acceleration levels induced by a commercial jet transport flyover. Noise-induced building acceleration levels were found to be lower than those levels which might be expected to cause structural damage and were also lower than some acceleration levels induced by such common domestic events as closing windows and doors. Author

N92-33719*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF MAGNITUDE ESTIMATION SCALING TO THE ASSESSMENT OF SUBJECTIVE LOUDNESS RESPONSE TO SIMULATED SONIC BOOMS
S. MCDANIEL (James Madison Univ., Harrisonburg, VA.), J. D. LEATHERWOOD, and B. M. SULLIVAN (Lockheed Engineering and Sciences Co., Hampton, VA.) Sep. 1992 33 p
(Contract RTOP 537-03-21-03)
(NASA-TM-107657; NAS 1.15:107657) Avail: CASI HC A03/MF A01

A laboratory study was conducted for the following reasons: (1) to investigate the application of magnitude estimation scaling for evaluating the subjective loudness of sonic booms; and (2) to compare the relative merits of magnitude estimation and numerical category scaling for sonic boom loudness evaluation. The study was conducted in the NASA LeRC's sonic boom simulator and used a total of 80 test subjects (48 for magnitude estimation and 32 for numerical category scaling). Results demonstrated that magnitude estimation was a practical and effective method for quantifying subjective loudness of sonic booms. When using magnitude estimation, the subjects made valid and consistent ratio judgments of sonic boom loudness irrespective of the frequency of presentation of the standard stimulus. Presentation of the standard as every fourth stimulus was preferred by the subjects and is recommended as the standard presentation frequency to be used in future tests. Author

N92-33743# National Inst. for Fusion Science, Nagoya (Japan).
SHAFRANOV SHIFT IN LOW-ASPECT-RATIO HELIOTRON/TORSATRON CHS
H. YAMADA, K. IDA, H. IGUCHI, K. HANATANI (Kyoto Univ., Uji, Japan), S. MORITA, O. KANEKO, H. C. HOWE (Oak Ridge National Lab., TN.), S. P. HIRSHMAN (Oak Ridge National Lab., TN.), D. K. LEE (Oak Ridge National Lab., TN.), H. ARIMOTO et al. Sep. 1991 31 p
(ISSN 0915-633X)
(NIFS-110) Avail: CASI HC A03/MF A01

The MHD equilibrium properties of neutral-beam-heated plasmas have been experimentally investigated in the Compact Helical System (CHS), a low-aspect-ratio (A(sub p) about 5) heliotron/torsatron. This configuration is characterized by a strong breaking of helical symmetry. The radial profiles measured by various diagnostics have shown significant Shafranov shift due to plasma pressure. The deviation of the magnetic axis from its vacuum position has reached 50 percent of the minor radius. When the three-dimensional equilibrium code VMEC is used to reconstruct the equilibrium from the experimental data, the result is in good agreement with the experimentally observed Shafranov shift as well as the diamagnetic pressure in plasmas with (beta) less than or equal to 1.2 percent and beta(sub 0) less or equal to 3.3 percent. This beta value corresponds to half of the conventional equilibrium beta limit defined by the Shafranov shift reaching a value of half of the minor radius. Although tangential neutral beam injection has caused pressure anisotropies p(sub parallel)/p(sub perpendicular) less than or equal to 3, the description of the equilibrium assuming isotropic pressure is consistent with the experiment. Author

N92-33876*# Texas Univ., Austin. Applied Research Labs.
A NUMERICAL MODEL FOR SONIC BOOM PROPAGATION THROUGH AN INHOMOGENEOUS, WINDY ATMOSPHERE
LEICK D. ROBINSON *In* NASA. Langley Research Center, High-Speed Research: Sonic Boom, Volume 1 p 7-30 Oct. 1992

(Contract N00039-88-C-0043; N00039-91-C-0082)
Avail: CASI HC A03/MF A03

The ZEPHYRUS computer model calculates sonic boom distortion during propagation through the atmosphere. The model includes the effects of nonlinear distortion, attenuation, dispersion, and wind. Trial runs with the model indicate that, in general, stable shocks have not formed when the sonic boom reaches the ground. Also, the rise time of the lead shock may strongly depend on the overall waveform shape, and may be significantly increased by purely dispersive effects when matching occurs between the rise time and the characteristic oxygen molecular relaxation time.

Author

N92-33877*# Pennsylvania State Univ., University Park. Dept. of Mechanical Engineering.

WAVE EQUATIONS AND COMPUTATIONAL MODELS FOR SONIC BOOM PROPAGATION THROUGH A TURBULENT ATMOSPHERE

ALLAN D. PIERCE *In* NASA. Langley Research Center, High-Speed Research: Sonic Boom, Volume 1 p 31-48 Oct. 1992
(Contract NAG1-947)
Avail: CASI HC A03/MF A03

The improved simulation of sonic boom propagation through the real atmosphere requires greater understanding of how the transient acoustic pulses popularly termed sonic booms are affected by atmospheric turbulence. A nonlinear partial differential equation that can be used to simulate the effects of smaller-scale atmospheric turbulence on sonic boom waveforms is described. The equation is first order in the time derivative and involves an extension of geometrical acoustics to include diffraction phenomena. Various terms in the equation are explained in physical terms. Such terms include those representing convection at the wave speed, diffraction, molecular relaxation, classical dissipation, and nonlinear steepening. The atmospheric turbulence enters through an effective sound speed, which varies with all three spatial coordinates, and which is the sum of the local sound speed and the component of the turbulent flow velocity projected along a central ray that connects the aircraft trajectory with the listener.

Author

N92-33878*# Pennsylvania State Univ., University Park.

SIMULATIONS OF SONIC BOOM RAY TUBE AREA FLUCTUATIONS FOR PROPAGATION THROUGH ATMOSPHERIC TURBULENCE INCLUDING CAUSTICS VIA A MONTE CARLO METHOD

VICTOR W. SPARROW and ALLAN D. PIERCE *In* NASA. Langley Research Center, High-Speed Research: Sonic Boom, Volume 1 p 49-62 Oct. 1992
(Contract NAG1-947)
Avail: CASI HC A03/MF A03

A theory which gives statistical predictions for how often sonic booms propagating through the earth's turbulent boundary layer will encounter caustics, given the spectral properties of the atmospheric turbulence, is outlined. The theory is simple but approximately accounts for the variation of ray tube areas along ray paths. This theory predicts that the variation of ray tube areas is determined by the product of two similar area factors, psi (x) and phi (x), each satisfying a generic harmonic oscillator equation. If an area factor increases the peak acoustic pressure decreases, and if the factor decreases the peak acoustic pressure increases. Additionally, if an area factor decreases to zero and becomes negative, the ray has propagated through a caustic, which contributes a phase change of 90 degrees to the wave. Thus, it is clear that the number of times that a sonic boom wave passes through a caustic should be related to the distorted boom waveform received on the ground. Examples are given based on a characterization of atmospheric turbulence due to the structure function of Tatarski as modified by Crow. Author

N92-33879*# Pennsylvania State Univ., University Park.

ANALYSIS OF SONIC BOOM DATA TO QUANTIFY DISTORTIONS OF SHOCK PROFILES

THOMAS A. GIONFRIDDO *In* NASA. Langley Research Center, High-Speed Research: Sonic Boom, Volume 1 p 63-76 Oct. 1992
(Contract NAG1-947)
Avail: CASI HC A03/MF A03

Researchers at Penn State have been examining some sonic boom waveforms recorded during overflights by the Air Force which have become available to NASA and its contractors. The quality of the digitized data and the supporting meteorological data was such that one could test the applicability of molecular relaxation theories. In the late sixties, it had been supposed that the finite rise times in the absence of turbulence had neglected the vibrational relaxation of nitrogen molecules. Bass et al. have demonstrated that molecular relaxation definitely gives the correct order of magnitude of the observed rise times. However, the Air Force data in conjunction with the recent steady-state shock profile model theory of Kang and Pierce give the first opportunity to make a detailed quantitative assessment of the molecular relaxation hypothesis. Currently an investigation is ongoing to establish a method of quantifying the distortion of a sonic boom wave from a classic N-wave shape using the Air Force data taken at Edwards AFB in 1987. Using the premise that energy will be conserved approximately for a sonic boom wave both before and after the boom passes through the Earth's turbulent boundary layer, a classic undistorted waveform is constructed from the distorted signature received at the ground. A correlation between the mean-squared deviation of the distorted and undistorted waveforms and the distance the boom travels through the turbulence is sought.

Author

N92-33880*# Wyle Labs., Inc., Arlington, VA.

THE EFFECT OF TURBULENCE ON THE LOUDNESS OF MINIMIZED SONIC BOOM SIGNATURES

KENNETH J. PLOTKIN *In* NASA. Langley Research Center, High-Speed Research: Sonic Boom, Volume 1 p 77-95 Oct. 1992
Avail: CASI HC A03/MF A03

An important issue for shaped minimized sonic booms is whether turbulence-induced distortions will adversely affect the benefits gained by shaping. This question was considerably simplified by two recent results. The first is the finding that the loudness of sonic booms is well quantified by loudness. The second is that loudness of a shaped boom is dominated by the shock waves. The issue is now the effect of turbulence on weak (1 psf or less) sonic booms. Since it is clear that molecular relaxation effects have a significant effect on shock structure and loudness, turbulence effects must be examined in conjunction with relaxation-thickened shocks. This analysis must be directed toward loudness calculations and include all pertinent mechanisms.

Author

N92-33881*# Texas Univ., Austin. Applied Research Labs. and Mechanical Engineering Dept.

MODEL EXPERIMENT TO STUDY THE EFFECT OF TURBULENCE ON RISETIME AND WAVEFORM OF N WAVES

BART LIPKENS and DAVID T. BLACKSTOCK *In* NASA. Langley Research Center, High-Speed Research: Sonic Boom, Volume 1 p 97-107 Oct. 1992
Avail: CASI HC A03/MF A03

Typical measured sonic boom rise times are two to five times longer than rise times calculated using molecular relaxation theory. The difference may be due to atmospheric turbulence. A model experiment was set up to study the influence of turbulence on waveform and rise time of spark-produced N waves. The N waves propagate through turbulence generated by a plane jet. The model turbulence is scaled down from atmospheric turbulence by approximately the same factor as the model N wave is scaled down from the sonic boom. Our experiments show that passage through the turbulence produces a wide variety of changes in the N waveform. Spiked and rounded N waves are observed, and average rise time is increased by a factor of about 2. A tentative observation based on data obtained so far is that rise time is always increased, never decreased, by turbulence. Author

N92-33882*# Mississippi Univ., University. Dept. of Physics and Astronomy.

STEADY STATE RISETIMES OF SHOCK WAVES IN THE ATMOSPHERE

RICHARD RASPET, HENRY BASS, LIXIN YAO, and WENLIANG WU *In* NASA. Langley Research Center, High-Speed Research: Sonic Boom, Volume 1 p 109-115 Oct. 1992

Avail: CASI HC A02/MF A03

A square wave shape is used in the Pestorius algorithm to calculate the risetime of a step shock in the atmosphere. These results agree closely with steady shock calculations. The healing distance of perturbed shocks due to finite wave effects is then investigated for quasi-steady shocks. Perturbed 100 Pa shocks require on the order of 1.0 km travel distance to return to within 10 percent of their steady shock risetime. For 30 Pa shocks, the minimum recovery distance increases to 3.0 km. It is unlikely that finite wave effects can remove the longer risetimes and irregular features introduced into the sonic boom by turbulent scattering in the planetary boundary layer. Author

N92-33883*# Air Force Systems Command, Wright-Patterson AFB, OH.

LATERAL SPREAD OF SONIC BOOM MEASUREMENTS FROM US AIR FORCE BOOMFILE FLIGHT TESTS

J. MICAH DOWNING *In* NASA. Langley Research Center, High-Speed Research: Sonic Boom, Volume 1 p 117-135 Oct. 1992

Avail: CASI HC A03/MF A03

A series of sonic boom flight tests were conducted by the US Air Force at Edwards AFB in 1987 with current supersonic DOD aircraft. These tests involved 43 flights by various aircraft at different Mach number and altitude combinations. The measured peak overpressures to predicted values as a function of lateral distance are compared. Some of the flights are combined into five groups because of the varying profiles and the limited number of sonic booms obtained during this study. The peak overpressures and the lateral distances are normalized with respect to the Carlson method predicted centerline overpressures and lateral cutoff distances, respectively, to facilitate comparisons between sonic boom data from similar flight profiles. It is demonstrated that the data agrees with sonic boom theory and previous studies and adds to the existing sonic boom database by including sonic boom signatures, tracking, and weather data in a digital format. Author

N92-33884*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PRELIMINARY RESULTS FROM THE WHITE SANDS MISSILE RANGE SONIC BOOM PROPAGATION EXPERIMENT

WILLIAM L. WILLSHIRE, JR. and DAVID W. DEVILBISS (Lockheed Engineering and Sciences Co., Hampton, VA.) *In its* High-Speed Research: Sonic Boom, Volume 1 p 137-149 Oct. 1992

Avail: CASI HC A03/MF A03

Sonic boom bow shock amplitude and rise time statistics from a recent sonic boom propagation experiment are presented. Distributions of bow shock overpressure and rise time measured under different atmospheric turbulence conditions for the same test aircraft are quite different. The peak overpressure distributions are skewed positively, indicating a tendency for positive deviations from the mean to be larger than negative deviations. Standard deviations of overpressure distributions measured under moderate turbulence were 40 percent larger than those measured under low turbulence. As turbulence increased, the difference between the median and the mean increased, indicating increased positive overpressure deviations. The effect of turbulence was more readily seen in the rise time distributions. Under moderate turbulence conditions, the rise time distribution means were larger by a factor of 4 and the standard deviations were larger by a factor of 3 from the low turbulence values. These distribution changes resulted in a transition from a peaked appearance of the rise time distribution for the morning to a flattened appearance for the afternoon rise time distributions. The sonic boom propagation experiment consisted of flying three types of aircraft supersonically over a ground-based microphone array with concurrent measurements of turbulence and other meteorological data. The test aircraft were a T-38, an F-15, and an F-111, and they were flown at speeds of Mach 1.2 to 1.3, 30,000 feet above a 16 element, linear microphone array with an inter-element spacing of 200 ft. In two weeks of testing, 57 supersonic passes of the test aircraft were flown from early morning to late afternoon. Author

N92-33885*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SUBJECTIVE LOUDNESS RESPONSE TO SIMULATED SONIC BOOMS

JACK D. LEATHERWOOD and BRENDA M. SULLIVAN (Lockheed Engineering and Sciences Co., Hampton, VA.) *In its* High-Speed Research: Sonic Boom, Volume 1 p 151-170 Oct. 1992

Avail: CASI HC A03/MF A03

A series of laboratory studies were conducted at LaRC to: (1) quantify the effects of sonic boom signature shaping on subjective loudness; (2) evaluate candidate loudness metrics; (3) quantify the effects of signature asymmetry on loudness; and (4) document sonic boom acceptability within the laboratory. A total of 212 test subjects evaluated a wide range of signatures using the NASA Langley Research Center's sonic boom simulator. Results indicated that signature shaping via front-shock minimization was particularly effective in reducing subjective loudness without requiring reductions in peak overpressure. Metric evaluations showed that A-weighted sound exposure level, Perceived Level (Stevens Mark 7), and Zwicker's Loudness level were effective descriptors of the loudness of symmetrical shaped signatures. The asymmetrical signatures were generally rated as being quieter than symmetrical signatures of equal calculated metric level. The magnitude of the loudness reductions were observed to increase as the degree of asymmetry increased and to be greatest when the rear half of the signature was loudest. This effect was not accounted for by the loudness metrics. Sonic boom acceptability criteria were determined within the laboratory. These agreed well with results previously obtained in more realistic situations. Author

N92-34148*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ADVANCED SUBSONIC TRANSPORT APPROACH NOISE: THE RELATIVE CONTRIBUTION OF AIRFRAME NOISE

WILLIAM L. WILLSHIRE, JR. and DONALD P. GARBER (Lockheed Engineering and Sciences Co., Hampton, VA.) Jun. 1992 37 p (Contract RTOP 537-03-21-04)

(NASA-TM-104112; NAS 1.15:104112) Avail: CASI HC A03/MF A01

With current engine technology, airframe noise is a contributing source for large commercial aircraft on approach, but not the major contributor. With the promise of much quieter jet engines with the planned new generation of high-by-pass turbofan engines, airframe noise has become a topic of interest in the advanced subsonic transport research program. The objective of this paper is to assess the contribution of airframe noise relative to the other aircraft noise sources on approach. The assessment will be made for a current technology large commercial transport aircraft and for an envisioned advanced technology aircraft. NASA's Aircraft Noise Prediction Program (ANOPP) will be used to make total aircraft noise predictions for these two aircraft types. Predicted noise levels and areas of noise contours will be used to determine the relative importance of the contributing approach noise sources. The actual set-up decks used to make the ANOPP runs for the two aircraft types are included in appendixes. Author

17

SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A92-54152#
IMPROVEMENTS IN TEACHING AIRCRAFT ENGINE DESIGN
JACK D. MATTINGLY (Seattle, University, WA) and WILLIAM H. HEISER (Tennessee, University, Tullahoma) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992. 9 p. refs
(AIAA PAPER 92-3758) Copyright

Aircraft gas turbine analysis and design pedagogy can be enriched through the incorporation improved preliminary engine thrust and fuel consumption models, novel computer programs for both aircraft system analysis and turbomechanical design, and a new perspective for engine-cycle analysis. Four computer programs have been developed for preliminary engine design; two of these automate aircraft system analysis, while another designs multistage axial-flow compressors and the last designs multistage axial-flow turbines. Student confusion with 'design-point' and 'off-design' concepts is by these means reduced. O.C.

A92-55272#
ENLISTING INDUSTRY SUPPORT FOR A FLIGHT CONTROLS DESIGN LAB
DANIEL J. BIEZAD (California Polytechnic State University, San Luis Obispo) IN: AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3. Washington, American Institute of Aeronautics and Astronautics, 1992, p. 1239-1248. Research supported by Teledyne Ryan Aeronautical. refs
(AIAA PAPER 92-4560) Copyright

A case study is presented which illustrates how industry support was obtained to build and equip a flight controls research and design laboratory. The project in question, the Flight Controls Design Laboratory at Cal Poly (San Luis Obispo), is discussed with emphasis on the benefits and pitfalls of enlisting industry support from an engineering education perspective. V.L.

A92-56212
IMPROVING RELIABILITY AND MAINTAINABILITY THROUGH PROCESS MANAGEMENT
TIMOTHY J. SHARP and CAY A. ERVIN (USAF, Wright-Patterson AFB, OH) IN: Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1992, p. 93-97. refs

A recent study by the Scientific Advisory Board found that the US Air Force spends approximately $2 billion a year on simple structural aircraft parts. Responsibility and management of these parts (fasteners, actuators, connectors, tools, and subsystems, or FACTS) is spread across the Air Force major commands and weapon systems. In order to improve the reliability and maintainability (R&M) of these parts and decrease the amount of time needed to acquire and provide the parts to the aircraft maintainers the Acquisition Logistics Division FACTS Office was founded. The FACTS Office acts as an advocate for maintainers by helping with the procurement of better parts. The office also attempts to change the systems by which the parts are acquired. The FACTS Office has established an internal process using project teams, a sophisticated computer hardware and software system, and management support to improve the R&M of simple aircraft parts. This management system was developed around the total quality management concept of process improvement. Several projects have been completed successfully with both tangible and intangible savings identified. I.E.

A92-56602* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ISSUES IN DEVELOPING CONTROL ZONES FOR INTERNATIONAL SPACE OPERATIONS
BLAIR A. NADER and KUMAR KRISHEN (NASA, Johnson Space Center, Houston, TX) (Spacecraft Rendezvous and Docking Conference, Houston, TX, July 9-12, 1990) Journal of Aerospace Engineering (ISSN 0893-1321), vol. 5, no. 4, Oct. 1992, p. 387-404. Previously announced in STAR as N91-20668. refs
Copyright

Cooperative missions in earth orbit can be facilitated by developing a strategy to regulate the manner in which vehicles interact in orbit. One means of implementing such a strategy is to utilize a control zones technique that assigns different types of orbital operations to specific regions of space surrounding a vehicle. Considered here are issues associated with developing a control zones technique to regulate the interactions of spacecraft in proximity to a manned vehicle. Technical and planning issues, flight hardware and software issues, mission management parameter, and other constraints are discussed. Also covered are manned and unmanned vehicle operations, and manual versus automated flight control. A review of the strategies utilized by the Apollo Soyuz Test Project and the Space Station Freedom Program is also presented. Author

A92-56842#
IMAGE PROCESSING IN THE UNDERGRADUATE FLUID DYNAMICS LABORATORY
NARAYANAN M. KOMERATH (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 11 p. refs
(AIAA PAPER 92-4020) Copyright

New curricula based on new developments in video imaging, digital frame grabbing, and image processing technology is discussed, and several examples of student work are presented. It is hypothesized that image-based curricula can revolutionize fluid dynamics education, and permit the undergraduate to become familiar with fluids engineering technology, exploiting unsteady flows. O.G.

A92-56844*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DEVELOPMENT AND INTEGRATION OF MODERN LABORATORIES IN AEROSPACE EDUCATION
D. DESAUTEL, N. HUNTER, N. MOURTOS, and H. PERNICKA (San Jose State University, CA) AIAA, Aerospace Ground Testing Conference, 17th, Nashville, TN, July 6-8, 1992. 19 p. Research supported by Lockheed Missiles & Space Co., Inc., Space Systems/Loral, and NASA. refs
(AIAA PAPER 92-4022) Copyright

This paper describes the development and integration of a suite of laboratories in an aerospace engineering program. The program's approach to undergraduate education is described as the source for the development of the supporting laboratories. Nine laboratories supporting instruction were developed and installed. The nine laboratories include most major flight-vehicle disciplines. The purpose and major equipments/experiments of each laboratory are briefly described, as is the integration of the laboratory with coursework. The laboratory education provided by this program successfully achieves its purpose of producing competitive aerospace engineering graduates and advancing the level of undergraduate education. Author

N92-32505# Committee on Appropriations (U.S. House).
DEPARTMENTS OF VETERANS AFFAIRS AND HOUSING AND URBAN DEVELOPMENT, AND INDEPENDENT AGENCIES APPROPRIATIONS FOR 1993, PART 6
BOB TRAXLER Washington GPO 1992 211 p Hearings before a Subcommittee of the Committee on Appropriations, 102nd Congress, 2nd Session
(GAO-55-636-PT-6; ISBN-0-16-038597-0) Avail: CASI HC A10/MF A03; Committee on Appropriations, House of Representatives, Washington, DC 20515 HC; SOD HC

Hearings before a subcommittee of the committee on Appropriations House of Representatives are presented for the National Aeronautics and Space Administration for the fiscal year 1993. All verbal testimony, procurement notices, and responses to written questions are included. The verbal testimony provides detailed outline of programs which include Space Station Freedom, science funding for Space Station, space science and applications, space transportation and operations, Advanced Solid Rocket Motor, National Aero-space Alane, aeronautics, space exploration, new launch system, research and program management, and construction of facilities. I.I.C.

N92-33147# Committee on Science, Space and Technology (U.S. House).
NASA AUTHORIZATION, 1993, VOLUME 1
Washington GPO 1992 201 p Hearing before the Committee on Science, Space, and Technology, 102nd Congress, 2nd Session, No. 128, 19 Feb. 1992
(GPO-55-260-VOL-1; ISBN-0-16-038832-5) Avail: CASI HC A10/MF A03; Subcommittee on Technology and Competitiveness, House of Representatives, Washington, DC 20515 HC

Discussed here is the NASA budget request for FY-93 for its Aeronautical Research and Technology Program. Additionally, the NASA Transatmospheric Research and Technology Program request is reviewed. Statements of witnesses from NASA and from outside the government are given. The testimony is related to a detailed study of the U.S. aviation industry's technical needs of the future. The testimony addresses whether or not NASA is on the path which is compatible with the recommendations of the study. Also given is testimony that represents a composite view of the manufacturers, their professional societies, and the industry's efforts to determine future needs for advanced technology. Author

N92-33237*# National Aeronautics and Space Administration, Washington, DC.
AN INTERNATIONAL AEROSPACE INFORMATION SYSTEM: A COOPERATIVE OPPORTUNITY
GLADYS A. COTTER and WALTER R. BLADOS Oct. 1992 15 p Presented at the Second East-West Online Meeting, Moscow, USSR, 30 Sep. - 2 Oct. 1992
(NASA-TM-108171; NAS 1.15:108171) Avail: CASI HC A03/MF A01

Scientific and technical information (STI) is a valuable resource which represents the results of large investments in research and development (R&D), and the expertise of a nation. NASA and its predecessor organizations have developed and managed the preeminent aerospace information system. We see information and information systems changing and becoming more international in scope. In Europe, consistent with joint R&D programs and a view toward a united Europe, we have seen the emergence of a European Aerospace Database concept. In addition, the development of aeronautics and astronautics in individual nations have also lead to initiatives for national aerospace databases. Considering recent technological developments in information science and technology, as well as the reality of scarce resources in all nations, it is time to reconsider the mutually beneficial possibilities offered by cooperation and international resource sharing. The new possibilities offered through cooperation among the various aerospace database efforts toward an international aerospace database initiative which can optimize the cost/benefit equation for all participants are considered. Author

N92-33305# Advanced Aviation Concepts, Jupiter, FL.
WORKSHOP ON AERONAUTICAL DECISION MAKING (ADM). VOLUME 1: EXECUTIVE SUMMARY Final Report
RICHARD J. ADAMS, CATHERINE A. ADAMS, and RONALD JOHN LOFARO Aug. 1992 76 p
(Contract DTFA01-90-C-00042)
(DOT/FAA/RD-92/14-VOL-1) Avail: CASI HC A05/MF A01

Presented here are the Aeronautical Decision Making (ADM) training accomplishments, limitations, and future needs from the perspectives of commercial operators, general aviation, military aviation and research development. A select group of experts on ADM was convened to share ideas, identify and explore future directions for advanced training. Cognitive training requirements based upon decision making task demands of both airplane and helicopter pilots and crews are analyzed. A major question which requires definitional research is: What is a real aircrew/pilot decision? (that is, when does an event generate a true decisional opportunity for a pilot or crew versus a 'one-path only' reaction, where the actual emphasis is not on cognitive decision making, but the application of procedures and basic airmanship). Going one step further, the group analyzed the decision making differences between expert and novice pilots when a real decision was required. Author

19

GENERAL

N92-32338# Research and Development Labs., Culver City, CA.
UNITED STATES AIR FORCE SUMMER RESEARCH PROGRAM 1991. VOLUME 1: PROGRAM MANAGEMENT REPORT Report, 30 Sep. 1990 - 30 Sep. 1991
GARY MOORE 9 Jan. 1992 638 p
(Contract F49620-90-C-0076)
(AD-A248763; AFOSR-92-0167TR-VOL-1) Avail: CASI HC A99/MF A06

The Summer Faculty Research Program (SFRP), Graduate Student Research Program (GSRP), and the High School Apprenticeship Program (HSAP) are summarized. Statistics on each program from 1979 to the present are given. Included are efforts to recruit participants from Historically Black Colleges and Universities and Minority Institutions (HBCU/MI). Participating Air Force laboratories are listed and information is given on a number of applicants and participants at each laboratory. Finally, an abstract is provided for each of the reports written by the program participants. GRA

N92-32453# Federal Aviation Administration, Washington, DC.
THE 1991 FEDERAL AVIATION ADMINISTRATION PLAN FOR RESEARCH, ENGINEERING AND DEVELOPMENT
Aug. 1992 171 p Prepared for Congress of the United States, Washington, DC Original contains color illustrations
Avail: CASI HC A08/MF A02

The FAA's Research, Engineering and Development (R,E&D) Program is very forward looking, and concentrates on the known needs of the aviation system and it constituency. The FAA has published a vision of the future system which has been broadly accepted by the industry. The vision is rooted in the pursuit of a safe system that does not constrain flight. The system that results from this work will be more capable, efficient, and economical to operate. Increased automation will involve the controller, pilot, and maintenance technicians in different roles than today's system requires. Specific areas of this project which are discussed at length include the following: quality control; R,E&D goals; past lessons learned; planning for future aviation systems; R,E&D plan components; and system engineering. H.A.

N92-33238# Department of Defense, Washington, DC. Director of Defense Research and Engineering.
DOD KEY TECHNOLOGIES PLAN
Jul. 1992 228 p
(AD-A253692) Avail: CASI HC A11/MF A03

The primary objective of these development plans is to prove out and mature the technologies required to attain the goals of the science and technology (S&T) program of the Department of Defense (DoD). The activities delineated in the plan involve proof of concept experiments, laboratory demonstrations, and evaluations

supported by models and simulations. The formulation of this Key Technology Plan is driven by the S&T Strategy. At the core of this strategy are the Seven Thrusts which focus the S&T program to address the users' most pressing military and operational requirements. These thrusts are global surveillance and communications, precision strike, air superiority and defense, sea control and undersea superiority, advanced land combat, synthetic environments, and technology for affordability. The key technology areas addressed in the plan are computers, software, sensors, communications networking, electronic devices, environmental effects, materials and processes, energy storage , propulsion and energy conversion, design automation, and human-system interfaces. The plan provides technology development roadmaps for the development and maturation of the technologies needed to achieve the stated goals of the thrusts. Author

N92-33694# National Aerospace Lab., Amsterdam (Netherlands).

ACTIVITIES REPORT OF THE NATIONAL AEROSPACE LABORATORY Annual Report, 1990 [STICHTING NATIONAAL LUCHT- EN RUIMTEVAARTLABORATORIUM JAARVERSLAG 1990]

31 Dec. 1990 114 p In DUTCH

(ETN-92-92053) Avail: CASI HC A06/MF A02

In the field of flows, research and development activities were carried out in the area of theoretical and numerical methods. In the field of aircraft, the evaluation and certification of the Fokker 50 and Fokker 100 were accomplished. In the field of constructions and materials, research activities were carried out in the areas of aircraft loading, dynamical behavior of constructions, strength and stiffness of contructions, crack growth, composites, fiber reinforced laminates, aluminum alloys, high temperature materials, corrosion and erosion, and damage assessment. Astronautics research was made in the fields of satellite positioning, heat budget, microgravity, robotics, and remote sensing. Research in the field of computer aided engineering was carried out. ESA

N92-33948*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

RESEARCH AND TECHNOLOGY, 1990

1990 487 p Original contains color illustrations

(NASA-TM-107967; A-91054; NAS 1.15:107967) Avail: CASI HC A21/MF A04; 15 functional color pages

Selected research and technology activities at Ames Research Center, including the Moffett Field site and the Dryden Flight Research Facility, are summarized. These accomplishments exemplify the Center's varied and highly productive research efforts for 1990. The activities addressed are under the directories of: (1) aerospace systems which contains aircraft technology, full-scale aerodynamics research, information sciences, aerospace human factors research, and flight systems and simulation research divisions; (2) Dryden flight research facility which contains research engineering division; (3) aerophysics which contains aerodynamics, fluid dynamics, and thermosciences divisions; and (4) space research which contains advanced life support, space projects, earth system science, life science, and space science divisions, and search for extraterrestrial intelligence and space life sciences payloads offices. I.I.C.

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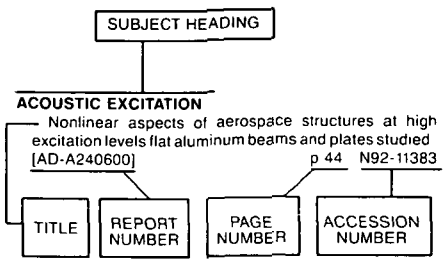

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A

A-310 AIRCRAFT
Comparison of recent results from different wind tunnel facilities along with comparisons of measured flight results and wind tunnel based predictions
[AIAA PAPER 92-3985] p 1060 A92-56809

A-320 AIRCRAFT
A320 flight control from the pilot's point of view
p 1083 A92-56028

ABRASION
Effects of the abrasiveness of test and training site soils on parachute life
[AD-A252389] p 1038 N92-32900

ACCELEROMETERS
Research on measurement and control of helicopter rotor response using blade-mounted accelerometers 1990-91 p 1057 A92-56316

ACOUSTIC ATTENUATION
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964

ACOUSTIC EXCITATION
Forcing level effects of internal acoustic excitation on the improvement of airfoil performance
p 1136 A92-56162

ACOUSTIC MEASUREMENT
Broadband shock associated noise from supersonic jets measured by a ground observer p 1135 A92-54909
The design of a subsonic low-noise, low-turbulence wind tunnel for acoustic measurements
[AIAA PAPER 92-3883] p 1094 A92-56726
Lateral spread of sonic boom measurements from US Air Force boomfile flight tests p 1140 N92-33883

ACOUSTIC PROPAGATION
Experimental study of noise generation and propagation in a turbofan model p 1136 A92-56169

ACOUSTIC PROPERTIES
Exposures from headset interference tones
[AD-A247175] p 1136 N92-32697

ACOUSTIC SCATTERING
Steady state risetimes of shock waves in the atmosphere p 1140 N92-33882

ACOUSTIC SIMULATION
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951

ACTIVE CONTROL
Dynamics and control of hypersonic aeropropulsive/aeroelastic vehicles
[AIAA PAPER 92-4326] p 1073 A92-55170
ATTAS flight test and simulation results of the advanced gust management system LARS
[AIAA PAPER 92-4343] p 1079 A92-55332
Active control of asymmetric vortical flows around cones using injection and heating
[AIAA PAPER 92-4426] p 1025 A92-55350
Experimental evaluation of a 50-percent thick airfoil with blowing and suction boundary layer control
[AIAA PAPER 92-4500] p 1026 A92-55368
Numerical simulations of flutter and its suppression by active control
[AIAA PAPER 92-4652] p 1082 A92-55396
Synthesis of gust load alleviation with flutter margin augmentation p 1082 A92-56021
Optimization of aeroelastic system with active control
p 1083 A92-56022
Smart structures in the active control of blade vortex interaction p 1085 A92-56314
Experimental investigation of helicopter coupled rotor/body control p 1086 A92-56318
Active control of sound transmission through stiff lightweight composite fuselage constructions
p 1137 N92-32957
Active control of interior noise in a large scale cylinder using piezoelectric actuators p 1137 N92-32958
Active vibrations and noise control for turboprop application research program activities
p 1138 N92-32962
Active synchrophasing of propeller unbalance
p 1138 N92-32963
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964
Active control of compressor surge and stall
[AD-A252771] p 1126 N92-33498

ACTUATORS
Active control of interior noise in a large scale cylinder using piezoelectric actuators p 1137 N92-32958
Active vibrations and noise control for turboprop application research program activities
p 1138 N92-32962
Simulation model of a twin-tail, high performance airplane
[NASA-TM-107601] p 1088 N92-33537

ADA (PROGRAMMING LANGUAGE)
Experience with Ada on the F-18 High Alpha Research Vehicle Flight Test Program
[NASA-TM-104259] p 1062 N92-34039

ADAPTIVE CONTROL
Discrete event fuzzy airport control
p 1046 A92-55973
An approach to the organization of an adaptive man-machine system for flight vehicle control
p 1133 A92-57445
A learning enhanced flight control system for high performance aircraft
[AD-A252520] p 1086 N92-32435

AERIAL RECONNAISSANCE
A small light-weight rotor platform for ground observation and pollution control p 1057 A92-56329

AEROACOUSTICS
Forcing level effects of internal acoustic excitation on the improvement of airfoil performance
p 1136 A92-56162
Experimental study of noise generation and propagation in a turbofan model p 1136 A92-56169
Design of a variable contraction for a full-scale automotive wind tunnel
[AIAA PAPER 92-3929] p 1096 A92-56760
Fourth Aircraft Interior Noise Workshop
[NASA-CP-10103] p 1136 N92-32948
Acoustic loads prediction on jet aircraft
p 1136 N92-32949

AERODYNAMIC BALANCE
Aerodynamic centre of wing-body combinations
[ESDU-92024] p 1036 N92-32479
Computational aspects of helicopter trim analysis and damping levels from Floquet theory
[NASA-CR-190736] p 1087 N92-33107

AERODYNAMIC CHARACTERISTICS
Calculations for aerodynamic characteristics of HOPE type vehicle in subsonic and hypersonic flow
p 1018 A92-53560
Aerodynamic study of H-II Orbiting Plane, HOPE
p 1103 A92-53639
Aerodynamic airfoils design by quasi-solutions method of inverse boundary-value problems
p 1020 A92-53998
A comparison of the calculated and experimental off-design performance of a radial flow turbine
[AIAA PAPER 92-3069] p 1020 A92-54004
An experimental investigation of the flow in a diffusing S-duct
[AIAA PAPER 92-3622] p 1021 A92-54090
Particle image velocimetry measurements of the aerodynamics of a wind turbine p 1115 A92-54337
An analysis of boundary layer for droplet aerodynamic stripped in high speed gas flow p 1116 A92-54563
Stability, control and gust response characteristics of an ultralight freewing airplane
[AIAA PAPER 92-4342] p 1079 A92-55331
Aerodynamic parameters of the X-31 drop model estimated from flight-data at high angles of attack
[AIAA PAPER 92-4357] p 1080 A92-55343
Parameter identification of AV-8B wingborne aerodynamics for flight simulator model updates
[AIAA PAPER 92-4506] p 1027 A92-55373
Aerodynamic analysis of the Pioneer unmanned air vehicle
[AIAA PAPER 92-4635] p 1027 A92-55382
State-space representation of aerodynamic characteristics of an aircraft at high angels of attack
[AIAA PAPER 92-4651] p 1028 A92-55395
New 1.27-m leg of the National Aerospace Laboratory hypersonic wind tunnel p 1092 A92-56003
Experimental investigation of the boundary layer in a corner formed by two circular arc airfoils
p 1029 A92-56046
Numerical simulation of supersonic unsteady flow using a panel method p 1030 A92-56048
On the effect of canards on NAL spaceplane model (0 order) in low speed area p 1030 A92-56052
Low-speed wind tunnel testing for the high-speed propeller at high shaft angle of attack
p 1030 A92-56054
A physical approach to the estimation of aerodynamic characteristics from flight data p 1030 A92-56058
A low speed wind tunnel investigation of the direct side force control of a joined-wing aircraft with overhanging fin p 1084 A92-56079
Direct simulation of low-density flow over airfoils
p 1030 A92-56159
The achievement of aerodynamic goals on the EH101 project through the 'single site' concept
p 1058 A92-56342
Predicted aerodynamic characteristics for HL-20 lifting-body using the aerodynamic preliminary analysis system (APAS)
[AIAA PAPER 92-3941] p 1033 A92-56771
Description of a pressure measurement technique for obtaining surface static pressures of a radial turbine
[AIAA PAPER 92-4006] p 1123 A92-56829
Numerical simulation of unsteady flow in a hypersonic shock tunnel facility
[AIAA PAPER 92-4029] p 1034 A92-56851
Effect of a simulated glaze ice shape on the aerodynamic performance of a rectangular wing
[AIAA PAPER 92-4042] p 1035 A92-56861
An integrated analytical aeropropulsive/aeroelastic model for the dynamic analysis of hypersonic vehicles
[AIAA PAPER 92-4567] p 1035 A92-57034
Turbine disk cavity aerodynamics and heat transfer
p 1124 N92-32265

A critical evaluation of a three-dimensional Navier-Stokes CFD as a tool to design supersonic turbine stages p 1124 N92-32268
User's manual for AeroFcn: A FORTRAN program to compute aerodynamic parameters
[NASA-TM-104237] p 1133 N92-32507
An examination of several high resolution schemes applied to complex problems in high speed flows
[AD-A250814] p 1124 N92-32632
Effect of afterbody geometry on aerodynamic *characteristics of isolated nonaxisymmetric afterbodies at* transonic Mach numbers
[NASA-TP-3236] p 1041 N92-33706
Analysis of spacecraft entry into Mars atmosphere p 1105 N92-33763
Numerical investigation of the effects of icing on fixed and rotary wing aircraft
[NASA-CR-190542] p 1044 N92-34105
Analysis of iced wings
[NASA-TM-105773] p 1042 N92-34144

AERODYNAMIC COEFFICIENTS
Application of recursive partially unknown system identification to aerodynamic coefficients estimation
[AIAA PAPER 92-4504] p 1081 A92-55371
Measurements of longitudinal static aerodynamic coefficients with cable mount system p 1093 A92-56013
A *physical approach to the estimation of aerodynamic* characteristics from flight data p 1030 A92-56058
Millisecond aerodynamic force measurement with side-jet model in the ISL shock tunnel
[AIAA PAPER 92-3963] p 1097 A92-56790
High Reynolds number testing in support of transport airplane development
[AIAA PAPER 92-3982] p 1099 A92-56807
Lift and rolling moment due to spoilers on wings with trailing-edge flaps deflected at subsonic speeds
[ESDU-92002-SUPPL] p 1037 N92-32782
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063
Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193

AERODYNAMIC CONFIGURATIONS
Aerodynamic studies on space plane configuration at hypersonic speed p 1019 A92-53641
Current European research activities in helicopter interactional aerodynamics p 1058 A92-56330
A method for designing blended wing-body configurations for low wave drag
[NASA-TP-3261] p 1036 N92-32480
New concepts for multi-block grid generation for flow domains around complex aerodynamic configurations
[NLR-TP-91046-U] p 1037 N92-32730
Investigation of advancing front method for generating unstructured grid
[NASA-CR-190902] p 1128 N92-34043

AERODYNAMIC DRAG
Drag computation by vortex methods p 1031 A92-56161
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063
Applications of a direct/iterative design method to *complex transonic configurations*
[NASA-TP-3234] p 1039 N92-33484
Analysis of the flight performance of the 155 mm M864 base burn projectile
[BRL-TR-3083] p 1041 N92-33699
Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193
Method of reducing drag in aerodynamic systems
[NASA-CASE-LEW-14791-1] p 1043 N92-34243

AERODYNAMIC FORCES
Stability and dynamic coupling of elastic vehicles with unsteady aerodynamic forces considered p 1102 A92-53545
Experimental investigation of the stability of a clearance-excited rotor system with optimal parameters p 1114 A92-54223
ATTAS flight test and simulation results of the advanced gust management system LARS
[AIAA PAPER 92-4343] p 1079 A92-55332
Parameter identification of unsteady aerodynamic forces for elastic vehicles
[AIAA PAPER 92-4505] p 1027 A92-55372
State-space representation of aerodynamic *characteristics of an aircraft at high angels of attack*
[AIAA PAPER 92-4651] p 1028 A92-55395
Calculations of aerodynamic forces on a wing with thrust using B.E.M p 1030 A92-56049
Millisecond aerodynamic force measurement with side-jet model in the ISL shock tunnel
[AIAA PAPER 92-3963] p 1097 A92-56790

AERODYNAMIC HEAT TRANSFER
Effect of porosity in transpiration cooling system p 1112 A92-53786
Quantitative heat transfer measurements in hypersonic wind tunnels by means of infrared thermography p 1115 A92-54321

AERODYNAMIC HEATING
Aerodynamic heating characteristics of space planes tested by NAL hypersonic wind tunnel p 1017 A92-53547
Numerical simulations of shock reflections by a TVD scheme p 1018 A92-53558
Spaceplane aerodynamic heating and thermal protection design method p 1102 A92-53578
HOPE re-entry experimental vehicle p 1103 A92-55098
Active control of asymmetric vortical flows around cones using injection and heating
[AIAA PAPER 92-4426] p 1025 A92-55350
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043

AERODYNAMIC INTERFERENCE
A simple three component velocity measurement method using a rotated split-film sensor p 1115 A92-54333
Application of a wall pressure method in a wind tunnel test section with adjustable longitudinal slots p 1091 A92-54336
Evaluation of sidewall interference in the NAL *two-dimensional transonic wind tunnel* p 1092 A92-56011
A shock tunnel experiment on aerodynamic interference induced by RCS jet p 1029 A92-56042
Analysis of helicopter rotor-fuselage interference with time averaged pressure distribution p 1032 A92-56331
Wind tunnel blockage effects on slender wings undergoing large amplitude motions
[AIAA PAPER 92-3926] p 1096 A92-56757

AERODYNAMIC LOADS
Methodology for calculating aerodynamic sensitivity derivatives p 1024 A92-54911
Tow-tank study of nonlinear aerodynamics of a 2-D airfoil
[AIAA PAPER 92-4499] p 1026 A92-55367
Response of helicopter blades to a sharp collective increase p 1084 A92-56282
Finite-element analysis and multibody dynamics issues in rotorcraft dynamic analysis p 1055 A92-56286
Simulation of helicopter see-saw rotor motion p 1055 A92-56287
Numerical simulation of unsteady rotor wakes p 1032 A92-56352
Aerodynamic centre of wing-body combinations
[ESDU-92024] p 1036 N92-32479
Turbulence-induced loads on a teetered rotor *p 1042 N92-34029*

AERODYNAMIC NOISE
Fourth Aircraft Interior Noise Workshop
[NASA-CP-10103] p 1136 N92-32948
Acoustic loads prediction on jet aircraft p 1136 N92-32949
Advanced subsonic transport approach noise: The *relative contribution of airframe noise*
[NASA-TM-104112] p 1140 N92-34148

AERODYNAMIC STABILITY
Experimental observations of instability modes in a rectangular jet p 1135 A92-54908
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test p 1093 A92-56114
Dynamics of helicopters with dissimilar blades in forward flight p 1056 A92-56288
Blade instability of horizontally stoppable rotors p 1085 A92-56308
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
Implementation of a personal computer based parameter estimation program
[AD-A252914] p 1061 N92-33502

AERODYNAMIC STALLING
Analysis of the onset of dynamic stall p 1024 A92-54919
The vortical structure in the wake during dynamic stall
[AIAA PAPER 92-4496] p 1026 A92-55364
Comparative numerical study of two turbulence models *for airfoil static and dynamic stall*
[AIAA PAPER 92-4649] p 1028 A92-55394
Flutter and stall response of a helicopter blade with structural nonlinearity p 1055 A92-56178
Helicopter tail rotor stall flutter p 1056 A92-56290
Measurements of the dynamic stall vortex convection speed p 1032 A92-56351
Performance evaluation of a transonic wind tunnel compressor
[AIAA PAPER 92-3927] p 1096 A92-56758
Aeroelasticity of bluff bodies p 1089 N92-34165

AERODYNAMICS
On-line identification and control of linearized aircraft dynamics p 1082 A92-55911
Future requirements for hypersonic aerodynamic and aerothermodynamic facilities
[AIAA PAPER 92-3903] p 1094 A92-56738
Transonic turbine blade cascade testing facility
[AIAA PAPER 92-4034] p 1101 A92-56856
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
On the anomalies in single-jet hover suckdown data
[NASA-TM-102261] p 1038 N92-33306
Implementation of a personal computer based parameter estimation program
[AD-A252914] p 1061 N92-33502
Research and technology, 1990
[NASA-TM-107967] p 1143 N92-33948

AEROELASTICITY
Stability and dynamic coupling of elastic vehicles with unsteady aerodynamic forces considered p 1102 A92-53545
FREPS - A forced response prediction system for *turbomachinery blade rows*
[AIAA PAPER 92-3072] p 1130 A92-54006
Rotary wing structural dynamics and aeroelasticity --- Book
[ISBN 1-56347-031-4] p 1052 A92-54550
Aeroelastic modal characteristics of mistuned blade assemblies - Mode localization and loss of *eigenstructure* p 1117 A92-54921
Vortical flow computations on a flexible blended wing-body configuration p 1024 A92-54922
Getting up to speed in hypersonic structures p 1117 A92-55127
Dynamics and control of hypersonic aeropropulsive/aeroelastic vehicles
[AIAA PAPER 92-4326] p 1073 A92-55170
New literal approximations for the longitudinal dynamic characteristics of flexible flight vehicles
[AIAA PAPER 92-4411] p 1075 A92-55205
E-6 flutter investigation and experience
[AIAA PAPER 92-4601] p 1077 A92-55280
Automated procedures for aircraft aeroservoelastic compensation
[AIAA PAPER 92-4606] p 1077 A92-55284
Parameter identification of unsteady aerodynamic forces for elastic vehicles
[AIAA PAPER 92-4505] p 1027 A92-55372
Numerical simulations of flutter and its suppression by active control
[AIAA PAPER 92-4652] p 1082 A92-55396
An example of whirl flutter analysis p 1052 A92-56015
Propeller-nacelle whirl flutter analysis and wind tunnel test p 1052 A92-56016
Optimization of composite material wing of fighter type aircrafts p 1053 A92-56018
Analysis and wind tunnel test of low aspect wing gust load alleviation p 1053 A92-56020
Synthesis of gust load alleviation with flutter margin *augmentation p 1082 A92-56021*
Optimization of aeroelastic system with active control p 1083 A92-56022
Measurements of blade flapping motion on a wind tunnel model p 1093 A92-56023
Generalized aerodynamics analysis by the boundary element method p 1030 A92-56050
Aeroelastic effects of spoiler surfaces on a low-aspect-ratio rectangular wing p 1030 A92-56154
Dynamic analysis of rotor blades with root retention design variations p 1054 A92-56156
Multidisciplinary optimization of aeroservoelastic systems using reduced-size models p 1054 A92-56176
Flutter and stall response of a helicopter blade with structural nonlinearity p 1055 A92-56178
Demonstration of structural optimization applied to wind-tunnel model design p 1119 A92-56181
Simulation of helicopter see-saw rotor motion p 1055 A92-56287
Dynamics of helicopters with dissimilar blades in forward flight p 1056 A92-56288
Aeroelasticity of a coaxial helicopter rotor p 1057 A92-56309
A time-dependent tip loss formula for rotor blade dynamic analysis p 1057 A92-56310
A finite element method for shear stresses calculation in composite blade models p 1121 A92-56322
An approach for increasing aeroelastic divergence dynamic pressure of wind-tunnel models
[AIAA PAPER 92-4002] p 1099 A92-56825

Buffet test in the National Transonic Facility
[AIAA PAPER 92-4032] p 1100 A92-56854
An integrated analytical aeropropulsive/aeroelastic model for the dynamic analysis of hypersonic vehicles
[AIAA PAPER 92-4567] p 1035 A92-57034
Strong coupling between inviscid fluid and boundary layer of sharp leading edges: Two-dimensional stationary and turbulent cases for isolated profiles and guard vanes
[ONERA-RT-44/1621-RY-016-R] p 1125 N92-32776
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter
[NASA-TM-104211] p 1042 N92-34147
Introduction to Flutter of Winged Aircraft, volume 2
[VKI-LS-1992-01-VOL-2] p 1088 N92-34161
Aeroelasticity of bluff bodies p 1089 N92-34165
Unsteady wind tunnel tests p 1089 N92-34166
Flutter in the transonic flight regime p 1089 N92-34167

AERONAUTICAL ENGINEERING
United States Air Force summer research program 1991. Volume 1: Program management report
[AD-A248763] p 1142 N92-32338
NASA authorization, 1993, volume 1
[GPO-55-260-VOL-1] p 1142 N92-33147
Activities report of the National Aerospace Laboratory
[ETN-92-92053] p 1143 N92-33694
Research and technology, 1990
[NASA-TM-107967] p 1143 N92-33948

AERONAUTICAL SATELLITES
History of aeronautical satellite communications p 1046 A92-56088
Aeronautical satellite communications system p 1046 A92-56089
Evaluation report of an experimental Satcom operation by a Japan Airline's B747 passenger plane p 1046 A92-56092

AERONAUTICS
An international aerospace information system: A *cooperative opportunity*
[NASA-TM-108171] p 1142 N92-33237
Research and technology, 1990
[NASA-TM-107967] p 1143 N92-33948

AEROSOLS
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630

AEROSPACE ENGINEERING
Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings p 1015 A92-56001
The wind tunnel, its evolution for aerospace test purposes, perspective for curriculum development
[AIAA PAPER 92-4017] p 1100 A92-56839
Development and integration of modern laboratories in aerospace education
[AIAA PAPER 92-4022] p 1141 A92-56844
An international aerospace information system: A cooperative opportunity
[NASA-TM-108171] p 1142 N92-33237
Research and technology, 1990
[NASA-TM-107967] p 1143 N92-33948

AEROSPACE INDUSTRY
Working together in the development of the B777 p 1015 A92-56080

AEROSPACE PLANES
Development study on air turbo-ramjet engine for space plane p 1065 A92-53487
Conceptual design of scramjet engine p 1065 A92-53490
Key design considerations for scramjet powered space plane p 1066 A92-53491
Performance analysis of idealized scramjet p 1066 A92-53493
Fabrication test and evaluation of graphite/PMR-15 polyimide for HOPE primary structure p 1105 A92-53516
Aerodynamic heating characteristics of space planes tested by NAL hypersonic wind tunnel p 1017 A92-53547
Calculations for aerodynamic characteristics of HOPE type vehicle in subsonic and hypersonic flow p 1018 A92-53560
Spaceplane aerodynamic heating and thermal protection design method p 1102 A92-53578
Space plane navigation simulation p 1103 A92-53603
Concepts of flight experiments for HOPE development p 1103 A92-53635
Aerodynamic study of H-II Orbiting Plane, HOPE p 1103 A92-53639
Aerodynamic studies on space plane configuration at hypersonic speed p 1019 A92-53641
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
HOPE re-entry experimental vehicle p 1103 A92-55098
Current status of R&D on materials for super/hypersonic transports p 1106 A92-56002
A shock tunnel experiment on aerodynamic interference induced by RCS jet p 1029 A92-56042
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043
On the effect of canards on NAL spaceplane model (0 order) in low speed area p 1030 A92-56052
Lateral control of spaceplane at hypersonic flight p 1104 A92-56069
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test p 1093 A92-56114
Evaluation of a IMU with optical fiber gyros in dynamic windtunnel tests p 1104 A92-56121
Tests results on Air Turbo Ramjet for a future space *plane*
[IAF PAPER 92-0657] p 1071 A92-57098
Combined exo/endoatmospheric transport alternatives
[IAF PAPER 92-0663] p 1104 A92-57102

AEROSPACE SCIENCES
An international aerospace information system: A cooperative opportunity
[NASA-TM-108171] p 1142 N92-33237

AEROSPACE SYSTEMS
Research and technology, 1990
[NASA-TM-107967] p 1143 N92-33948

AEROSPACE TECHNOLOGY TRANSFER
777 - The airlines' higher-order technology airplane p 1052 A92-55104
An international aerospace information system: A cooperative opportunity
[NASA-TM-108171] p 1142 N92-33237

AEROSPACE VEHICLES
Navier-Stokes simulation for the winged space vehicle 'HOPE' at subsonic, transonic, and supersonic regimes p 1018 A92-53559

AEROTHERMOCHEMISTRY
Thermally and chemically nonequilibrium hypersonic *flow in three-dimensional geometry* p 1019 A92-53580

AEROTHERMODYNAMICS
Radiative heat transfer from nonequilibrium shock layer to a hypersonic reentry body p 1019 A92-53579
Thermally and chemically nonequilibrium hypersonic flow in three-dimensional geometry p 1019 A92-53580
Performance benefits of adaptive in-flight propulsion system optimization
[AIAA PAPER 92-3749] p 1068 A92-54149
Evaluation of a multigrid-based Navier-Stokes solver for aerothermodynamic computations
[AIAA PAPER 92-4563] p 1027 A92-55375
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043
Future requirements for hypersonic aerodynamic and aerothermodynamic facilities
[AIAA PAPER 92-3903] p 1094 A92-56738
Hypersonic aerodynamic/aerothermodynamic testing capabilities at Langley Research Center
[AIAA PAPER 92-3937] p 1096 A92-56767
The trisonic wind tunnel Muenchen and its involvement in the German SAeNGER-programme
[AIAA PAPER 92-4019] p 1100 A92-56841
A database of aerothermal measurements in hypersonic flow for CFD validation
[AIAA PAPER 92-4023] p 1034 A92-56845
Laboratory simulation of aerothermodynamic phenomena - A review
[AIAA PAPER 92-4025] p 1104 A92-56847
The German Hypersonics Technology Programme - Status report 1992
[IAF PAPER 92-0867] p 1105 A92-57258
Technologies for the National Aero-Space Plane
[IAF PAPER 92-0868] p 1105 A92-57259
Perspectives on hypersonic viscous and nonequilibrium flow research
[NASA-CR-190817] p 1039 N92-33413

AFTERBODIES
Experimental results for a hypersonic nozzle/afterbody flow field
[AIAA PAPER 92-3915] p 1032 A92-56747
Aerodynamic centre of wing-body combinations
[ESDU-92024] p 1036 N92-32479
Effect of afterbody geometry on aerodynamic characteristics of isolated nonaxisymmetric afterbodies at transonic Mach numbers
[NASA-TP-3236] p 1041 N92-33706

AGING (MATERIALS)
Effective maintenance practices to manage system aging p 1119 A92-56215
Evaluation of the effects of the environment on the behavior of the primary structures of composite material aircraft in service: Historic and current situation p 1110 N92-33048
Isothermal aging of IM7/8320 and IM7/5260
[NASA-TM-107666] p 1110 N92-33423
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480

AH-64 HELICOPTER
Flight simulation modeling in support of engine/airframe integration p 1055 A92-56279
Cost/benefit analysis of the AH-64 (Apache) helicopter Automated Test Equipment (ATE)
[AD-A252909] p 1101 N92-33398
Developing robust support structures for high-technology subsystems: The AH-64 Apache helicopter
[AD-A252773] p 1017 N92-33499
On the calculation of the response of helicopters to *control inputs*
[NASA-CR-190812] p 1088 N92-33536

AILERONS
Optimization of aeroelastic system with active control p 1083 A92-56022
Application of automation for structural-composites production p 1119 A92-56109
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063

AIR BREATHING ENGINES
Development study on air turbo-ramjet engine for space plane p 1065 A92-53487
Flowpath and sensitivity analyses of high speed propulsion systems
[AIAA PAPER 92-3806] p 1069 A92-54178
Interaction between chemical reaction and turbulence in supersonic nonpremixed H2-air combustion p 1117 A92-54931
Development of local nonintrusive measurements of inlet and exhaust flows for the ground testing of air-breathing engines
[AIAA PAPER 92-3899] p 1122 A92-56735
Laser-driven hypersonic air-breathing propulsion simulator
[AIAA PAPER 92-3922] p 1095 A92-56753
Effects of oxygen dissociation on hypervelocity combustion experiments
[AIAA PAPER 92-3964] p 1098 A92-56791
Airbreathing engine selection criteria for SSTO propulsion system
[IAF PAPER 92-0658] p 1071 A92-57099
Optimization of two stage reusable space transportation systems with rocket and airbreathing propulsion concepts
[IAF PAPER 92-0863] p 1104 A92-57254
The German Hypersonics Technology Programme - Status report 1992
[IAF PAPER 92-0867] p 1105 A92-57258

AIR COOLING
Cooled high-temperature radial turbine program 2
[NASA-CR-189122] p 1073 N92-34236

AIR DATA SYSTEMS
Some important factors in turbulence in flight measurement p 1063 A92-54324
A new system for recording unstable aerodynamic phenomena in NAVSWC Hypervelocity Wind Tunnel No. 9 p 1091 A92-54325
High angle-of-attack flush airdata sensing system p 1064 A92-56172

AIR DEFENSE
DoD key technologies plan
[AD-A253692] p 1142 N92-33238

AIR FLOW
Aerodynamic heating characteristics of space planes tested by NAL hypersonic wind tunnel p 1017 A92-53547

AIR INTAKES
Automatic control of test parameters for intake measurements in a low-speed wind tunnel p 1091 A92-54341
Supersonic wind tunnel test of airintake/airframe integrated models p 1028 A92-56006

AIR JETS
Acoustic control of combustor primary zone air-jet mixing
[AIAA PAPER 92-3651] p 1067 A92-54104

AIR LAW
Re-engining for real stage 3 compliance
[PNR-90872] p 1072 N92-33748

AIR NAVIGATION
Height keeping performance requirements for reducing vertical separation minima used for air traffic control p 1046 A92-56081
The 1991 Federal Aviation Administration plan for research, engineering and development p 1142 N92-32453
CTAS: Computer intelligence for air traffic control in the terminal area
[NASA-TM-103959] p 1044 N92-33080

Integrated Russian VLF/Omega receiver design
[PB92-193390] p 1051 N92-33809

AIR TRAFFIC
Analysis of delay reducing and fuel saving sequencing and spacing algorithms for arrival traffic
[NASA-TM-103880] p 1044 N92-33194

AIR TRAFFIC CONTROL
Discrete event fuzzy airport control
p 1046 A92-55973
Height keeping performance requirements for reducing vertical separation minima used for air traffic control
p 1046 A92-56081
History of aeronautical satellite communications
p 1046 A92-56088
A data processing system for oceanic air traffic control p 1046 A92-56090
An experimental program concerning a satellite data link for oceanic ATC p 1046 A92-56093
A consideration on air traffic control processing capability in terminal area p 1047 A92-56110
The 1991 Federal Aviation Administration plan for research, engineering and development
p 1142 N92-32453
Safety study of TCAS 2 for logic version 6.04
[DOT/FAA/RD-92/22] p 1047 N92-32537
Airport Surveillance Radar (ASR-9) wind shear processor: 1991 test at Orlando, Florida
[AD-A252246] p 1124 N92-32686
Air traffic control: FAA's advanced automation system contract
[GAO/IMTEC-91-25] p 1048 N92-32861
CTAS: Computer intelligence for air traffic control in the terminal area
[NASA-TM-103959] p 1044 N92-33080
Simulation test and evaluation of TCAS 2 logic version 6.04
[DOT/FAA/RD-92/23] p 1048 N92-33098
Analysis of delay reducing and fuel saving sequencing and spacing algorithms for arrival traffic
[NASA-TM-103880] p 1044 N92-33194
Design and evaluation of an advanced air-ground data-link system for air traffic control
[NASA-TM-103899] p 1050 N92-33407
Radar clutter classification
[ISBN-0-315-57981-1] p 1126 N92-33440
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
Impacts of technology on the capacity needs of the US national airspace system
[NASA-CR-4470] p 1045 N92-34192
Human factors issues in the use of artificial intelligence in air traffic control. October 1990 Workshop
[NASA-CR-190925] p 1051 N92-34203

AIR TRAFFIC CONTROLLERS (PERSONNEL)
Exposures from headset interference tones
[AD-A247175] p 1136 N92-32697
Design and evaluation of an advanced air-ground data-link system for air traffic control
[NASA-TM-103899] p 1050 N92-33407
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
Human factors issues in the use of artificial intelligence in air traffic control. October 1990 Workshop
[NASA-CR-190925] p 1051 N92-34203

AIR TRANSPORTATION
Air transports in the 21st century
p 1015 A92-55103
The impact of air transport on the environment
[PNR-90876] p 1129 N92-33751
Impacts of technology on the capacity needs of the US national airspace system
[NASA-CR-4470] p 1045 N92-34192

AIRBORNE EQUIPMENT
Time Resolved Lidar Fluorosensor operating from helicopter p 1121 A92-56296
High temperature aircraft research furnace facilities
[NASA-CR-184384] p 1101 N92-33826

AIRBORNE/SPACEBORNE COMPUTERS
Recent developments in data acquisition and control systems at the Aircraft Research Association Limited
p 1091 A92-54323
Experience with Ada on the F-18 High Alpha Research Vehicle Flight Test Program
[NASA-TM-104259] p 1062 N92-34039

AIRCRAFT ACCIDENT INVESTIGATION
Aircraft accident report: L'Express Airlines, Inc., Flight 508, Beech C99, N7217L weather encounter and crash near Birmingham, Alabama, July 10, 1991
[PB92-910401] p 1043 N92-32455
Development of rating instruments and procedures for aviation mishap investigation
[AD-A253072] p 1044 N92-33288
Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081

AIRCRAFT ACCIDENTS
Effect of atmospheric disturbances on airplane response
[AIAA PAPER 92-4340] p 1078 A92-55329
Severe turbulence and maneuvering from airline flight records
[AIAA PAPER 92-4341] p 1078 A92-55330
Aircraft accident report: L'Express Airlines, Inc., Flight 508, Beech C99, N7217L weather encounter and crash near Birmingham, Alabama, July 10, 1991
[PB92-910401] p 1043 N92-32455
Development of rating instruments and procedures for aviation mishap investigation
[AD-A253072] p 1044 N92-33288

AIRCRAFT ANTENNAS
Finite difference time domain grid generation from AMC helicopter models
[NASA-TM-107679] p 1128 N92-34017

AIRCRAFT APPROACH SPACING
Height keeping performance requirements for reducing vertical separation minima used for air traffic control
p 1046 A92-56081
Analysis of delay reducing and fuel saving sequencing and spacing algorithms for arrival traffic
[NASA-TM-103880] p 1044 N92-33194

AIRCRAFT COMMUNICATION
Aeronautical satellite communications system
p 1046 A92-56089
Aircraft satellite communication systems
p 1046 A92-56091
A consideration on air traffic control processing capability in terminal area p 1047 A92-56110
The 1991 Federal Aviation Administration plan for research, engineering and development
p 1142 N92-32453
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964
Feasibility of measuring transverse electric noise at VLF and LF on an ice cap
[AD-A252280] p 1129 N92-33220

AIRCRAFT COMPARTMENTS
Aluminium-lithium alloys - Application on helicopters
p 1106 A92-56326
Design method of a helicopter cockpit
p 1058 A92-56337
Vibro-acoustic FE analyses of the Saab 2000 aircraft
p 1137 N92-32952
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956

AIRCRAFT CONFIGURATIONS
Reduction of the side force on pointed forebodies through add-on tip devices p 1024 A92-54918
The flow field characteristics about a fighter configuration at high angles of attack
[AIAA PAPER 92-4358] p 1025 A92-55344
Model flight tests of a spin-resistant trainer configuration p 1054 A92-56158
Wing mass formula for twin fuselage aircraft
p 1054 A92-56171
Comparison of recent results from different wind tunnel facilities along with comparisons of measured flight results and wind tunnel based predictions
[AIAA PAPER 92-3985] p 1060 A92-56809
The F-18 high alpha research vehicle: A high-angle-of-attack testbed aircraft
[NASA-TM-104253] p 1060 N92-33404
Applications of a direct/iterative design method to complex transonic configurations
[NASA-TP-3234] p 1039 N92-33484
Dynamic response of induced pressures, suckdown, and temperatures for two tandem jet STOVL configurations
[NASA-TM-103934] p 1039 N92-33581
On the estimation of jet-induced fountain lift and additional suckdown in hover for two-jet configurations
[NASA-TM-102268] p 1040 N92-33618
Effect of afterbody geometry on aerodynamic characteristics of isolated nonaxisymmetric afterbodies at transonic Mach numbers
[NASA-TP-3236] p 1041 N92-33706

AIRCRAFT CONSTRUCTION MATERIALS
New materials drive high-performance aircraft
p 1105 A92-55134
Current status of R&D on materials for super/hypersonic transports p 1106 A92-56002
Detailed analysis and test correlation of a stiffened composite wing panel p 1121 A92-56324
Residual strength of repaired graphite/epoxy laminates after 5 years of outdoor exposure p 1108 N92-32577
Damage tolerance certification methodology for composite structures p 1108 N92-32579
Examples of advanced near-net shape manufacturing techniques for aerospace
[MBB-Z-0399-91-PUB] p 1125 N92-32742
Isothermal aging of IM7/8320 and IM7/5260
[NASA-TM-107666] p 1110 N92-33423
Advanced airframe structural materials: A primer and cost estimating methodology
[AD-A253371] p 1062 N92-34182

AIRCRAFT CONTROL
Parameter estimation of an augmented airplane with unsteady aerodynamics modelling p 1073 A92-53546
A simulator evaluation of various manual control concepts for fly-by-wire transport aircraft
[AIAA PAPER 92-4328] p 1073 A92-55172
Robust dynamic inversion control laws for aircraft control
[AIAA PAPER 92-4329] p 1073 A92-55173
Neural networks for feedback linearization in aircraft control
[AIAA PAPER 92-4391] p 1074 A92-55192
Identification and control of aircraft dynamics using radial basis function neural networks
[AIAA PAPER 92-4393] p 1074 A92-55194
Aircraft ride quality controller design using new robust root clustering theory for linear uncertain systems
[AIAA PAPER 92-4399] p 1075 A92-55199
Robust sampled data eigenstructure assignment using the delta operator
[AIAA PAPER 92-4400] p 1075 A92-55200
Design of robust Quantitative Feedback Theory controllers for pitch attitude hold systems
[AIAA PAPER 92-4409] p 1075 A92-55203
A robust gain scheduler interpolated into multiple models by membership functions
[AIAA PAPER 92-4553] p 1131 A92-55265
Automated procedures for aircraft aeroservoelastic compensation
[AIAA PAPER 92-4606] p 1077 A92-55284
Nonlinear model-following control application to airplane control (1992 AIAA Controls Design Challenge)
[AIAA PAPER 92-4625] p 1077 A92-55302
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pts. 1-2 p 1078 A92-55326
Stability, control and gust response characteristics of an ultralight freewing airplane
[AIAA PAPER 92-4342] p 1079 A92-55331
Optimal trajectories for an unmanned air-vehicle in the horizontal plane
[AIAA PAPER 92-4344] p 1079 A92-55333
Development of a high-angle-of-attack stability and control prediction code
[AIAA PAPER 92-4354] p 1079 A92-55340
Dynamic derivative data for high angle of attack simulation
[AIAA PAPER 92-4355] p 1079 A92-55341
Analytical development of an equivalent system mismatch function
[AIAA PAPER 92-4422] p 1080 A92-55346
Computer aided evaluation of aircraft handling qualities and flight control system robustness
[AIAA PAPER 92-4423] p 1080 A92-55347
Flight test results using a low order equivalent systems technique to estimate flying qualities
[AIAA PAPER 92-4425] p 1080 A92-55349
High angle-of-attack control enhancement on a forward swept wing aircraft
[AIAA PAPER 92-4427] p 1080 A92-55351
Vortical flow control on a wing-body combination using tangential blowing
[AIAA PAPER 92-4430] p 1081 A92-55354
An identification procedure for a system with a choice of feedback structures p 1132 A92-55426
Application of fuzzy control to aircraft guidance
p 1083 A92-56033
Using the simulation modeling method to estimate the reliability of the crew-flight vehicle system
p 1133 A92-57444
An approach to the organization of an adaptive man-machine system for flight vehicle control
p 1133 A92-57445
A background to the handling qualities of aircraft
[ESDU-92006] p 1087 N92-32780
Simulation model of a twin-tail, high performance airplane
[NASA-TM-107601] p 1088 N92-33537
Nonlinear dynamic-inversion flight control of supermaneuverable aircraft p 1062 N92-33953
Piloted evaluation of an integrated propulsion and flight control simulator
[NASA-TM-105797] p 1088 N92-34107

Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131

AIRCRAFT DESIGN

Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
Aerodynamic airfoils design by quasi-solutions method of inverse boundary-value problems p 1020 A92-53998
An experimental investigation of the flow in a diffusing S-duct
[AIAA PAPER 92-3622] p 1021 A92-54090
Optimization of a 2D scramjet-vehicle using CFD and simplified approximate flow analysis techniques
[AIAA PAPER 92-3673] p 1022 A92-54116
Mikoyan's market-buster p 1052 A92-54981
777 - The airlines' higher-order technology airplane p 1052 A92-55104
Turning up the heat on aircraft structures --- design and analysis for high-temperature conditions p 1052 A92-55131
Continuous flying quality improvement - The measure and the payoff
[AIAA PAPER 92-4327] p 1073 A92-55171
PAYCOS, a multidisciplinary sizing code for hypersonic vehicles
[AIAA PAPER 92-4564] p 1132 A92-55376
Whirl flutter analysis and application to aircraft design p 1053 A92-56017
A development of hypermedia type database system for instruction of aircraft conceptual design p 1132 A92-56113
Application of advanced multidisciplinary analysis and optimization methods to vehicle design synthesis p 1054 A92-56160
Wing mass formula for twin fuselage aircraft p 1054 A92-56171
High angle-of-attack flush airdata sensing system p 1064 A92-56172
Solutions to supportability concerns related to reduced-signature aircraft p 1055 A92-56220
New aircraft technologies - Challenges for dependability p 1120 A92-56225
Electronics/avionics integrity - Definition, measurement and improvement p 1120 A92-56252
Research needs for a commercial passenger tiltrotor p 1056 A92-56298
The Eurotar program - An European overview on advanced VTOL civil transportation system p 1016 A92-56299
A simulation study of tiltrotor vertical takeoff procedures using conventional and variable diameter rotor systems p 1056 A92-56301
Technology exploitation for in-service support of future rotorcraft p 1016 A92-56327
Roles of wind tunnel tests and CFD analyses in the design of energy-efficient SST
[AIAA PAPER 92-3923] p 1133 A92-56754
A multi-diagnostic approach to testing V/STOL craft
[AIAA PAPER 92-4008] p 1099 A92-56831
CFD validation experiments for hypersonic flows
[AIAA PAPER 92-4024] p 1034 A92-56846
Combined exo/endoatmospheric transport alternatives
[IAF PAPER 92-0663] p 1104 A92-57102
A method for designing blended wing-body configurations for low wave drag
[NASA-TP-3261] p 1036 N92-32480
Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, part 1
[NASA-CP-3087-PT-1] p 1106 N92-32513
Design, evaluation and experimental effort toward development of a high strain composite wing for Navy aircraft p 1107 N92-32514
Development of thermoplastic components for structural validation p 1107 N92-32522
Global/local methods research using the CSM testbed p 1107 N92-32528
Computational methods for global/local analysis
[NASA-TM-107591] p 1125 N92-33104
An investigation of switched reluctance rotor position estimation using neural networks
[AD-A252846] p 1061 N92-33414
Applications of a direct/iterative design method to complex transonic configurations
[NASA-TP-3234] p 1039 N92-33484
Survey and analysis of research on supersonic drag-due-to-lift minimization with recommendations for wing design
[NASA-TP-3202] p 1040 N92-33656
Activities report of the National Aerospace Laboratory
[ETN-92-92053] p 1143 N92-33694
The Rolls-Royce Trent
[PNR-90875] p 1061 N92-33750
Introduction to Flutter of Winged Aircraft, volume 2
[VKI-LS-1992-01-VOL-2] p 1088 N92-34161
Flutter models: Their design, manufacture, and ground testing p 1089 N92-34164
Flutter analyses using high speed computers. Part 1: Flutter analyses for large aircraft p 1089 N92-34168

AIRCRAFT ENGINES

Japan pushes high speed research p 1015 A92-53434
Viscosity characteristics of synthetic aviation oils at low temperatures p 1105 A92-53875
The VRT gas turbine combustor - Phase II
[AIAA PAPER 92-3471] p 1067 A92-54035
Thermal paints for shock/boundary layer interaction in inlet flows
[AIAA PAPER 92-3626] p 1113 A92-54093
Improvements in teaching aircraft engine design
[AIAA PAPER 92-3758] p 1141 A92-54152
CIS engines - The range revealed. II p 1069 A92-54546
Development of ITS90 small gas turbine engine p 1070 A92-55500
Test data models to characterize turbine engine operation in altitude test facilities
[AIAA PAPER 92-3917] p 1095 A92-56749
An acceptance process for the evaluation of inlet distortion
[AIAA PAPER 92-3918] p 1032 A92-56750
Development and validation of a freejet technique for inlet-engine compatibility testing
[AIAA PAPER 92-3921] p 1033 A92-56752
Smoothing CFM56 engine removal rate at USAir
[AIAA PAPER 92-3928] p 1070 A92-56759
Turbine engine performance test and evaluation techniques
[AIAA PAPER 92-3977] p 1071 A92-56803
A conceptual study for future engine test facility
[AIAA PAPER 92-3992] p 1099 A92-56815
Liquid lubricants for advanced aircraft engines
[NASA-TM-104531] p 1109 N92-32863
Bird ingestion into large turbofan engines
[DOT/FAA/CT-91/17] p 1043 N92-33005
Statistics on aircraft gas turbine engine rotor failures that occurred in US commercial aviation during 1988
[DOT/FAA/CT-91/28] p 1071 N92-33105
Re-engining for real stage 3 compliance
[PNR-90872] p 1072 N92-33748
The impact of air transport on the environment
[PNR-90876] p 1129 N92-33751
Joint study on the computerisation of in-field aero engines vibration diagnosis
[PNR-90799] p 1072 N92-33815
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-34019

AIRCRAFT EQUIPMENT

Airborne experimental FLIR program p 1064 N92-32447
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program
[AD-A247886] p 1108 N92-32629
Method of reducing drag in aerodynamic systems
[NASA-CASE-LEW-14791-1] p 1043 N92-34243

AIRCRAFT GUIDANCE

A general approach to optimal real-time guidance of dynamic systems based on nonlinear programming
[AIAA PAPER 92-4378] p 1131 A92-55182
Concepts for pilot interaction with an automated NOE obstacle-avoidance system
[AIAA PAPER 92-4472] p 1076 A92-55232
Application of fuzzy control to aircraft guidance p 1083 A92-56033
Change and reliability of the DC-9-81 digital flight guidance system p 1084 A92-56086
Development of new flight procedures for the Microwave Landing System (MLS)
[NLR-TP-91156-U] p 1047 N92-32830
CTAS: Computer intelligence for air traffic control in the terminal area
[NASA-TM-103959] p 1044 N92-33080

AIRCRAFT HAZARDS

A data fusion algorithm for multi-sensor microburst hazard assessment
[AIAA PAPER 92-4339] p 1063 A92-55328
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301
[AD-A252912] p 1126 N92-33501

AIRCRAFT ICING

Predicting droplet impingement on yawed wings p 1043 A92-56180
Low energy ice protection for helicopters p 1059 A92-56348
Numerical investigation of the effects of icing on fixed and rotary wing aircraft
[NASA-CR-190542] p 1044 N92-34105

AIRCRAFT INDUSTRY

Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings p 1015 A92-56001
Examples of advanced near-net shape manufacturing techniques for aerospace
[MBB-Z-0399-91-PUB] p 1125 N92-32742

AIRCRAFT INSTRUMENTS

Mechanisms of high-current pulses in lightning and long-spark stepped leaders p 1116 A92-54678
Modified Doppler detects wind shear more reliably p 1015 A92-55099

AIRCRAFT LANDING

The application of imaging sensors to aircraft landings in adverse weather p 1045 A92-54902
A fuzzy logic based F/A-18 automatic carrier landing system
[AIAA PAPER 92-4392] p 1074 A92-55193
An investigation of the automation of emergency landings for helicopters p 1083 A92-56026
Optimal control of tiltrotor aircraft following power failure p 1085 A92-56303
Flight testing and simulation of an F-15 airplane using throttles for flight control
[NASA-TM-104255] p 1087 N92-32864
CTAS: Computer intelligence for air traffic control in the terminal area
[NASA-TM-103959] p 1044 N92-33080

AIRCRAFT MAINTENANCE

Working together in the development of the B777 p 1015 A92-56080
Engine condition monitoring system for B747-400 p 1064 A92-56082
Current repair technologies for jet engine components p 1016 A92-56085
The operational status of automated aircraft washing system p 1016 A92-56087
Solutions to supportability concerns related to reduced-signature aircraft p 1055 A92-56220
Field test of an advanced maintenance-system p 1016 A92-56221
Developing robust support structures for high-technology subsystems: The AH-64 Apache helicopter
[AD-A252773] p 1017 N92-33499

AIRCRAFT MANEUVERS

Invertibility and trajectory control for nonlinear maneuvers of aircraft
[AIAA PAPER 92-4410] p 1075 A92-55204
An efficient algorithm for optimal aircraft trajectories
[AIAA PAPER 92-4412] p 1076 A92-55206
Severe turbulence and maneuvering from airline flight records
[AIAA PAPER 92-4341] p 1078 A92-55330
Aerodynamic parameters of the X-31 drop model estimated from flight-data at high angles of attack
[AIAA PAPER 92-4357] p 1080 A92-55343
Flight simulator fidelity assessment in a rotorcraft lateral translation maneuver
[AIAA PAPER 92-4424] p 1092 A92-55348
Force production mechanisms of a tangential jet on bodies at high alpha
[AIAA PAPER 92-4648] p 1082 A92-55393
Optimization approach for helicopter maneuverability with a point mass model p 1083 A92-56025
High angle-of-attack flush airdata sensing system p 1064 A92-56172
The solution of the helicopter flight dynamics tasks by *the methods of optimal control theory* p 1085 A92-56284
A study of helicopter rotor/fuselage response in low-speed manoeuvres - Comparison of theory with flight p 1086 A92-56334
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
The F-18 high alpha research vehicle: A *high-angle-of-attack testbed aircraft*
[NASA-TM-104253] p 1060 N92-33404
Nonlinear dynamic-inversion flight control of supermaneuverable aircraft p 1062 N92-33953

AIRCRAFT MODELS

Preliminary assessment of the robustness of dynamic inversion based flight control laws
[AIAA PAPER 92-4330] p 1074 A92-55174
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
Intelligent control law tuning for AIAA Controls Design Challenge
[AIAA PAPER 92-4631] p 1132 A92-55306
Analytical development of an equivalent system mismatch function
[AIAA PAPER 92-4422] p 1080 A92-55346
Computer aided evaluation of aircraft handling qualities and flight control system robustness
[AIAA PAPER 92-4423] p 1080 A92-55347
Flight simulator fidelity assessment in a rotorcraft lateral translation maneuver
[AIAA PAPER 92-4424] p 1092 A92-55348

Buffet test in the National Transonic Facility
[AIAA PAPER 92-4032] p 1100 A92-56854
Simulation model of a twin-tail, high performance airplane
[NASA-TM-107601] p 1088 N92-33537
Static and dynamic flow visualization studies of two double-delta wing models at high angles of attack
[AD-A252878] p 1040 N92-33678
Effect of afterbody geometry on aerodynamic characteristics of isolated nonaxisymmetric afterbodies at transonic Mach numbers
[NASA-TP-3236] p 1041 N92-33706
Flutter models: Their design, manufacture, and ground testing p 1089 N92-34164

AIRCRAFT NOISE
Path identification in structural acoustics p 1059 A92-56346
Fourth Aircraft Interior Noise Workshop
[NASA-CP-10103] p 1136 N92-32948
MD-80 aft cabin noise control: A case history p 1137 N92-32950
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951
Use of SEA to predict structure-borne noise in aircraft p 1137 N92-32955
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
Active control of interior noise in a large scale cylinder using piezoelectric actuators p 1137 N92-32958
Active vibrations and noise control for turboprop application research program activities p 1138 N92-32962
Active synchrophasing of propeller unbalance p 1138 N92-32963
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers
[NASA-TM-104170] p 1138 N92-33160
Advanced subsonic transport approach noise: The relative contribution of airframe noise
[NASA-TM-104112] p 1140 N92-34148
Impacts of technology on the capacity needs of the US national airspace system
[NASA-CR-4470] p 1045 N92-34192

AIRCRAFT PARTS
Structural design and testing results of composite landing gear components p 1057 A92-56328
Damage tolerant design of critical aircraft structural components
[AIAA PAPER 92-4041] p 1123 A92-56860

AIRCRAFT PERFORMANCE
Identification and control of aircraft dynamics using radial basis function neural networks
[AIAA PAPER 92-4393] p 1074 A92-55194
Height keeping performance requirements for reducing vertical separation minima used for air traffic control p 1046 A92-56081
Engine condition monitoring system for B747-400 p 1064 A92-56082
Multidisciplinary optimization of aeroservoelastic systems using reduced-size models p 1054 A92-56176
The Eurofar program - An European overview on advanced VTOL civil transportation system p 1016 A92-56299
First level release of 2GCHAS for comprehensive helicopter analysis p 1133 A92-56339
The compound helicopter - A concept revisited p 1058 A92-56341
Comparison of recent results from different wind tunnel facilities along with comparisons of measured flight results and wind tunnel based predictions
[AIAA PAPER 92-3985] p 1060 A92-56809
The design and development of a portable, DSP micro-processor based, high-accuracy data acquisition system
[NRC-32146] p 1134 N92-32851
Simulation model of a twin-tail, high performance airplane
[NASA-TM-107601] p 1088 N92-33537
The Rolls-Royce Trent
[PNR-90875] p 1061 N92-33750
Numerical investigation of the effects of icing on fixed and rotary wing aircraft
[NASA-CR-190542] p 1044 N92-34105

AIRCRAFT PILOTS
An approach to the organization of an adaptive man-machine system for flight vehicle control p 1133 A92-57445
An experimental study of organismic principles of the functioning of the crew-transport aircraft system p 1133 A92-57446

AIRCRAFT PRODUCTION
Automatic function testing in the aircraft production p 1015 A92-56083
Development of an automatic drilling system. II p 1118 A92-56107

AIRCRAFT PRODUCTION COSTS
Lynx - A 50 year product? p 1056 A92-56307

AIRCRAFT RELIABILITY
Working together in the development of the B777 p 1015 A92-56080
Solutions to supportability concerns related to reduced-signature aircraft p 1055 A92-56220
New aircraft technologies - Challenges for dependability p 1120 A92-56225
A background to the handling qualities of aircraft
[ESDU-92006] p 1087 N92-32780
Flight flutter testing p 1089 N92-34163

AIRCRAFT SAFETY
Continuous flying quality improvement - The measure and the payoff
[AIAA PAPER 92-4327] p 1073 A92-55171
Working together in the development of the B777 p 1015 A92-56080
Change and reliability of the DC-9-81 digital flight guidance system p 1084 A92-56086
The 1991 Federal Aviation Administration plan for research, engineering and development p 1142 N92-32453
Aircraft accident report: L'Express Airlines, Inc., Flight 508, Beech C99, N7217L weather encounter and crash near Birmingham, Alabama, July 10, 1991
[PB92-910401] p 1043 N92-32455
A review and discussion of flight management system incidents reported to the aviation safety reporting system
[AD-A252438] p 1043 N92-32941
Accomplishments under the Airport Improvement Program, FY 1991
[AD-A253046] p 1101 N92-33434
Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081

AIRCRAFT STABILITY
Parameter estimation of an augmented airplane with unsteady aerodynamics modelling p 1073 A92-53546
AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pts. 1-2 p 1078 A92-55326
Stability, control and gust response characteristics of an ultralight freewing airplane
[AIAA PAPER 92-4342] p 1079 A92-55331
Development of a high-angle-of-attack stability and control prediction code
[AIAA PAPER 92-4354] p 1079 A92-55340
Navier-Stokes prediction of large-amplitude delta-wing roll oscillations characterizing wing rock
[AIAA PAPER 92-4428] p 1080 A92-55352
Stochastic self-induced roll oscillations of slender delta wing at high angles of attack
[AIAA PAPER 92-4498] p 1081 A92-55366
Application of recursive partially unknown system identification to aerodynamic coefficients estimation
[AIAA PAPER 92-4504] p 1081 A92-55371
Parameter identification of AV-8B wingborne aerodynamics for flight simulator model updates
[AIAA PAPER 92-4506] p 1027 A92-55373
Aerodynamic analysis of the Pioneer unmanned air vehicle
[AIAA PAPER 92-4635] p 1027 A92-55382
Motion analysis of 2-dimensional flat plate in ground effect p 1030 A92-56053

AIRCRAFT STRUCTURES
New materials drive high-performance aircraft p 1105 A92-55134
New literal approximations for the longitudinal dynamic characteristics of flexible flight vehicles
[AIAA PAPER 92-4411] p 1075 A92-55205
E-6 flutter investigation and experience
[AIAA PAPER 92-4601] p 1077 A92-55280
Optimization of composite material wing of fighter type aircrafts p 1053 A92-56018
Application of X-ray image radiography system for aircraft p 1118 A92-56084
Development of aircraft bonded structure and the NDI method p 1016 A92-56100
Mechanical properties of laminate aluminum matrix composites p 1106 A92-56102
Titanium alloy casting for aerospace p 1106 A92-56103
Effects of spectrum variations on fatigue crack growth p 1123 A92-57399
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
Global/local methods research using the CSM testbed p 1107 N92-32528
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575
Damage tolerance certification methodology for composite structures p 1108 N92-32579
Detection of honeycomb damage using hexagonal grid discontinuities
[DREP-89-9] p 1109 N92-32846
Aspects of compression in aerospace composites: Future requirements p 1109 N92-33036
Evaluation of the effects of the environment on the behavior of the primary structures of composite material aircraft in service: Historic and current situation p 1110 N92-33048
Computational methods for global/local analysis
[NASA-TM-107591] p 1125 N92-33104
Lightning strike tests of composite connectors
[AD-A252281] p 1044 N92-33249
Development of 3D electromagnetic modeling tools for airborne vehicles
[NASA-CR-190810] p 1126 N92-33307
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480
Inspection of fabricated fuselage panels using electronic shearography
[DOT/FAA/CT-TN92/26] p 1127 N92-33627
Activities report of the National Aerospace Laboratory
[ETN-92-92053] p 1143 N92-33694
Effects of constraint on crack growth under aircraft spectrum loading
[NASA-TM-107677] p 1128 N92-34178
Advanced airframe structural materials: A primer and cost estimating methodology
[AD-A253371] p 1062 N92-34182

AIRCRAFT WAKES
Computation of vortex wake flows and control of their effects on trailing wings
[AIAA PAPER 92-4429] p 1025 A92-55353

AIRFOIL OSCILLATIONS
Analysis of the onset of dynamic stall p 1024 A92-54919
Vortical flow computations on a flexible blended wing-body configuration p 1024 A92-54922
The vortical structure in the wake during dynamic stall
[AIAA PAPER 92-4496] p 1026 A92-55364
Tow-tank study of nonlinear aerodynamics of a 2-D airfoil
[AIAA PAPER 92-4499] p 1026 A92-55367
Understanding and development of a prediction method of transonic limit cycle oscillation characteristics of fighter aircraft
[AIAA PAPER 92-4501] p 1026 A92-55369
Computing high-speed flows past an oscillating cylinder near a vertical wall
[AIAA PAPER 92-4653] p 1028 A92-55397
On the structure of unsteady shock induced separation of the transonic airfoil in the NAL two-dimensional wind tunnel p 1029 A92-56010
Wind tunnel blockage effects on slender wings undergoing large amplitude motions
[AIAA PAPER 92-3926] p 1096 A92-56757
Flutter in the transonic flight regime p 1089 N92-34167

AIRFOIL PROFILES
Aerodynamic airfoils design by quasi-solutions method of inverse boundary-value problems p 1020 A92-53998
Analysis of the onset of dynamic stall p 1024 A92-54919
Grid studies for thin-layer Navier-Stokes computations of airfoil flowfields p 1025 A92-54935
Experimental evaluation of a 50-percent thick airfoil with blowing and suction boundary layer control
[AIAA PAPER 92-4500] p 1026 A92-55368
Direct simulation of low-density flow over airfoils p 1030 A92-56159
Forcing level effects of internal acoustic excitation on the improvement of airfoil performance p 1136 A92-56162
Two-fence concept for efficient trapping of vortices on airfoils p 1031 A92-56165

AIRFOILS
Preliminary airfoil testing experience in the NDA cryogenic wind tunnel p 1091 A92-54326
Shock detection on airfoils by means of piezo foil- and hot film arrays p 1115 A92-54334
The use of silicon microsensors in smart skins for aerodynamic research p 1116 A92-54348
Comparative numerical study of two turbulence models for airfoil static and dynamic stall
[AIAA PAPER 92-4649] p 1028 A92-55394
Evaluation of sidewall interference in the NAL two-dimensional transonic wind tunnel p 1092 A92-56011
BGK1 airfoil oilflow tests in the NAL two-dimensional wind tunnel. II p 1029 A92-56044

High subsonic wind tunnel test of a two-dimensional hybrid-laminar-flow-control airfoil with slotted surface p 1029 A92-56045
Experimental investigation of the boundary layer in a corner formed by two circular arc airfoils p 1029 A92-56046
Design and wind tunnel test of low-Reynolds-number airfoil p 1029 A92-56047
Sound produced by vortex-airfoil interaction p 1136 A92-56345
High-lift testing at high Reynolds numbers [AIAA PAPER 92-3986] p 1033 A92-56810
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators [NASA-CR-190702] p 1038 N92-33063
Investigation of advancing front method for generating unstructured grid [NASA-CR-190902] p 1128 N92-34043
Analysis of iced wings [NASA-TM-105773] p 1042 N92-34144
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter [NASA-TM-104211] p 1042 N92-34147

AIRFRAME MATERIALS
Present status of Al-Li alloys p 1106 A92-56105
Modern helicopter technologies at MBB and the application in future programmes p 1016 A92-56304
Structural assessment of ultralightweight composites p 1107 N92-32525
Out of plane analysis for composite structures p 1107 N92-32527
Advanced airframe structural materials: A primer and cost estimating methodology [AD-A253371] p 1062 N92-34182

AIRFRAMES
Supersonic wind tunnel test of airintake/airframe integrated models p 1028 A92-56006
Aluminium-lithium alloys - Application on helicopters p 1106 A92-56326
Structural assessment of ultralightweight composites p 1107 N92-32525
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program [AD-A247886] p 1108 N92-32629
Current nondestructive inspection methods for aging aircraft [DOT/FAA/CT-91/5] p 1126 N92-33480
Thermal-structural test facilities at NASA Dryden [NASA-TM-104249] p 1062 N92-34202

AIRLINE OPERATIONS
Regional airline and equipment review - Evolution, trends, and future prospects p 1015 A92-55102
Aircraft accident report: L'Express Airlines, Inc., Flight 508, Beech C99, N7217L weather encounter and crash near Birmingham, Alabama, July 10, 1991 [PB92-910401] p 1043 N92-32455
Statistics on aircraft gas turbine engine rotor failures that occurred in US commercial aviation during 1988 [DOT/FAA/CT-91/28] p 1071 N92-33105
Workshop on Aeronautical Decision Making (ADM). Volume 1: Executive summary [DOT/FAA/RD-92/14-VOL-1] p 1142 N92-33305
Impacts of technology on the capacity needs of the US national airspace system [NASA-CR-4470] p 1045 N92-34192

AIRPORTS
Grooved runway surface texture before and after rubber removal p 1093 A92-56111
Airport Surveillance Radar (ASR-9) wind shear processor: 1991 test at Orlando, Florida [AD-A252246] p 1124 N92-32686
Air traffic control: FAA's advanced automation system contract [GAO/IMTEC-91-25] p 1048 N92-32861
Performance of insulated pavements at Newton Fields, Jackman, Maine [CRREL-92-9] p 1101 N92-32903
ILS mathematical modeling study of an ILS localizer and glide slope proposed for runway 32R, Moffett Field Airport, California [DOT/FAA/CT-TN92/28] p 1048 N92-33308
Accomplishments under the Airport Improvement Program, FY 1991 [AD-A253046] p 1101 N92-33434
Criteria for use of seal coats on airport pavements [DOT/FAA/RD-92/18] p 1102 N92-34247

AIRSHIPS
ILS mathematical modeling study of an ILS localizer and glide slope proposed for runway 32R, Moffett Field Airport, California [DOT/FAA/CT-TN92/28] p 1048 N92-33308

AIRSPACE
Impacts of technology on the capacity needs of the US national airspace system [NASA-CR-4470] p 1045 N92-34192

AIRSPEED
A note on thrust control for jetliner during approach p 1053 A92-56061

ALGORITHMS
Safety study of TCAS 2 for logic version 6.04 [DOT/FAA/RD-92/22] p 1047 N92-32537
An examination of several high resolution schemes applied to complex problems in high speed flows [AD-A250814] p 1124 N92-32632
Airport Surveillance Radar (ASR-9) wind shear processor: 1991 test at Orlando, Florida [AD-A252246] p 1124 N92-32686
The use of Kalman filtering techniques to improve the accuracy of flight test data [NRC-32139] p 1064 N92-32850
Analysis of delay reducing and fuel saving sequencing and spacing algorithms for arrival traffic [NASA-TM-103880] p 1044 N92-33194
Computational algorithms for increased control of depth-viewing volume for stereo three-dimensional graphic displays [NASA-TM-4379] p 1065 N92-34109

ALL-WEATHER LANDING SYSTEMS
The application of imaging sensors to aircraft landings in adverse weather p 1045 A92-54902

ALTIMETERS
The utility of analog vertical velocity information during instrument flight with a Head-Up Display (HUD) [AD-A252863] p 1065 N92-33277

ALTITUDE
User's manual for AeroFcn: A FORTRAN program to compute aerodynamic parameters [NASA-TM-104237] p 1133 N92-32507

ALTITUDE CONTROL
Nonlinear model-following control application to airplane control (1992 AIAA Controls Design Challenge) [AIAA PAPER 92-4625] p 1077 A92-55302

ALTITUDE SIMULATION
Turbine engine hot-part temperature measurement techniques [AIAA PAPER 92-3960] p 1122 A92-56788

ALTITUDE TESTS
Turbine engine performance test and evaluation techniques [AIAA PAPER 92-3977] p 1071 A92-56803

ALUMINUM ALLOYS
Mechanical properties of laminate aluminum matrix composites p 1106 A92-56102
Effects of constraint on crack growth under aircraft spectrum loading [NASA-TM-107677] p 1128 N92-34178

ALUMINUM-LITHIUM ALLOYS
Present status of Al-Li alloys p 1106 A92-56105
Aluminium-lithium alloys - Application on helicopters p 1106 A92-56326

AMBIENT TEMPERATURE
Experimental study of performance degradation of a rotating system in the NASA Lewis RC icing tunnel [NASA-CR-190684] p 1102 N92-34141

AMPLIFICATION
A robust gain scheduler interpolated into multiple models by membership functions [AIAA PAPER 92-4553] p 1131 A92-55265

ANALOG DATA
The utility of analog vertical velocity information during instrument flight with a Head-Up Display (HUD) [AD-A252863] p 1065 N92-33277

ANALYSIS (MATHEMATICS)
Implementation of a personal computer based parameter estimation program [AD-A252914] p 1061 N92-33502

ANECHOIC CHAMBERS
The design of a subsonic low-noise, low-turbulence wind tunnel for acoustic measurements [AIAA PAPER 92-3883] p 1094 A92-56726

ANGLE OF ATTACK
Full Navier-Stokes calculations on the installed F/A-18 inlet at a high angle of attack [AIAA PAPER 92-3175] p 1020 A92-54012
Unsteady blade pressures on a propfan - Predicted and measured compressibility effects [AIAA PAPER 92-3774] p 1023 A92-54161
Evaluation of electrolytic tilt sensors for wind tunnel model angle-of-attack (AOA) measurements p 1116 A92-54344
Development of a high-angle-of-attack stability and control prediction code [AIAA PAPER 92-4354] p 1079 A92-55340
Dynamic derivative data for high angle of attack simulation [AIAA PAPER 92-4355] p 1079 A92-55341
Effects of the roll angle on cruciform wing-body configurations at high incidences [AIAA PAPER 92-4356] p 1079 A92-55342
The flow field characteristics about a fighter configuration at high angles of attack [AIAA PAPER 92-4358] p 1025 A92-55344
High angle-of-attack control enhancement on a forward swept wing aircraft [AIAA PAPER 92-4427] p 1080 A92-55351
Force production mechanisms of a tangential jet on bodies at high alpha [AIAA PAPER 92-4648] p 1082 A92-55393
Comparative numerical study of two turbulence models for airfoil static and dynamic stall [AIAA PAPER 92-4649] p 1028 A92-55394
State-space representation of aerodynamic characteristics of an aircraft at high angels of attack [AIAA PAPER 92-4651] p 1028 A92-55395
Low-speed wind tunnel testing for the high-speed propeller at high shaft angle of attack p 1030 A92-56054
Lateral control of spaceplane at hypersonic flight p 1104 A92-56069
High angle-of-attack flush airdata sensing system p 1064 A92-56172
Aerodynamic calculation of an elliptic ring wing [AIAA PAPER 91-0068] p 1035 A92-57035
Static and dynamic flow visualization studies of two double-delta wing models at high angles of attack [AD-A252878] p 1040 N92-33678
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations p 1127 N92-33968

ANGULAR ACCELERATION
Blade instability of horizontally stoppable rotors p 1085 A92-56308

ANGULAR MOMENTUM
Effect of atmospheric disturbances on airplane response [AIAA PAPER 92-4340] p 1078 A92-55329

ANISOTROPIC MEDIA
Oscillations of an anisotropic rotor on an elastic anisotropic support p 1057 A92-56311

ANISOTROPIC PLATES
Initial postbuckling response of an unsymmetrically laminated rectangular plate p 1108 N92-32586

ANISOTROPY
Life prediction and constitutive models for engine hot section anisotropic materials program [NASA-CR-189223] p 1072 N92-33479
Continuation of tailored composite structures of ordered staple thermoplastic material [NASA-CR-189671] p 1110 N92-33613

ANNULAR DUCTS
Experimental performance of three design factors for ventral nozzles for SSTOVL aircraft [AIAA PAPER 92-3789] p 1069 A92-54168

ANNULI
Computational and experimental investigation of annulus heat transfer with swirl [AIAA PAPER 92-4060] p 1119 A92-56143

ANTENNA DESIGN
Transfer function between airborne VLF transmit and receive loop antenna p 1045 A92-54754
ILS mathematical modeling study of an ILS localizer and glide slope proposed for runway 32R, Moffett Field Airport, California [DOT/FAA/CT-TN92/28] p 1048 N92-33308

APOLLO SOYUZ TEST PROJECT
Issues in developing control zones for international space operations p 1141 A92-56602

APPLICATIONS PROGRAMS (COMPUTERS)
Potential flow theory and operation guide for the panel code PMARC [NASA-TM-102851] p 1036 N92-32422
Computations of unsteady multistage compressor flows in a workstation environment [NASA-TM-103839] p 1071 N92-32452
User's manual for AeroFcn: A FORTRAN program to compute aerodynamic parameters [NASA-TM-104237] p 1133 N92-32507
Safety study of TCAS 2 for logic version 6.04 [DOT/FAA/RD-92/22] p 1047 N92-32537
Further development of the CANAERO computer code to include propulsor modelling [DREA-CR-90-425] p 1038 N92-32811
Advanced software development workstation: Effectiveness of constraint-checking --- spaceflight simulation and planning [NASA-CR-190712] p 1134 N92-32865
Experience with Ada on the F-18 High Alpha Research Vehicle Flight Test Program [NASA-TM-104259] p 1062 N92-34039

APPROACH CONTROL
Application of fuzzy control to aircraft guidance p 1083 A92-56033
Development of new flight procedures for the Microwave Landing System (MLS) [NLR-TP-91156-U] p 1047 N92-32830

APPROPRIATIONS
Departments of Veterans Affairs and Housing and Urban Development, and independent agencies appropriations for 1993, part 6
[GAO-55-636-PT-6] p 1141 N92-32505
NASA authorization, 1993, volume 1
[GPO-55-260-VOL-1] p 1142 N92-33147
APPROXIMATION
New literal approximations for the longitudinal dynamic characteristics of flexible flight vehicles
[AIAA PAPER 92-4411] p 1075 A92-55205
An approximate viscous shock layer technique for calculating chemically reacting hypersonic flows about blunt-nosed bodies p 1041 N92-33837
ARC HEATING
Numerical prediction of the flow characteristics in an arc wind tunnel
[AIAA PAPER 92-4016] p 1100 A92-56838
Flow contamination and flow quality in arc heaters used for hypersonic testing
[AIAA PAPER 92-4028] p 1100 A92-56850
ARC WELDING
Stainless steel welding shines through on wind tunnel project p 1123 A92-57039
ARCHITECTURE (COMPUTERS)
Neural networks for feedback linearization in aircraft control
[AIAA PAPER 92-4391] p 1074 A92-55192
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
The development of an airborne information management system for flight test
[NASA-TM-104251] p 1065 N92-32866
ARMED FORCES (UNITED STATES)
United States Air Force summer research program 1991. Volume 1: Program management report
[AD-A248763] p 1142 N92-32338
ARTIFICIAL INTELLIGENCE
CTAS: Computer intelligence for air traffic control in the terminal area
[NASA-TM-103959] p 1044 N92-33080
Human factors issues in the use of artificial intelligence in air traffic control. October 1990 Workshop
[NASA-CR-190925] p 1051 N92-34203
ASPHALT
Criteria for use of seal coats on airport pavements
[DOT/FAA/RD-92/18] p 1102 N92-34247
ASTRONAUTICS
An international aerospace information system: A cooperative opportunity
[NASA-TM-108171] p 1142 N92-33237
ASTRONOMY
United States Air Force summer research program 1991. Volume 1: Program management report
[AD-A248763] p 1142 N92-32338
ASYMMETRY
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations
p 1127 N92-33968
ATMOSPHERIC ATTENUATION
A numerical model for sonic boom propagation through an inhomogeneous, windy atmosphere
p 1138 N92-33876
ATMOSPHERIC CHEMISTRY
Hypersonic flows with air chemistry over a reentry vehicle at high altitudes p 1017 A92-53549
ATMOSPHERIC EFFECTS
High-Speed Research: Sonic Boom, volume 1
[NASA-CP-3172] p 1061 N92-33874
ATMOSPHERIC ELECTRICITY
Mechanisms of high-current pulses in lightning and *long-spark stepped leaders* p 1116 A92-54678
ATMOSPHERIC ENTRY
Concepts of flight experiments for HOPE development
p 1103 A92-53635
Three-dimensional calculation of radiative field in hypersonic air shock layers p 1023 A92-54498
HOPE re-entry experimental vehicle
p 1103 A92-55098
ATMOSPHERIC MODELS
A numerical model for sonic boom propagation through an inhomogeneous, windy atmosphere
p 1138 N92-33876
ATMOSPHERIC TURBULENCE
Effect of atmospheric disturbances on airplane response
[AIAA PAPER 92-4340] p 1078 A92-55329
ATTAS flight test and simulation results of the advanced gust management system LARS
[AIAA PAPER 92-4343] p 1079 A92-55332
High-Speed Research: Sonic Boom, volume 1
[NASA-CP-3172] p 1061 N92-33874
Wave equations and computational models for sonic boom propagation through a turbulent atmosphere
p 1139 N92-33877
Simulations of sonic boom ray tube area fluctuations for propagation through atmospheric turbulence including caustics via a Monte Carlo method
p 1139 N92-33878
Analysis of sonic boom data to quantify distortions of shock profiles p 1139 N92-33879
The effect of turbulence on the loudness of minimized sonic boom signatures p 1139 N92-33880
Model experiment to study the effect of turbulence on risetime and waveform of N waves
p 1139 N92-33881
Steady state risetimes of shock waves in the atmosphere p 1140 N92-33882
Preliminary results from the White Sands Missile Range sonic boom propagation experiment
p 1140 N92-33884
Turbulence-induced loads on a teetered rotor
p 1042 N92-34029
ATTACK AIRCRAFT
Flight management system of the F-117A
p 1082 A92-55910
ATTITUDE CONTROL
Design of robust Quantitative Feedback Theory controllers for pitch attitude hold systems
[AIAA PAPER 92-4409] p 1075 A92-55203
An autorotation-entry control for a helicopter with a fuzzy controller p 1083 A92-56032
V-22 propulsion system design p 1070 A92-56300
ATTITUDE INDICATORS
Measurement of position and attitude using laser and retro-reflectors p 1047 A92-56120
AUDIO FREQUENCIES
Exposures from headset interference tones
[AD-A247175] p 1136 N92-32697
AUTOMATED RADAR TERMINAL SYSTEM
Safety study of TCAS 2 for logic version 6.04
[DOT/FAA/RD-92/22] p 1047 N92-32537
AUTOMATIC CONTROL
Automatic control of test parameters for intake measurements in a low-speed wind tunnel
p 1091 A92-54341
The operational status of automated aircraft washing system p 1016 A92-56087
Development of an automatic drilling system. II
p 1118 A92-56107
Issues in developing control zones for international space operations p 1141 A92-56602
Air traffic control: FAA's advanced automation system contract
[GAO/IMTEC-91-25] p 1048 N92-32861
A workstation-based evaluation of a far-field route planner for helicopters
[NASA-TM-102882] p 1051 N92-33609
Human factors issues in the use of artificial intelligence in air traffic control. October 1990 Workshop
[NASA-CR-190925] p 1051 N92-34203
AUTOMATIC FLIGHT CONTROL
Automatic formation flight control
[AIAA PAPER 92-4473] p 1076 A92-55233
Flight management system of the F-117A
p 1082 A92-55910
AUTOMATIC LANDING CONTROL
A fuzzy logic based F/A-18 automatic carrier landing system
[AIAA PAPER 92-4392] p 1074 A92-55193
An investigation of the automation of emergency *landings for helicopters* p 1083 A92-56026
Synthesis of a MLS automatic landing control law for the NAL experimental research aircraft Do-228
p 1084 A92-56062
CTAS: Computer intelligence for air traffic control in the terminal area
[NASA-TM-103959] p 1044 N92-33080
AUTOMATIC PILOTS
Automatic formation flight control
[AIAA PAPER 92-4473] p 1076 A92-55233
Gain scheduled linear PID autopilot for the AIAA Controls Design Challenge aircraft
[AIAA PAPER 92-4629] p 1078 A92-55304
Flight management system of the F-117A
p 1082 A92-55910
A module-level testing environment for safety-critical software systems p 1132 A92-56293
AUTOMATIC TEST EQUIPMENT
Recent developments in data acquisition and control systems at the *Aircraft Research Association Limited*
p 1091 A92-54323
Automatic function testing in the aircraft production
p 1015 A92-56083
AUTOMATION
Application of automation for structural-composites production p 1119 A92-56109
AUTONOMOUS NAVIGATION
Analysis of image-based navigation system for rotorcraft low-altitude flight p 1046 A92-55968
AUTOREGRESSIVE PROCESSES
An identification procedure for a system with a choice of feedback structures p 1132 A92-55426
Real-time processing of radar return on a parallel computer
[NASA-CR-4456] p 1043 N92-32606
AUTOROTATION
Optimization approach for helicopter maneuverability with a point mass model p 1083 A92-56025
An autorotation-entry control for a helicopter with a fuzzy controller p 1083 A92-56032
AUXILIARY POWER SOURCES
Design of the Boeing 777 electric system
p 1070 A92-55902
AVAILABILITY
HiRel - Reliability/availability integrated workstation tool p 1120 A92-56257
AVIATION METEOROLOGY
Optimal recovery from microburst wind shear
[AIAA PAPER 92-4338] p 1078 A92-55327
A data fusion algorithm for multi-sensor microburst hazard assessment
[AIAA PAPER 92-4339] p 1063 A92-55328
Severe turbulence and maneuvering from airline flight records
[AIAA PAPER 92-4341] p 1078 A92-55330
AVIONICS
Change and reliability of the DC-9-81 digital flight guidance system p 1084 A92-56086
Aeronautical satellite communications system
p 1046 A92-56089
Electronics/avionics integrity - Definition, measurement and improvement p 1120 A92-56252
Engineering reliability and maintainability review - A regimen for discovering production deficiencies
p 1120 A92-56254
HiRel - Reliability/availability integrated workstation tool p 1120 A92-56257
Test and integration concept for complex helicopter avionic systems p 1064 A92-56292
Modern helicopter technologies at MBB and the application in future programmes p 1016 A92-56304
Analysis of data from a DO-178A software development process p 1134 N92-32880
SATWG networked quality function deployment
p 1134 N92-33339
Study objectives: Will commercial avionics do the job? Improvements needed? p 1065 N92-33340
AXIAL FLOW TURBINES
Experimental modeling of film-cooled axial turbine tip seals
[AIAA PAPER 92-4058] p 1119 A92-56141
AXISYMMETRIC BODIES
Aerodynamic centre of wing-body combinations
[ESDU-92024] p 1036 N92-32479
AXISYMMETRIC FLOW
The behaviour of the pressure temperature and density in an inviscid unsteady transonic axisymmetric flow with shock waves p 1018 A92-53553
Detecting 3-D, turbulent separation regions using unsteady computerized thermographic technique
p 1023 A92-54308

B

BALANCING
Active synchrophasing of propeller unbalance
p 1138 N92-32963
BASE FLOW
Analysis of the flight performance of the 155 mm M864 base burn projectile
[BRL-TR-3083] p 1041 N92-33699
BASE PRESSURE
Analysis of the flight performance of the 155 mm M864 *base burn projectile*
[BRL-TR-3083] p 1041 N92-33699
BAYES THEOREM
Radar clutter classification
[ISBN-0-315-57981-1] p 1126 N92-33440
BEAM INJECTION
Formation and sustainment of a very low aspect ratio tokamak using coaxial helicity injection: Helicity Injected Torus (HIT) experiment
[DE92-014311] p 1136 N92-32595
BEECHCRAFT AIRCRAFT
Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081
BELL AIRCRAFT
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575
BENARD CELLS
Experimental study of convection effects around the phase charge interface p 1111 A92-53755

BIOT METHOD
Aerodynamic calculation of an elliptic ring wing
[AIAA PAPER 91-0068] p 1035 A92-57035
BIRD-AIRCRAFT COLLISIONS
Bird ingestion into large turbofan engines
[DOT/FAA/CT-91/17] p 1043 N92-33005
Engine bird ingestion experience of the Boeing 737 aircraft: Expanded data base
[DOT/FAA/CT-91/32] p 1045 N92-34151
BIRDS
Bird ingestion into large turbofan engines
[DOT/FAA/CT-91/17] p 1043 N92-33005
BLADE SLAP NOISE
A calculation method to predict helicopter noise and its verification p 1135 A92-56074
BLADE TIPS
Experimental modeling of film-cooled axial turbine tip seals
[AIAA PAPER 92-4058] p 1119 A92-56141
A time-dependent tip loss formula for rotor blade dynamic analysis p 1057 A92-56310
BLADE-VORTEX INTERACTION
Smart structures in the active control of blade vortex interaction p 1085 A92-56314
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344
Sound produced by vortex-airfoil interaction p 1136 A92-56345
BLASIUS FLOW
Leading-edge receptivity for blunt-nose bodies
[NASA-CR-190563] p 1036 N92-32648
BLOWDOWN WIND TUNNELS
Quantitative heat transfer measurements in hypersonic wind tunnels by means of infrared thermography p 1115 A92-54321
A new system for recording unstable aerodynamic phenomena in NAVSWC Hypervelocity Wind Tunnel No. 9 p 1091 A92-54325
The Langley 15-inch Mach 6 High Temperature Tunnel
[AIAA PAPER 92-3938] p 1096 A92-56768
BLOWING
Pulsating spanwise blowing on a fighter aircraft
[AIAA PAPER 92-4359] p 1025 A92-55345
High angle-of-attack control enhancement on a forward swept wing aircraft
[AIAA PAPER 92-4427] p 1080 A92-55351
Vortical flow control on a wing-body combination using tangential blowing
[AIAA PAPER 92-4430] p 1081 A92-55354
Experimental evaluation of a 50-percent thick airfoil with blowing and suction boundary layer control
[AIAA PAPER 92-4500] p 1026 A92-55368
Force production mechanisms of a tangential jet on bodies at high alpha
[AIAA PAPER 92-4648] p 1082 A92-55393
BLUFF BODIES
Aeroelasticity of bluff bodies p 1089 N92-34165
BLUNT BODIES
Hypersonic flows with air chemistry over a reentry vehicle at high altitudes p 1017 A92-53549
Experimental investigation on turbulent phenomena in three-dimensional shock wave/turbulent boundary layer interaction induced by blunt fin p 1018 A92-53557
Interaction between a body flying at a supersonic velocity and a point explosion p 1019 A92-53867
Approximate aerodynamic analysis of jet interaction
[AIAA PAPER 92-4640] p 1027 A92-55387
Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance p 1029 A92-56009
An examination of several high resolution schemes applied to complex problems in high speed flows
[AD-A250814] p 1124 N92-32632
An approximate viscous shock layer technique for calculating chemically reacting hypersonic flows about blunt-nosed bodies p 1041 N92-33837
Computation and stability analysis of laminar flow over a blunt cone in hypersonic flow p 1041 N92-33839
BLUNT LEADING EDGES
Leading-edge receptivity for blunt-nose bodies
[NASA-CR-190563] p 1036 N92-32648
BOATTAILS
Effect of afterbody geometry on aerodynamic characteristics of isolated nonaxisymmetric afterbodies at transonic Mach numbers
[NASA-TP-3236] p 1041 N92-33706
BODY-WING CONFIGURATIONS
Vortical flow computations on a flexible blended wing-body configuration p 1024 A92-54922
Effects of the roll angle on cruciform wing-body configurations at high incidences
[AIAA PAPER 92-4356] p 1079 A92-55342
Optimization of aeroelastic system with active control p 1083 A92-56022
Navier-Stokes simulation of a close-coupled canard-wing-body configuration p 1031 A92-56163
Aerodynamic centre of wing-body combinations
[ESDU-92024] p 1036 N92-32479
A method for designing blended wing-body configurations for low wave drag
[NASA-TP-3261] p 1036 N92-32480
Survey and analysis of research on supersonic drag-due-to-lift minimization with recommendations for wing design
[NASA-TP-3202] p 1040 N92-33656
BOEING AIRCRAFT
Design of the Boeing 777 electric system p 1070 A92-55902
Study objectives: Will commercial avionics do the job? Improvements needed? p 1065 N92-33340
BOEING 737 AIRCRAFT
Engine bird ingestion experience of the Boeing 737 aircraft: Expanded data base
[DOT/FAA/CT-91/32] p 1045 N92-34151
BOEING 747 AIRCRAFT
Engine condition monitoring system for B747-400 p 1064 A92-56082
Aeronautical satellite communications system p 1046 A92-56089
Evaluation report of an experimental Satcom operation by a Japan Airline's B747 passenger plane p 1046 A92-56092
Structural assessment of ultralightweight composites p 1107 N92-32525
BONDING
Development of aircraft bonded structure and the NDI method p 1016 A92-56100
BOOSTER ROCKET ENGINES
Optimal launch trajectory of a hypersonic research vehicle
[AIAA PAPER 92-4302] p 1103 A92-55310
BOUNDARIES
Development of 3D electromagnetic modeling tools for airborne vehicles
[NASA-CR-190810] p 1126 N92-33307
BOUNDARY ELEMENT METHOD
Calculations of aerodynamic forces on a wing with thrust using B.E.M p 1030 A92-56049
Generalized aerodynamics analysis by the boundary element method p 1030 A92-56050
BOUNDARY LAYER CONTROL
Experimental evaluation of a 50-percent thick airfoil with blowing and suction boundary layer control
[AIAA PAPER 92-4500] p 1026 A92-55368
Method of reducing drag in aerodynamic systems
[NASA-CASE-LEW-14791-1] p 1043 N92-34243
BOUNDARY LAYER FLOW
An analysis of boundary layer for droplet aerodynamic stripped in high speed gas flow p 1116 A92-54563
Boundary layer study on nozzle wall at hypersonic velocities
[AIAA PAPER 92-4013] p 1034 A92-56836
Numerical modeling of transonic juncture flow
[AIAA PAPER 92-4036] p 1035 A92-56858
Strong coupling between inviscid fluid and boundary layer of sharp leading edges: Two-dimensional stationary and turbulent cases for isolated profiles and guard vanes
[ONERA-RT-44/1621-RY-016-R] p 1125 N92-32776
BOUNDARY LAYER SEPARATION
Dynamical scaling of a model unsteady separating flow p 1117 A92-54932
On the structure of unsteady shock induced separation of the transonic airfoil in the NAL two-dimensional wind tunnel p 1029 A92-56010
Forcing level effects of internal acoustic excitation on the improvement of airfoil performance p 1136 A92-56162
Physics of vortical flows p 1031 A92-56166
Small two-dimensional surface excrescences on aircraft wings approaching separation p 1031 A92-56170
BOUNDARY LAYER STABILITY
Linear stability of supersonic cone boundary layers p 1024 A92-54910
BOUNDARY LAYER TRANSITION
Problems and solutions for transition detection in cryogenic wind tunnels by infrared imaging p 1090 A92-54319
A quiet-flow Ludwieg tube for experimental study of high speed boundary layer transition
[AIAA PAPER 92-3885] p 1094 A92-56727
Supersonic and hypersonic quiet tunnel technology at NASA Langley
[AIAA PAPER 92-3908] p 1094 A92-56743
The ASU Transition Research Facility
[AIAA PAPER 92-3910] p 1094 A92-56744
Tohoku University low-turbulence wind tunnel
[AIAA PAPER 92-3913] p 1095 A92-56746
Leading-edge receptivity for blunt-nose bodies
[NASA-CR-190563] p 1036 N92-32648
High speed transition prediction
[NASA-CR-190836] p 1039 N92-33424
BOUNDARY LAYERS
Rayleigh imaging and flow tagging in ground test facilities p 1115 A92-54330
Approximate Riemann solver for hypervelocity flows p 1117 A92-54934
A hypersonic wind tunnel test of a mixed-compression air inlet model p 1028 A92-56007
BGK1 airfoil oilflow tests in the NAL two-dimensional wind tunnel. II p 1029 A92-56044
Experimental investigation of the boundary layer in a corner formed by two circular arc airfoils p 1029 A92-56046
Swept shock/boundary layer interaction experiments in support of CFD code validation
[NASA-CR-190583] p 1036 N92-32494
Leading-edge receptivity for blunt-nose bodies
[NASA-CR-190563] p 1036 N92-32648
An approximate viscous shock layer technique for calculating chemically reacting hypersonic flows about blunt-nosed bodies p 1041 N92-33837
BOUNDARY VALUE PROBLEMS
Aerodynamic airfoils design by quasi-solutions method of inverse boundary-value problems p 1020 A92-53998
Integration of wall interference assessment and wall adaptation
[NLR-TP-91119-U] p 1101 N92-32734
Computational aspects of helicopter trim analysis and damping levels from Floquet theory
[NASA-CR-190736] p 1087 N92-33107
BOW WAVES
Preliminary results from the White Sands Missile Range sonic boom propagation experiment p 1140 N92-33884
BRAYTON CYCLE
Detonation duct gas generator demonstration program
[AIAA PAPER 92-3174] p 1066 A92-54011
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
BRAZING
Joining a Ni-based creep-resistant (ODS) alloy by brazing p 1116 A92-54867
BRIDGMAN METHOD
Fundamental studies on Marangoni convection related to Bridgman crystal growth p 1111 A92-53758
BRIGHTNESS DISTRIBUTION
The C-17 Multifunction Display - A building block for avionic systems p 1063 A92-55907
BRUSH SEALS
Effects of material choices on brush seal performance p 1116 A92-54650
BUBBLES
On the origin and acoustical behaviour of cloud cavitation
[ISBN-90-9004317-9] p 1125 N92-33066
BUCKLING
Initial postbuckling response of an unsymmetrically laminated rectangular plate p 1108 N92-32586
BUILDINGS
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers
[NASA-TM-104170] p 1138 N92-33160
BURNING RATE
Free-radicals aided combustion with scramjet applications
[IAF PAPER 92-0659] p 1106 A92-57100
Analysis of the flight performance of the 155 mm M864 base burn projectile
[BRL-TR-3083] p 1041 N92-33699

C

C-135 AIRCRAFT
High temperature aircraft research furnace facilities
[NASA-CR-184384] p 1101 N92-33826
CABLES (ROPES)
Measurements of longitudinal static aerodynamic coefficients with cable mount system p 1093 A92-56013
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test p 1093 A92-56114
CALIBRATING
Thrust stand design principles
[AIAA PAPER 92-3976] p 1098 A92-56802
The cryogenic balance design and balance calibration methods
[AIAA PAPER 92-4001] p 1122 A92-56824
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG p 1050 N92-33356

Calibration of GPS antennas
[ETN-92-92034] p 1051 N92-33693

CAMBERED WINGS
Survey and analysis of research on supersonic drag-due-to-lift minimization with recommendations for wing design
[NASA-TP-3202] p 1040 N92-33656

CANARD CONFIGURATIONS
On the effect of canards on NAL spaceplane model (0 order) in low speed area p 1030 A92-56052
Navier-Stokes simulation of a close-coupled canard-wing-body configuration p 1031 A92-56163

CANONICAL FORMS
A Lie Bracket solution of the optimal thrust magnitude on a singular arc in atmospheric flight
[AIAA PAPER 92-4345] p 1079 A92-55334

CANTILEVER BEAMS
Structural optimization of a cantilevered beam subject to combined static loadings p 1118 A92-56024

CARBON FIBER REINFORCED PLASTICS
Fabrication test and evaluation of graphite/PMR-15 polyimide for HOPE primary structure p 1105 A92-53516
Structural design and testing results of composite landing gear components p 1057 A92-56328
CFRP stiffened panels under compression p 1109 N92-33044

CARBON FIBERS
Jet fuel absorption and dynamic mechanical analysis of carbon fibre composites p 1110 N92-33050

CASCADE FLOW
Transonic turbine blade cascade testing facility
[AIAA PAPER 92-4034] p 1101 A92-56856
Experimental unsteady pressures on an oscillating cascade with supersonic leading edge locus
[AIAA PAPER 92-4035] p 1035 A92-56857

CASTING
Titanium alloy casting for aerospace p 1106 A92-56103

CATHODE RAY TUBES
The C-17 Multifunction Display - A building block for avionic systems p 1063 A92-55907

CAUCHY PROBLEM
Increasing the accuracy of the Godunov scheme for calculating steady-state supersonic gas flows by solving the generalized Riemann problem p 1035 A92-57499

CAVITATION FLOW
On the origin and acoustical behaviour of cloud cavitation
[ISBN-90-9004317-9] p 1125 N92-33066

CAVITIES
Turbine disk cavity aerodynamics and heat transfer p 1124 N92-32265

CAVITY FLOW
Turbine disk cavity aerodynamics and heat transfer p 1124 N92-32265

CENTRIFUGAL COMPRESSORS
Mixed flow compressor surge margin gain using a manifolded diffuser system
[AIAA PAPER 92-3753] p 1068 A92-54151
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
Effects of curvature and rotation on turbulence in the NASA low-speed centrifugal compressor impeller p 1124 N92-32292

CENTRIFUGAL FORCE
Surface heat transfer and flow properties of vortex arrays induced artificially and from centrifugal instabilities p 1121 A92-56371

CERTIFICATION
AS 332 MKII - Development and certification p 1059 A92-56343

CHANNEL FLOW
Detonation duct gas generator demonstration program
[AIAA PAPER 92-3174] p 1066 A92-54011
Physics of vortical flows p 1031 A92-56166

CHAOS
A double chaotic attractor in transonic flow p 1019 A92-53561

CHECKOUT
An evaluation of decelerating IFR approaches utilizing a helicopter flight simulator
[CTN-92-60348] p 1048 N92-32845

CHEMICAL BONDS
H-N2 interaction energies, transport cross sections, and collision integrals p 1135 A92-54660

CHEMICAL COMPOSITION
Flow characterization in the NASA Ames 16-inch Shock Tunnel
[AIAA PAPER 92-3810] p 1090 A92-54180
Flow contamination and flow quality in arc heaters used for hypersonic testing
[AIAA PAPER 92-4028] p 1100 A92-56850

CHEMICAL REACTIONS
Interaction between chemical reaction and turbulence in supersonic nonpremixed H2-air combustion p 1117 A92-54931

CHROMIUM ALLOYS
High-temperature metal matrix composite p 1105 A92-53878

CHUTES
Fire bombing and fire bombers
[CA-PATENT-1-268-164] p 1061 N92-33582

CINEMATOGRAPHY
High-speed cinematography of supersonic mixing layers
[AIAA PAPER 92-3545] p 1112 A92-54044

CIVIL AVIATION
Regional airline and equipment review - Evolution, trends, and future prospects p 1015 A92-55102
Air transports in the 21st century p 1015 A92-55103
777 - The airlines' higher-order technology airplane p 1052 A92-55104
Research needs for a commercial passenger tiltrotor p 1056 A92-56298
The Eurofar program - An European overview on advanced VTOL civil transportation system p 1016 A92-56299
Federal aviation regulations. Part 91: General operating and flight rules
[PB92-197334] p 1017 N92-33176
Isothermal aging of IM7/8320 and IM7/5260
[NASA-TM-107666] p 1110 N92-33423
Engine bird ingestion experience of the Boeing 737 aircraft: Expanded data base
[DOT/FAA/CT-91/32] p 1045 N92-34151
Impacts of technology on the capacity needs of the US national airspace system
[NASA-CR-4470] p 1045 N92-34192

CLASSIFICATIONS
Radar clutter classification
[ISBN-0-315-57981-1] p 1126 N92-33440

CLASSIFIERS
Radar clutter classification
[ISBN-0-315-57981-1] p 1126 N92-33440

CLEAR AIR TURBULENCE
Severe turbulence and maneuvering from airline flight records
[AIAA PAPER 92-4341] p 1078 A92-55330

CLIMBING FLIGHT
Key design considerations for scramjet powered space plane p 1066 A92-53491

CLOCKS
LORAN-C data reduction at the US Naval Observatory p 1050 N92-33358

CLUSTER ANALYSIS
Aircraft ride quality controller design using new robust root clustering theory for linear uncertain systems
[AIAA PAPER 92-4399] p 1075 A92-55199

CLUTCHES
Thermal mechanical analysis of sprag clutches
[NASA-CR-190686] p 1128 N92-34207

CLUTTER
Radar clutter classification
[ISBN-0-315-57981-1] p 1126 N92-33440

COATINGS
Criteria for use of seal coats on airport pavements
[DOT/FAA/RD-92/18] p 1102 N92-34247

COCKPITS
Design method of a helicopter cockpit p 1058 A92-56337

COGNITION
Workshop on Aeronautical Decision Making (ADM). Volume 1: Executive summary
[DOT/FAA/RD-92/14-VOL-1] p 1142 N92-33305

COLD FLOW TESTS
Test description and preliminary pitot-pressure surveys for Langley Test Technique Demonstrator at Mach 6
[AIAA PAPER 92-3940] p 1096 A92-56770

COLLISION AVOIDANCE
Height keeping performance requirements for reducing vertical separation minima used for air traffic control p 1046 A92-56081
Safety study of TCAS 2 for logic version 6.04
[DOT/FAA/RD-92/22] p 1047 N92-32537
Simulation test and evaluation of TCAS 2 logic version 6.04
[DOT/FAA/RD-92/23] p 1048 N92-33098

COMBAT
DoD key technologies plan
[AD-A253692] p 1142 N92-33238

COMBINED CYCLE POWER GENERATION
Japan pushes high speed research p 1015 A92-53434

COMBINED STRESS
Structural optimization of a cantilevered beam subject to combined static loadings p 1118 A92-56024

COMBUSTIBLE FLOW
Instrumentation key to NASP combustor tests p 1092 A92-55100
Theories of turbulent combustion in high speed flows
[AD-A253032] p 1111 N92-33624

COMBUSTION
Advanced nozzle and engine components test facility
[AIAA PAPER 92-3993] p 1099 A92-56816

COMBUSTION CHAMBERS
Some thermodynamical aspects in the optimization of supersonic combustors p 1065 A92-53486
Detailed numerical analysis of standing oblique detonation p 1111 A92-53550
Applied analytical combustion/emissions research at the NASA Lewis Research Center - A progress report
[AIAA PAPER 92-3338] p 1067 A92-54025
The VRT gas turbine combustor - Phase II
[AIAA PAPER 92-3471] p 1067 A92-54035
Acoustic control of combustor primary zone air-jet mixing
[AIAA PAPER 92-3651] p 1067 A92-54104
Instrumentation key to NASP combustor tests p 1092 A92-55100
The impact of air transport on the environment
[PNR-90876] p 1129 N92-33751

COMBUSTION CHEMISTRY
Interaction between chemical reaction and turbulence in supersonic nonpremixed H2-air combustion p 1117 A92-54931

COMBUSTION STABILITY
Acoustic control of combustor primary zone air-jet mixing
[AIAA PAPER 92-3651] p 1067 A92-54104

COMMERCIAL AIRCRAFT
Air transports in the 21st century p 1015 A92-55103
The application of direct transcription to commercial aircraft trajectory optimization
[AIAA PAPER 92-4528] p 1077 A92-55246
Research needs for a commercial passenger tiltrotor p 1056 A92-56298
High Reynolds number testing in support of transport airplane development
[AIAA PAPER 92-3982] p 1099 A92-56807
High-lift testing at high Reynolds numbers
[AIAA PAPER 92-3986] p 1033 A92-56810
Buffet test in the National Transonic Facility
[AIAA PAPER 92-4032] p 1100 A92-56854
Aircraft accident report: L'Express Airlines, Inc., Flight 508, Beech C99, N7217L weather encounter and crash near Birmingham, Alabama, July 10, 1991
[PB92-910401] p 1043 N92-32455
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
Flight service environmental effects on composite materials and structures p 1110 N92-33054
Statistics on aircraft gas turbine engine rotor failures that occurred in US commercial aviation during 1988
[DOT/FAA/CT-91/28] p 1071 N92-33105
Study objectives: Will commercial avionics do the job? Improvements needed? p 1065 N92-33340
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480
The Rolls-Royce Trent
[PNR-90875] p 1061 N92-33750
Advanced subsonic transport approach noise: The relative contribution of airframe noise
[NASA-TM-104112] p 1140 N92-34148

COMMUNICATION EQUIPMENT
DoD key technologies plan
[AD-A253692] p 1142 N92-33238

COMMUNICATION NETWORKS
Aeronautical satellite communications system p 1046 A92-56089
Aircraft satellite communication systems p 1046 A92-56091

COMPONENT RELIABILITY
Damage tolerant design of critical aircraft structural components
[AIAA PAPER 92-4041] p 1123 A92-56860

COMPOSITE MATERIALS
New materials drive high-performance aircraft p 1105 A92-55134
Design and testing of a composite hingeless hub for rotary-wing aircraft p 1053 A92-56075
Application of automation for structural-composites production p 1119 A92-56109
State-of-the-art materials for future gas turbine engines p 1070 A92-56122
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575
Supportability evaluation of thermoplastic and thermoset composites p 1108 N92-32576

PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program
[AD-A247886] p 1108 N92-32629
Active control of sound transmission through stiff lightweight composite fuselage constructions
p 1137 N92-32957
The Utilization of Advanced Composites in Military Aircraft
[AGARD-R-785] p 1109 N92-33033
Aspects of compression in aerospace composites: Future requirements p 1109 N92-33036
Evaluation of the effects of the environment on the behavior of the primary structures of composite material aircraft in service: Historic and current situation
p 1110 N92-33048
Fluid effects: Thermoset and thermoplastic matrix composites p 1110 N92-33049
Flight service environmental effects on composite materials and structures p 1110 N92-33054
Lightning strike tests of composite connectors
[AD-A252281] p 1044 N92-33249

COMPOSITE STRUCTURES
Fabrication test and evaluation of graphite/PMR-15 polyimide for HOPE primary structure
p 1105 A92-53516
Computed tomography (CT) as a nondestructive test method used for composite helicopter components
p 1121 A92-56276
Influence of cross section variations on the structural behaviour of composite rotor blades
p 1121 A92-56320
Detailed analysis and test correlation of a stiffened composite wing panel p 1121 A92-56324
Composite blades for helicopter main and tail rotors developed by Mil Design Bureau p 1057 A92-56325
Transverse shear effect on flutter of composite panels
p 1122 A92-56607
Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, part 1
[NASA-CP-3087-PT-1] p 1106 N92-32513
Design, evaluation and experimental effort toward development of a high strain composite wing for Navy aircraft p 1107 N92-32514
Development of thermoplastic components for structural validation p 1107 N92-32522
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program
[AD-A247886] p 1108 N92-32629
Active control of sound transmission through stiff lightweight composite fuselage constructions
p 1137 N92-32957
The Utilization of Advanced Composites in Military Aircraft
[AGARD-R-785] p 1109 N92-33033
Aspects of compression in aerospace composites: Future requirements p 1109 N92-33036
CFRP stiffened panels under compression
p 1109 N92-33044
Evaluation of the effects of the environment on the behavior of the primary structures of composite material aircraft in service: Historic and current situation
p 1110 N92-33048
Fluid effects: Thermoset and thermoplastic matrix composites p 1110 N92-33049
Flight service environmental effects on composite materials and structures p 1110 N92-33054
Computational methods for global/local analysis
[NASA-TM-107591] p 1125 N92-33104
Global/local interlaminar stress analysis of a grid-stiffened composite panel
[NASA-CR-190822] p 1125 N92-33139
Lightning strike tests of composite connectors
[AD-A252281] p 1044 N92-33249
Continuation of tailored composite structures of ordered staple thermoplastic material
[NASA-CR-189671] p 1110 N92-33613

COMPRESSIBILITY EFFECTS
Unsteady blade pressures on a propfan - Predicted and measured compressibility effects
[AIAA PAPER 92-3774] p 1023 A92-54161
Numerical simulation of turbulence at the back of the airplane
[ETN-92-91664] p 1037 N92-32769
Theories of turbulent combustion in high speed flows
[AD-A253032] p 1111 N92-33624

COMPRESSIBLE BOUNDARY LAYER
An experimental examination of the effects of incoming boundary layer modifications on the dynamics of a turbulent compression corner interaction
[AIAA PAPER 92-3667] p 1022 A92-54111

COMPRESSIBLE FLOW
An experimental investigation of the flow in a diffusing S-duct
[AIAA PAPER 92-3622] p 1021 A92-54090
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
Assessment of compressibility corrections to the k-epsilon model in high-speed shear layers
p 1024 A92-54905
Measurements of turbulence in hypersonic flow
p 1092 A92-56005
A hypersonic wind tunnel test of a mixed-compression air inlet model p 1028 A92-56007
Wind tunnel test of M = 2.5 mixed compression inlet
p 1028 A92-56008
User's manual for AeroFcn: A FORTRAN program to compute aerodynamic parameters
[NASA-TM-104237] p 1133 N92-32507
Navier-Stokes analysis and experimental data comparison of compressible flow in a diffusing S-duct
[NASA-TM-105683] p 1072 N92-33746

COMPRESSION LOADS
Initial postbuckling response of an unsymmetrically laminated rectangular plate p 1108 N92-32586
Aspects of compression in aerospace composites: Future requirements p 1109 N92-33036
CFRP stiffened panels under compression
p 1109 N92-33044

COMPRESSION TESTS
The Utilization of Advanced Composites in Military Aircraft
[AGARD-R-785] p 1109 N92-33033
Aspects of compression in aerospace composites: Future requirements p 1109 N92-33036
CFRP stiffened panels under compression
p 1109 N92-33044

COMPRESSIVE STRENGTH
The Utilization of Advanced Composites in Military Aircraft
[AGARD-R-785] p 1109 N92-33033
Aspects of compression in aerospace composites: Future requirements p 1109 N92-33036

COMPRESSOR BLADES
An improved compressor performance prediction model
[PNR-90873] p 1072 N92-33749

COMPRESSORS
Performance evaluation of a transonic wind tunnel compressor
[AIAA PAPER 92-3927] p 1096 A92-56758
Small engine components test facility compressor testing cell at NASA Lewis Research Center
[AIAA PAPER 92-3980] p 1098 A92-56806
Active control of compressor surge and stall
[AD-A252771] p 1126 N92-33498
An improved compressor performance prediction model
[PNR-90873] p 1072 N92-33749
Method of reducing drag in aerodynamic systems
[NASA-CASE-LEW-14791-1] p 1043 N92-34243

COMPUTATION
Computational methods for global/local analysis
[NASA-TM-107591] p 1125 N92-33104
Computation and stability analysis of laminar flow over a blunt cone in hypersonic flow p 1041 N92-33839

COMPUTATIONAL FLUID DYNAMICS
Detailed numerical analysis of standing oblique detonation p 1111 A92-53550
A comparison of the calculated and experimental off-design performance of a radial flow turbine
[AIAA PAPER 92-3069] p 1020 A92-54004
Full Navier-Stokes calculations on the installed F/A-18 inlet at a high angle of attack
[AIAA PAPER 92-3175] p 1020 A92-54012
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[AIAA PAPER 92-3177] p 1020 A92-54013
Applied analytical combustion/emissions research at the NASA Lewis Research Center - A progress report
[AIAA PAPER 92-3338] p 1067 A92-54025
Computational and experimental studies of flow in multi-lobed forced mixers
[AIAA PAPER 92-3568] p 1112 A92-54057
Heat transfer measurements and CFD comparison of swept shock wave/boundary-layer interactions
[AIAA PAPER 92-3665] p 1021 A92-54110
Optimization of a 2D scramjet-vehicle using CFD and simplified approximate flow analysis techniques
[AIAA PAPER 92-3673] p 1022 A92-54116
Numerical study of the 3-D flowfield for a supersonic jet exiting into a hypersonic stream from a conical surface
[AIAA PAPER 92-3675] p 1022 A92-54118
Numerical calculations of propfan/swirl recovery vane flow field
[AIAA PAPER 92-3771] p 1022 A92-54160
Comparison between computational and experimental data for a hypersonic laser propelled vehicle
[AIAA PAPER 92-3808] p 1023 A92-54179
Flow characterization in the NASA Ames 16-inch Shock Tunnel
[AIAA PAPER 92-3810] p 1090 A92-54180
Three-dimensional calculation of radiative field in hypersonic air shock layers p 1023 A92-54498
Assessment of compressibility corrections to the k-epsilon model in high-speed shear layers
p 1024 A92-54905
Numerical simulation of slot injection into a turbulent supersonic stream p 1024 A92-54914
Application of a parallel direct simulation Monte Carlo method to hypersonic rarefied flows
p 1024 A92-54916
Efficient iterative methods for the transonic small disturbance equation p 1025 A92-54933
Approximate Riemann solver for hypervelocity flows
p 1117 A92-54934
Grid studies for thin-layer Navier-Stokes computations of airfoil flowfields p 1025 A92-54935
Computation of vortex wake flows and control of their effects on trailing wings
[AIAA PAPER 92-4429] p 1025 A92-55353
Navier-Stokes computations for oscillating control surfaces
[AIAA PAPER 92-4431] p 1026 A92-55355
The vortical structure in the wake during dynamic stall
[AIAA PAPER 92-4496] p 1026 A92-55364
A discrete vortex model for predicting wing rock of slender wings
[AIAA PAPER 92-4497] p 1026 A92-55365
Tow-tank study of nonlinear aerodynamics of a 2-D airfoil
[AIAA PAPER 92-4499] p 1026 A92-55367
Evaluation of a multigrid-based Navier-Stokes solver for aerothermodynamic computations
[AIAA PAPER 92-4563] p 1027 A92-55375
Computations of the unsteady flow about a generic wing/pylon/finned-store configuration
[AIAA PAPER 92-4568] p 1027 A92-55377
Approximate aerodynamic analysis of jet interaction
[AIAA PAPER 92-4640] p 1027 A92-55387
Comparative numerical study of two turbulence models for airfoil static and dynamic stall
[AIAA PAPER 92-4649] p 1028 A92-55394
Computing high-speed flows past an oscillating cylinder near a vertical wall
[AIAA PAPER 92-4653] p 1028 A92-55397
Wind tunnel test of M = 2.5 mixed compression inlet
p 1028 A92-56008
Generalized aerodynamics analysis by the boundary element method p 1030 A92-56050
Computational and experimental investigation of annulus heat transfer with swirl
[AIAA PAPER 92-4060] p 1119 A92-56143
Navier-Stokes simulation of a close-coupled canard-wing-body configuration p 1031 A92-56163
Euler/experiment correlation of a generic fighter
p 1031 A92-56164
Application of computational fluid dynamics to sonic boom near- and mid-field prediction
p 1031 A92-56173
The computation and validation of hovering rotor performance p 1055 A92-56285
Current European rotorcraft research activities on development of advanced CFD methods for the design of rotor blades (BRITE/EURAM 'DACRO' project)
p 1032 A92-56332
Roles of wind tunnel tests and CFD analyses in the design of energy-efficient SST
[AIAA PAPER 92-3923] p 1133 A92-56754
A code validation strategy and facility for nonequilibrium, reacting flows
[AIAA PAPER 92-3970] p 1098 A92-56796
High-lift testing at high Reynolds numbers
[AIAA PAPER 92-3986] p 1033 A92-56810
CAN-DO, CFD-based Aerodynamic Nozzle Design and Optimization program for supersonic/hypersonic wind tunnels
[AIAA PAPER 92-4009] p 1033 A92-56832
Computational and numerical analysis of hypersonic nozzle flows with comparisons to wind tunnel calibration data
[AIAA PAPER 92-4011] p 1033 A92-56834
A database of aerothermal measurements in hypersonic flow for CFD validation
[AIAA PAPER 92-4023] p 1034 A92-56845
CFD validation experiments for hypersonic flows
[AIAA PAPER 92-4024] p 1034 A92-56846
Numerical simulation of unsteady flow in a hypersonic shock tunnel facility
[AIAA PAPER 92-4029] p 1034 A92-56851

Increasing the accuracy of the Godunov scheme for calculating steady-state supersonic gas flows by solving the generalized Riemann problem p 1035 A92-57499
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
Potential flow theory and operation guide for the panel code PMARC
[NASA-TM-102851] p 1036 N92-32422
Computations of unsteady multistage compressor flows in a workstation environment
[NASA-TM-103839] p 1071 N92-32452
Modeling and numerical simulation of vortex flow in aerodynamics
[NLR-TP-91154-U] p 1037 N92-32673
Numerical simulation of turbulence at the back of the airplane
[ETN-92-91664] p 1037 N92-32769
Further development of the CANAERO computer code to include propulsor modelling
[DREA-CR-90-425] p 1038 N92-32811
Perspectives on hypersonic viscous and nonequilibrium flow research
[NASA-CR-190817] p 1039 N92-33413
Activities report of the National Aerospace Laboratory
[ETN-92-92053] p 1143 N92-33694
Navier-Stokes analysis and experimental data comparison of compressible flow in a diffusing S-duct
[NASA-TM-105683] p 1072 N92-33746
Numerical investigation of the effects of icing on fixed and rotary wing aircraft
[NASA-CR-190542] p 1044 N92-34105
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[NASA-TM-105672] p 1128 N92-34112
Flutter in the transonic flight regime
p 1089 N92-34167

COMPUTATIONAL GRIDS
Comparison of turbulence models for powered-lift flow fields
[AIAA PAPER 92-3674] p 1022 A92-54117
Grid studies for thin-layer Navier-Stokes computations of airfoil flowfields p 1025 A92-54935
A method for designing blended wing-body configurations for low wave drag
[NASA-TP-3261] p 1036 N92-32480
New concepts for multi-block grid generation for flow domains around complex aerodynamic configurations
[NLR-TP-91046-U] p 1037 N92-32730
Research on some centered implicit methods for calculating transonic flows by solving Navier-Stokes equations
[ONERA-RSF-24/1408-AY-150A] p 1037 N92-32773
Development of 3D electromagnetic modeling tools for airborne vehicles
[NASA-CR-190810] p 1126 N92-33307
Investigation of advancing front method for generating unstructured grid
[NASA-CR-190902] p 1128 N92-34043

COMPUTER AIDED DESIGN
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
Computer aided evaluation of aircraft handling qualities and flight control system robustness
[AIAA PAPER 92-4423] p 1080 A92-55347
PAYCOS, a multidisciplinary sizing code for hypersonic vehicles
[AIAA PAPER 92-4564] p 1132 A92-55376
Configuration of flexible-skirts for an ACV and its CAD
p 1118 A92-56036
A development of hypermedia type database system for instruction of aircraft conceptual design
p 1132 A92-56113
Application of advanced multidisciplinary analysis and optimization methods to vehicle design synthesis
p 1054 A92-56160
HiRel - Reliability/availability integrated workstation tool p 1120 A92-56257
Design of a variable contraction for a full-scale automotive wind tunnel
[AIAA PAPER 92-3929] p 1096 A92-56760
Flutter analyses using high speed computers. Part 1: Flutter analyses for large aircraft p 1089 N92-34168
Flutter analyses using high speed computers. Part 2: Aerodynamic procedures p 1089 N92-34169

COMPUTER AIDED MAPPING
Integration of radar altimeter, precision navigation, and digital terrain data for low-altitude flight
[AIAA PAPER 92-4420] p 1063 A92-55212

COMPUTER AIDED TOMOGRAPHY
Computed tomography (CT) as a nondestructive test method used for composite helicopter components
p 1121 A92-56276

COMPUTER ASSISTED INSTRUCTION
Implementation of a personal computer based parameter estimation program
[AD-A252914] p 1061 N92-33502

COMPUTER GRAPHICS
A simulation study of tiltrotor vertical takeoff procedures using conventional and variable diameter rotor systems
p 1056 A92-56301
A graphical user-interface for propulsion system *analysis*
[NASA-TM-105696] p 1134 N92-33894
Computational algorithms for increased control of depth-viewing volume for stereo three-dimensional graphic displays
[NASA-TM-4379] p 1065 N92-34109

COMPUTER NETWORKS
SATWG networked quality function deployment
p 1134 N92-33339

COMPUTER PROGRAM INTEGRITY
Distributed systems: Interconnection and fault tolerance studies
[AD-A252869] p 1135 N92-33920

COMPUTER PROGRAMMING
Analysis of data from a DO-178A software development process p 1134 N92-32880

COMPUTER PROGRAMS
Dynamic derivative data for high angle of attack simulation
[AIAA PAPER 92-4355] p 1079 A92-55341
Engine condition monitoring system for B747-400
p 1064 A92-56082
The operational status of automated aircraft washing system p 1016 A92-56087
A module-level testing environment for safety-critical software systems p 1132 A92-56293
Aerodynamic calculation of an elliptic ring wing
[AIAA PAPER 91-0068] p 1035 A92-57035
Analysis of data from a DO-178A software development process p 1134 N92-32880
Simulation test and evaluation of TCAS 2 logic version 6.04
[DOT/FAA/RD-92/23] p 1048 N92-33098
Implementation of a personal computer based parameter estimation program
[AD-A252914] p 1061 N92-33502
Distributed systems: Interconnection and fault tolerance studies
[AD-A252869] p 1135 N92-33920
Finite difference time domain grid generation from AMC helicopter models
[NASA-TM-107679] p 1128 N92-34017
Turbulence-induced loads on a teetered rotor
p 1042 N92-34029
Investigation of advancing front method for generating unstructured grid
[NASA-CR-190902] p 1128 N92-34043

COMPUTER SYSTEMS DESIGN
Modular techniques for dynamic fault-tree analysis
p 1120 A92-56241
The design and development of a portable, DSP micro-processor based, high-accuracy data acquisition system
[NRC-32146] p 1134 N92-32851
The development of an airborne information management system for flight test
[NASA-TM-104251] p 1065 N92-32866
Human factors issues in the use of artificial intelligence in air traffic control. October 1990 Workshop
[NASA-CR-190925] p 1051 N92-34203

COMPUTER SYSTEMS PERFORMANCE
Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483

COMPUTER TECHNIQUES
Detecting 3-D, turbulent separation regions using unsteady computerized thermographic technique
p 1023 A92-54308

COMPUTER VISION
Vision-based stereo ranging as an optimal control problem
[AIAA PAPER 92-4418] p 1045 A92-55211
Vision-based range estimation using helicopter flight data
[NASA-TM-103930] p 1047 N92-32424

COMPUTERIZED SIMULATION
Numerical simulations of flutter and its suppression by active control
[AIAA PAPER 92-4652] p 1082 A92-55396
Direct simulation of low-density flow over airfoils
p 1030 A92-56159
A simulation study of tiltrotor vertical takeoff procedures using conventional and variable diameter rotor systems
p 1056 A92-56301
Short takeoff optimization for the XV-15 tiltrotor aircraft p 1056 A92-56302
Sound produced by vortex-airfoil interaction
p 1136 A92-56345
A high speed edgewise rotor using circulation control only in the reversed flow area p 1059 A92-56347
Integrated test and evaluation for hypervelocity systems
[AIAA PAPER 92-3901] p 1017 A92-56736
Application of electronically scanned pressure measurement system for engine simulation tests in the German-Dutch Wind Tunnel
[AIAA PAPER 92-4003] p 1122 A92-56826
Laboratory simulation of aerothermodynamic phenomena - A review
[AIAA PAPER 92-4025] p 1104 A92-56847
Modeling and numerical simulation of vortex flow in aerodynamics
[NLR-TP-91154-U] p 1037 N92-32673
Numerical simulation of turbulence at the back of the airplane
[ETN-92-91664] p 1037 N92-32769
Simulation test and evaluation of TCAS 2 logic version 6.04
[DOT/FAA/RD-92/23] p 1048 N92-33098
Ideal efficiency of propellers based on Theodorsen's theory: A review and computer study, with extended plus simplified charts
[UTIAS-TN-271] p 1071 N92-33102
Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483
Simulation model of a twin-tail, high performance airplane
[NASA-TM-107601] p 1088 N92-33537
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
Simulations of sonic boom ray tube area fluctuations for propagation through atmospheric turbulence including caustics via a Monte Carlo method
p 1139 N92-33878
Subjective loudness response to simulated sonic booms p 1140 N92-33885
Dynamics and control of a five degree-of-freedom magnetic suspension system
[NASA-CR-191259] p 1102 N92-34222

CONCURRENT PROCESSING
Real-time processing of radar return on a parallel computer
[NASA-CR-4456] p 1043 N92-32606

CONDENSERS (LIQUEFIERS)
Study of potassium turbine electric generator system
p 1129 N92-33794

CONDUCTIVE HEAT TRANSFER
Assessment of calculation methods for efficiency of straight fins of rectangular profile p 1121 A92-56374

CONES
Computation and stability analysis of laminar flow over a blunt cone in hypersonic flow p 1041 N92-33839

CONFERENCES
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[ISBN 0-7803-0521-3] p 1119 A92-56201
Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, part 1
[NASA-CP-3087-PT-1] p 1106 N92-32513
Fourth Aircraft Interior Noise Workshop
[NASA-CP-10103] p 1136 N92-32948
Workshop on Aeronautical Decision Making (ADM). Volume 1: Executive summary
[DOT/FAA/RD-92/14-VOL-1] p 1142 N92-33305

CONFIGURATION INTERACTION
H-N2 interaction energies, transport cross sections, and collision integrals p 1135 A92-54660

CONGRESSIONAL REPORTS
Departments of Veterans Affairs and Housing and Urban Development, and independent agencies appropriations for 1993, part 6
[GAO-55-636-PT-6] p 1141 N92-32505
Air traffic control: FAA's advanced automation system contract
[GAO/IMTEC-91-25] p 1048 N92-32861
NASA authorization, 1993, volume 1
[GPO-55-260-VOL-1] p 1142 N92-33147

CONICAL BODIES
Numerical study of the 3-D flowfield for a supersonic jet exiting into a hypersonic stream from a conical surface
[AIAA PAPER 92-3675] p 1022 A92-54118
Linear stability of supersonic cone boundary layers p 1024 A92-54910
CONNECTORS
Lightning strike tests of composite connectors
[AD-A252281] p 1044 N92-33249
CONSTRAINTS
Constrained control allocation
[AIAA PAPER 92-4550] p 1131 A92-55262
Advanced software development workstation: Effectiveness of constraint-checking --- spaceflight simulation and planning
[NASA-CR-190712] p 1134 N92-32865
CONSTRUCTION MATERIALS
Effects of material choices on brush seal performance p 1116 A92-54650
CONTAMINANTS
Applied analytical combustion/emissions research at the NASA Lewis Research Center - A progress report
[AIAA PAPER 92-3338] p 1067 A92-54025
CONTINUUM FLOW
A clean air continuous flow propulsion facility
[AIAA PAPER 92-3912] p 1094 A92-56745
CONTINUUM MECHANICS
Thermal mechanical analysis of sprag clutches
[NASA-CR-190686] p 1128 N92-34207
CONTRACTION
Design of a variable contraction for a full-scale automotive wind tunnel
[AIAA PAPER 92-3929] p 1096 A92-56760
CONTRACTS
Air traffic control: FAA's advanced automation system contract
[GAO/IMTEC-91-25] p 1048 N92-32861
CONTRAROTATING PROPELLERS
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055
CONTROL
Preliminary dynamic tests of a flight-type ejector
[AIAA PAPER 92-3261] p 1066 A92-54020
CONTROL EQUIPMENT
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
Piloted evaluation of an integrated propulsion and flight control simulator
[NASA-TM-105797] p 1088 N92-34107
CONTROL SIMULATION
A simulator evaluation of various manual control concepts for fly-by-wire transport aircraft
[AIAA PAPER 92-4328] p 1073 A92-55172
A consideration on air traffic control processing capability in terminal area p 1047 A92-56110
Nonlinear dynamic-inversion flight control of supermaneuverable aircraft p 1062 N92-33953
Piloted evaluation of an integrated propulsion and flight control simulator
[NASA-TM-105797] p 1088 N92-34107
CONTROL STABILITY
Robustness of a helicopter flight control system designed using eigenstructure assignment
[AIAA PAPER 92-4469] p 1076 A92-55229
Multiple delay model approach applied to the AIAA 1922 Controls Design Challenge
[AIAA PAPER 92-4630] p 1078 A92-55305
CONTROL SURFACES
Parameter estimation of an augmented airplane with unsteady aerodynamics modelling p 1073 A92-53546
Navier-Stokes computations for oscillating control surfaces
[AIAA PAPER 92-4431] p 1026 A92-55355
C-17 flight control system overview p 1082 A92-55906
Flutter analysis and wind tunnel test with respect to a low-aspect-ratio wing with free-rotational control surface p 1052 A92-56014
Lateral control of spaceplane at hypersonic flight p 1104 A92-56069
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131
CONTROL SYSTEMS DESIGN
Improvement of atmospheric flight performance of a space vehicle through H infinity-control theory p 1130 A92-53785
Development of the full-envelope Performance Seeking Control algorithm
[AIAA PAPER 92-3748] p 1068 A92-54148
Performance benefits of adaptive in-flight propulsion system optimization
[AIAA PAPER 92-3749] p 1068 A92-54149
Hypervelocity Wind Tunnel 9 control system p 1092 A92-54343
AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pts. 1-3 p 1130 A92-55151
Robust dynamic inversion control laws for aircraft control
[AIAA PAPER 92-4329] p 1073 A92-55173
Aircraft ride quality controller design using new robust root clustering theory for linear uncertain systems
[AIAA PAPER 92-4399] p 1075 A92-55199
Design of robust Quantitative Feedback Theory controllers for pitch attitude hold systems
[AIAA PAPER 92-4409] p 1075 A92-55203
New literal approximations for the longitudinal dynamic characteristics of flexible flight vehicles
[AIAA PAPER 92-4411] p 1075 A92-55205
Robustness of a helicopter flight control system designed using eigenstructure assignment
[AIAA PAPER 92-4469] p 1076 A92-55229
Control design of a UH-60 rotorcraft via CLTR and direct optimization
[AIAA PAPER 92-4470] p 1076 A92-55230
Automatic formation flight control
[AIAA PAPER 92-4473] p 1076 A92-55233
An algorithm for robust eigenstructure assignment using the Linear Quadratic Regulator
[AIAA PAPER 92-4478] p 1131 A92-55237
Constrained control allocation
[AIAA PAPER 92-4550] p 1131 A92-55262
A robust gain scheduler interpolated into multiple models by membership functions
[AIAA PAPER 92-4553] p 1131 A92-55265
G-Field Control of nonlinear systems
[AIAA PAPER 92-4555] p 1131 A92-55267
Enlisting industry support for a flight controls design lab
[AIAA PAPER 92-4560] p 1141 A92-55272
Propulsion system performance resulting from an Integrated Flight/Propulsion Control design
[AIAA PAPER 92-4602] p 1069 A92-55281
An framework for robust flight control design using constrained optimization
[AIAA PAPER 92-4603] p 1131 A92-55282
Automated procedures for aircraft aeroservoelastic compensation
[AIAA PAPER 92-4606] p 1077 A92-55284
Robust control design of an automatic carrier landing system
[AIAA PAPER 92-4619] p 1077 A92-55296
Nonlinear model-following control application to airplane control (1992 AIAA Controls Design Challenge)
[AIAA PAPER 92-4625] p 1077 A92-55302
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
Multiple delay model approach applied to the AIAA 1922 Controls Design Challenge
[AIAA PAPER 92-4630] p 1078 A92-55305
Intelligent control law tuning for AIAA Controls Design Challenge
[AIAA PAPER 92-4631] p 1132 A92-55306
Computer aided evaluation of aircraft handling qualities and flight control system robustness
[AIAA PAPER 92-4423] p 1080 A92-55347
Flight test results using a low order equivalent systems technique to estimate flying qualities
[AIAA PAPER 92-4425] p 1080 A92-55349
Robust control system design with multiple model approach p 1083 A92-56029
Flight control system design using H(infinity) optimal control p 1083 A92-56030
MIMO state-feedback control system considering phase stability by -90 deg phase-locus method p 1084 A92-56066
Design of a flight control system using a feedback-error-learning-type neural network p 1132 A92-56067
Multidisciplinary optimization of aeroservoelastic systems using reduced-size models p 1054 A92-56176
Redundancy design philosophy for catastrophic loss protection p 1119 A92-56202
Experimental investigation of helicopter coupled rotor/body control p 1086 A92-56318
Control of large cryogenic tunnels
[AIAA PAPER 92-3930] p 1096 A92-56761
A learning enhanced flight control system for high performance aircraft
[AD-A252520] p 1086 N92-32435
Analysis of delay reducing and fuel saving sequencing and spacing algorithms for arrival traffic
[NASA-TM-103880] p 1044 N92-33194
An investigation of switched reluctance rotor position estimation using neural networks
[AD-A252846] p 1061 N92-33414
Design of helicopter flight control systems for hover and low speed using eigenstructure assignment p 1061 N92-33952
Human factors issues in the use of artificial intelligence in air traffic control. October 1990 Workshop
[NASA-CR-190925] p 1051 N92-34203
CONTROL THEORY
Improvement of atmospheric flight performance of a space vehicle through H infinity-control theory p 1130 A92-53785
Flight control law synthesis using neural network theory
[AIAA PAPER 92-4390] p 1074 A92-55191
Invertibility and trajectory control for nonlinear maneuvers of aircraft
[AIAA PAPER 92-4410] p 1075 A92-55204
G-Field Control of nonlinear systems
[AIAA PAPER 92-4555] p 1131 A92-55267
Applications of robust control theory - Educational implications
[AIAA PAPER 92-4559] p 1131 A92-55271
Intelligent control law tuning for AIAA Controls Design Challenge
[AIAA PAPER 92-4631] p 1132 A92-55306
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
CONTROLLABILITY
Piloted simulation for the BK117 FBW demonstrator p 1053 A92-56077
Mission oriented investigation of handling qualities through simulation p 1059 A92-56353
A background to the handling qualities of aircraft
[ESDU-92006] p 1087 N92-32780
CONTROLLERS
Constrained control allocation
[AIAA PAPER 92-4550] p 1131 A92-55262
Propulsion system performance resulting from an Integrated Flight/Propulsion Control design
[AIAA PAPER 92-4602] p 1069 A92-55281
An framework for robust flight control design using constrained optimization
[AIAA PAPER 92-4603] p 1131 A92-55282
Discrete event fuzzy airport control p 1046 A92-55973
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
An investigation of switched reluctance rotor position estimation using neural networks
[AD-A252846] p 1061 N92-33414
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
Dynamics and control of a five degree-of-freedom magnetic suspension system
[NASA-CR-191259] p 1102 N92-34222
CONVECTION
Measurements of the dynamic stall vortex convection speed p 1032 A92-56351
CONVECTIVE HEAT TRANSFER
Enhancement of laminar boundary layer heat transfer by a vortex generator p 1118 A92-55453
Experimental modeling of film-cooled axial turbine tip seals
[AIAA PAPER 92-4058] p 1119 A92-56141
Stokes flows in superposed immiscible liquids with horizontal heating
[IAF PAPER 92-0909] p 1123 A92-57288
Swept shock/boundary layer interaction experiments in support of CFD code validation
[NASA-CR-190583] p 1036 N92-32494
CONVERGENT NOZZLES
Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193
CONVERGENT-DIVERGENT NOZZLES
Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193
COOLING SYSTEMS
Effect of porosity in transpiration cooling system p 1112 A92-53786
Study of potassium turbine electric generator system p 1129 N92-33794
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131
CORIOLIS EFFECT
An integrated development of the equations of motion for elastic hypersonic flight vehicles
[AIAA PAPER 92-4605] p 1077 A92-55283
CORNER FLOW
Experimental investigation of the boundary layer in a corner formed by two circular arc airfoils p 1029 A92-56046

Investigation of a plate-ramp-configuration by means of laser Doppler anemometry at Mach 2.95
[AIAA PAPER 92-3956] p 1097 A92-56784
CORNERS
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-34019
COST ANALYSIS
Cost/benefit analysis of the AH-64 (Apache) helicopter Automated Test Equipment (ATE)
[AD-A252909] p 1101 N92-33398
COST EFFECTIVENESS
The wind tunnel test 'system' of 1995 - Cost effective experimentation through a fusion of related technologies
p 1091 A92-54342
Designing to cost effectiveness - Enhancing quality
p 1119 A92-56209
Continuation of tailored composite structures of ordered staple thermoplastic material
[NASA-CR-189671] p 1110 N92-33613
COST ESTIMATES
Air traffic control: FAA's advanced automation system contract
[GAO/IMTEC-91-25] p 1048 N92-32861
Advanced airframe structural materials: A primer and cost estimating methodology
[AD-A253371] p 1062 N92-34182
COUNTERFLOW
Theories of turbulent combustion in high speed flows
[AD-A253032] p 1111 N92-33624
COUPLING
Proof of concept of a magnetically coupled Stirling engine-driven heat pump
[DE92-017129] p 1129 N92-33271
CRACK CLOSURE
Effects of constraint on crack growth under aircraft spectrum loading
[NASA-TM-107677] p 1128 N92-34178
CRACK INITIATION
Monitoring fatigue cracks in gears
p 1116 A92-54496
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-34019
CRACK PROPAGATION
Damage tolerant design of critical aircraft structural components
[AIAA PAPER 92-4041] p 1123 A92-56860
Effects of spectrum variations on fatigue crack growth
p 1123 A92-57399
Effects of constraint on crack growth under aircraft spectrum loading
[NASA-TM-107677] p 1128 N92-34178
CRACKING (FRACTURING)
Fatigue cracking threshold prediction of transport airplanes p 1118 A92-56094
Criteria for use of seal coats on airport pavements
[DOT/FAA/RD-92/18] p 1102 N92-34247
CRASHES
Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081
CREEP STRENGTH
Joining a Ni-based creep-resistant (ODS) alloy by brazing p 1116 A92-54867
Diffusion bonding a creep-resistant Fe-ODS alloy
p 1117 A92-54868
CRITERIA
Airbreathing engine selection criteria for SSTO propulsion system
[IAF PAPER 92-0658] p 1071 A92-57099
CRITICAL FREQUENCIES
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
CROSS COUPLING
Multiaxis control in longitudinal mode of aircraft
p 1083 A92-56027
CROSS FLOW
Assessment of passive porosity with free and fixed separation on a tangent ogive forebody
[AIAA PAPER 92-4494] p 1081 A92-55363
Unsteady response of the leading-edge vortices on a pitching delta wing p 1041 N92-33851
CROSS SECTIONS
Influence of cross section variations on the structural behaviour of composite rotor blades
p 1121 A92-56320
CRUCIFORM WINGS
Effects of the roll angle on cruciform wing-body configurations at high incidences
[AIAA PAPER 92-4356] p 1079 A92-55342
CRUISING FLIGHT
Technologies for the National Aero-Space Plane
[IAF PAPER 92-0868] p 1105 A92-57259
CRYOGENIC WIND TUNNELS
Problems and solutions for transition detection in cryogenic wind tunnels by infrared imaging
p 1090 A92-54319
Preliminary airfoil testing experience in the NDA cryogenic wind tunnel p 1091 A92-54326
Control of large cryogenic tunnels
[AIAA PAPER 92-3930] p 1096 A92-56761
The cryogenic balance design and balance calibration methods
[AIAA PAPER 92-4001] p 1122 A92-56824
CRYSTAL GROWTH
Fundamental studies on Marangoni convection related to Bridgman crystal growth p 1111 A92-53758
CURVATURE
Effects of curvature and rotation on turbulence in the NASA low-speed centrifugal compressor impeller
p 1124 N92-32292
CYCLIC LOADS
Turbulence-induced loads on a teetered rotor
p 1042 N92-34029
Thermal mechanical analysis of sprag clutches
[NASA-CR-190686] p 1128 N92-34207

D

DAMAGE
Damage tolerance analysis for rotorcraft - What the issues are p 1058 A92-56336
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
Criteria for use of seal coats on airport pavements
[DOT/FAA/RD-92/18] p 1102 N92-34247
DAMAGE ASSESSMENT
Repair procedures for advanced composites for helicopters p 1016 A92-56277
Damage tolerant design of critical aircraft structural components
[AIAA PAPER 92-4041] p 1123 A92-56860
Damage tolerance certification methodology for composite structures p 1108 N92-32579
Effects of the abrasiveness of test and training site soils on parachute life
[AD-A252389] p 1038 N92-32900
Bird ingestion into large turbofan engines
[DOT/FAA/CT-91/17] p 1043 N92-33005
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers
[NASA-TM-104170] p 1138 N92-33160
Lightning strike tests of composite connectors
[AD-A252281] p 1044 N92-33249
DAMPING
Landing gear mechanism including runway-roughness restrictor assembly
[CA-PATENT-1-257-618] p 1061 N92-33585
DATA ACQUISITION
Recent developments in data acquisition and control systems at the Aircraft Research Association Limited
p 1091 A92-54323
Some important factors in turbulence in flight measurement p 1063 A92-54324
A new system for recording unstable aerodynamic phenomena in NAVSWC Hypervelocity Wind Tunnel No. 9 p 1091 A92-54325
Preliminary airfoil testing experience in the NDA cryogenic wind tunnel p 1091 A92-54326
The wind tunnel test 'system' of 1995 - Cost effective experimentation through a fusion of related technologies
p 1091 A92-54342
Hypervelocity Wind Tunnel 9 control system
p 1092 A92-54343
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of MLS
p 1047 A92-56117
Correlation of flight, tunnel and prediction data on a helicopter main rotor p 1059 A92-56350
Advanced nozzle and engine components test facility
[AIAA PAPER 92-3993] p 1099 A92-56816
The design and development of a portable, DSP micro-processor based, high-accuracy data acquisition system
[NRC-32146] p 1134 N92-32851
The development of an airborne information management system for flight test
[NASA-TM-104251] p 1065 N92-32866
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951
Pilots noise exposure during a Boeing 747-400 round trip: Ambient noise and acoustic-head recording and analysis of data p 1137 N92-32960
DATA BASES
A development of hypermedia type database system for instruction of aircraft conceptual design
p 1132 A92-56113
A database of aerothermal measurements in hypersonic flow for CFD validation
[AIAA PAPER 92-4023] p 1034 A92-56845
An international aerospace information system: A cooperative opportunity
[NASA-TM-108171] p 1142 N92-33237
Simulation model of a twin-tail, high performance airplane
[NASA-TM-107601] p 1088 N92-33537
Experimental study of a generic high-speed civil transport
[NASA-TM-4382] p 1040 N92-33631
Joint study on the computerisation of in-field aero engines vibration diagnosis
[PNR-90799] p 1072 N92-33815
Engine bird ingestion experience of the Boeing 737 aircraft: Expanded data base
[DOT/FAA/CT-91/32] p 1045 N92-34151
DATA COMPRESSION
The development of an airborne information management system for flight test
[NASA-TM-104251] p 1065 N92-32866
DATA INTEGRATION
A Kalman filter integrated navigation design for the IAR Twin Otter Atmospheric Research Aircraft
[NRC-32148] p 1048 N92-32849
The use of Kalman filtering techniques to improve the accuracy of flight test data
[NRC-32139] p 1064 N92-32850
DATA LINKS
An experimental program concerning a satellite data link for oceanic ATC p 1046 A92-56093
US Coast Guard GPS Information Center (GPSIC) and its function within the Civil GPS Service (CGS)
p 1049 N92-33352
Design and evaluation of an advanced air-ground data-link system for air traffic control
[NASA-TM-103899] p 1050 N92-33407
DATA PROCESSING
A data processing system for oceanic air traffic control p 1046 A92-56090
Analysis of data from a DO-178A software development process p 1134 N92-32880
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
DATA RECORDING
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
DATA REDUCTION
LORAN-C data reduction at the US Naval Observatory
p 1050 N92-33358
DATA SAMPLING
Selection of sampling rate for nonlinear flight trajectory controller of aircraft p 1084 A92-56070
DATA STORAGE
A development of hypermedia type database system for instruction of aircraft conceptual design
p 1132 A92-56113
DC 9 AIRCRAFT
Change and reliability of the DC-9-81 digital flight guidance system p 1084 A92-56086
DECELERATION
Blade instability of horizontally stoppable rotors
p 1085 A92-56308
DECISION MAKING
An experimental study of organismic principles of the functioning of the crew-transport aircraft system
p 1133 A92-57446
Workshop on Aeronautical Decision Making (ADM). Volume 1: Executive summary
[DOT/FAA/RD-92/14-VOL-1] p 1142 N92-33305
Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081
Human factors issues in the use of artificial intelligence in air traffic control. October 1990 Workshop
[NASA-CR-190925] p 1051 N92-34203
DECISION THEORY
Radar clutter classification
[ISBN-0-315-57981-1] p 1126 N92-33440
DEFECTS
Inspection of fabricated fuselage panels using electronic shearography
[DOT/FAA/CT-TN92/26] p 1127 N92-33627
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-84019

DEFENSE PROGRAM
DoD key technologies plan
[AD-A253692] p 1142 N92-33238
DEFLECTION
Lift and rolling moment due to spoilers on wings with trailing-edge flaps deflected at subsonic speeds
[ESDU-92002-SUPPL] p 1037 N92-32782
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063
DEGRADATION
Jet fuel absorption and dynamic mechanical analysis of carbon fibre composites p 1110 N92-33050
Experimental study of performance degradation of a rotating system in the NASA Lewis RC icing tunnel
[NASA-CR-190684] p 1102 N92-34141
DEGREES OF FREEDOM
Application of restructurable flight control system using nonlinear control to an airliner p 1084 A92-56068
Turbulence-induced loads on a teetered rotor p 1042 N92-34029
Dynamics and control of a five degree-of-freedom magnetic suspension system
[NASA-CR-191259] p 1102 N92-34222
DEICING
Low energy ice protection for helicopters p 1059 A92-56348
DELTA FUNCTION
Robust sampled data eigenstructure assignment using the delta operator
[AIAA PAPER 92-4400] p 1075 A92-55200
DELTA WINGS
Signal processing schemes for Doppler global velocimetry p 1115 A92-54338
Navier-Stokes prediction of large-amplitude delta-wing roll oscillations characterizing wing rock
[AIAA PAPER 92-4428] p 1080 A92-55352
Vortical flow control on a wing-body combination using tangential blowing
[AIAA PAPER 92-4430] p 1081 A92-55354
A discrete vortex model for predicting wing rock of slender wings
[AIAA PAPER 92-4497] p 1026 A92-55365
Stochastic self-induced roll oscillations of slender delta wing at high angles of attack
[AIAA PAPER 92-4498] p 1081 A92-55366
Unsteady shock-vortex interaction on a flexible delta wing p 1030 A92-56157
Effects of external influences in subsonic delta wing vortices
[AIAA PAPER 92-4033] p 1034 A92-56855
Vortex flow visualization using colored and fluorescent dyes on flat plate delta wing with leading edge extension
[AD-A251139] p 1036 N92-32651
An experimental study of the flow over a sharp-edged delta wing at subsonic and transonic speeds
[NLR-TP-91117-U] p 1037 N92-32732
Static and dynamic flow visualization studies of two double-delta wing models at high angles of attack
[AD-A252878] p 1040 N92-33678
Unsteady response of the leading-edge vortices on a pitching delta wing p 1041 N92-33851
DESCENT TRAJECTORIES
A guidance law for hypersonic descent to a point
[AIAA PAPER 92-4303] p 1104 A92-55311
DESIGN ANALYSIS
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
Aerodynamic study of H-II Orbiting Plane, HOPE p 1103 A92-53639
Turning up the heat on aircraft structures --- design and analysis for high-temperature conditions p 1052 A92-55131
PAYCOS, a multidisciplinary sizing code for hypersonic vehicles
[AIAA PAPER 92-4564] p 1132 A92-55376
Redundancy design philosophy for catastrophic loss protection p 1119 A92-56202
Organization and technical status of the NH90 European helicopter programme p 1016 A92-56306
Technology exploitation for in-service support of future rotorcraft p 1016 A92-56327
Predicted aerodynamic characteristics for HL-20 lifting-body using the aerodynamic preliminary analysis system (APAS)
[AIAA PAPER 92-3941] p 1033 A92-56771
Global/local interlaminar stress analysis of a grid-stiffened composite panel
[NASA-CR-190822] p 1125 N92-33139
Study objectives: Will commercial avionics do the job? Improvements needed? p 1065 N92-33340
Integrated Russian VLF/Omega receiver design
[PB92-193390] p 1051 N92-33809
DESIGN TO COST
Intelligent control law tuning for AIAA Controls Design Challenge
[AIAA PAPER 92-4631] p 1132 A92-55306
DETONATION WAVES
Detailed numerical analysis of standing oblique detonation p 1111 A92-53550
Interaction between a body flying at a supersonic velocity and a point explosion p 1019 A92-53867
Detonation duct gas generator demonstration program
[AIAA PAPER 92-3174] p 1066 A92-54011
DIAPHRAGMS (MECHANICS)
Double piston shock-wave valve p 1117 A92-54938
DIELECTRICS
Development of 3D electromagnetic modeling tools for airborne vehicles
[NASA-CR-190810] p 1126 N92-33307
DIFFERENCE EQUATIONS
A dynamic stiffness technique for the vibration analysis of stiffened shell structures p 1123 A92-56866
DIFFERENTIAL PRESSURE
Calibration of hemispherical-head flow angularity probes
[AIAA PAPER 92-4005] p 1122 A92-56828
DIFFUSERS
Mixed flow compressor surge margin gain using a manifolded diffuser system
[AIAA PAPER 92-3753] p 1068 A92-54151
DIFFUSION FLAMES
Theories of turbulent combustion in high speed flows
[AD-A253032] p 1111 N92-33624
Influence of the swirl producing construction in the flow and reaction field of turbulent diffusion flames
[ETN-92-92103] p 1127 N92-33916
DIFFUSION WELDING
Diffusion bonding a creep-resistant Fe-ODS alloy p 1117 A92-54868
DIGITAL COMMAND SYSTEMS
Change and reliability of the DC-9-81 digital flight guidance system p 1084 A92-56086
DIGITAL COMPUTERS
Selection of sampling rate for nonlinear flight trajectory controller of aircraft p 1084 A92-56070
Development of a conceptual design method for rotary-wing aircraft using digital computers p 1058 A92-56340
DIGITAL FILTERS
The development of an airborne information management system for flight test
[NASA-TM-104251] p 1065 N92-32866
DIGITAL SIMULATION
Rarefied gas numerical wind tunnel p 1017 A92-53552
Numerical simulations of shock reflections by a TVD scheme p 1018 A92-53558
Numerical simulation of slot injection into a turbulent supersonic stream p 1024 A92-54914
Numerical simulation of unsteady flow in a hypersonic shock tunnel facility
[AIAA PAPER 92-4029] p 1034 A92-56851
DIGITAL SYSTEMS
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
The utility of analog vertical velocity information during instrument flight with a Head-Up Display (HUD)
[AD-A252863] p 1065 N92-33277
DIMENSIONAL ANALYSIS
Out of plane analysis for composite structures p 1107 N92-32527
DIRECTIONAL SOLIDIFICATION (CRYSTALS)
Experimental study of convection effects around the phase charge interface p 1111 A92-53755
DIRECTIONAL STABILITY
High angle-of-attack control enhancement on a forward swept wing aircraft
[AIAA PAPER 92-4427] p 1080 A92-55351
DISCHARGE COEFFICIENT
A nozzle internal performance prediction method
[NASA-TP-3221] p 1040 N92-33625
DISCRETE FUNCTIONS
Discrete event fuzzy airport control p 1046 A92-55973
DISCRIMINANT ANALYSIS (STATISTICS)
Radar clutter classification
[ISBN-0-315-57981-1] p 1126 N92-33440
DISPLAY DEVICES
The C-17 Multifunction Display - A building block for avionic systems p 1063 A92-55907
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
Collaborative research on V/STOL control system/cockpit display tradeoffs under the NASA/MOD joint aeronautical program
[NASA-TM-103910] p 1087 N92-32788
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
Computational algorithms for increased control of depth-viewing volume for stereo three-dimensional graphic displays
[NASA-TM-4379] p 1065 N92-34109
DISTORTION
A numerical model for sonic boom propagation through an inhomogeneous, windy atmosphere p 1138 N92-33876
Analysis of sonic boom data to quantify distortions of shock profiles p 1139 N92-33879
DISTRIBUTED PROCESSING
Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483
DOPPLER NAVIGATION
A Kalman filter integrated navigation design for the IAR Twin Otter Atmospheric Research Aircraft
[NRC-32148] p 1048 N92-32849
DOPPLER RADAR
Modified Doppler detects wind shear more reliably p 1015 A92-55099
DRAG COEFFICIENTS
Optimal trajectories for an unmanned air-vehicle in the horizontal plane
[AIAA PAPER 92-4344] p 1079 A92-55333
Drag computation by vortex methods p 1031 A92-56161
DRAG DEVICES
Structural design and testing results of composite landing gear components p 1057 A92-56328
DRAG MEASUREMENT
Evaluation of sidewall interference in the NAL two-dimensional transonic wind tunnel p 1092 A92-56011
DRAG REDUCTION
Optimal design of wing shape by use of neural-network p 1054 A92-56112
A method for designing blended wing-body configurations for low wave drag
[NASA-TP-3261] p 1036 N92-32480
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063
Applications of a direct/iterative design method to complex transonic configurations
[NASA-TP-3234] p 1039 N92-33484
Method of reducing drag in aerodynamic systems
[NASA-CASE-LEW-14791-1] p 1043 N92-34243
DRILLING
Development of an automatic drilling system. II p 1118 A92-56107
DROP TESTS
Aerodynamic parameters of the X-31 drop model estimated from flight-data at high angles of attack
[AIAA PAPER 92-4357] p 1080 A92-55343
DROPS (LIQUIDS)
An analysis of boundary layer for droplet aerodynamic stripped in high speed gas flow p 1116 A92-54563
Experimental study of performance degradation of a rotating system in the NASA Lewis RC icing tunnel
[NASA-CR-190684] p 1102 N92-34141
DUCTED FAN ENGINES
Conception of a UHB engine simulator for the essential characteristics of a true-scale engine --- ultrahigh bypass p 1090 A92-54322
DUCTED FANS
Investigation of the flight control requirements of a half-scale ducted fan unmanned aerial vehicle
[AD-A252730] p 1087 N92-32988
DUCTED FLOW
An experimental investigation of the flow in a diffusing S-duct
[AIAA PAPER 92-3622] p 1021 A92-54090
Navier-Stokes analysis and experimental data comparison of compressible flow in a diffusing S-duct
[NASA-TM-105683] p 1072 N92-33746
DUMP COMBUSTORS
Turbulent combustion modelling in a side dump ramjet combustor
[AIAA PAPER 92-3599] p 1112 A92-54075
DUMPING
Fire bombing and fire bombers
[CA-PATENT-1-268-164] p 1061 N92-33582
DURABILITY
Supportability evaluation of thermoplastic and thermoset composites p 1108 N92-32576
Residual strength of repaired graphite/epoxy laminates after 5 years of outdoor exposure p 1108 N92-32577
DYNAMIC CONTROL
Gust response and cross wind performance of a hovercraft with vertical wings p 1118 A92-56034

Design of helicopter flight control systems for hover and low speed using eigenstructure assignment
p 1061 N92-33952
Nonlinear dynamic-inversion flight control of supermaneuverable aircraft p 1062 N92-33953
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131
Dynamics and control of a five degree-of-freedom magnetic suspension system
[NASA-CR-191259] p 1102 N92-34222

DYNAMIC MODELS
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
Dynamical scaling of a model unsteady separating flow p 1117 A92-54932
Robust identification of nonlinear aerodynamic model structure
[AIAA PAPER 92-4503] p 1081 A92-55370
Simulation of helicopter see-saw rotor motion
p 1055 A92-56287
The application of math-dynamic models to characterise a range of helicopter rotor system faults
p 1056 A92-56297
Optimal control of tiltrotor aircraft following power failure p 1085 A92-56303
The identification of coupled flapping/inflow models for hovering flight p 1058 A92-56335
Approximations for inclusion of rotor lag dynamics in helicopter flight dynamics models p 1060 A92-56354

DYNAMIC PRESSURE
An approach for increasing aeroelastic divergence dynamic pressure of wind-tunnel models
[AIAA PAPER 92-4002] p 1099 A92-56825

DYNAMIC RESPONSE
Stability and dynamic coupling of elastic vehicles with unsteady aerodynamic forces considered
p 1102 A92-53545
Gust response and cross wind performance of a hovercraft with vertical wings p 1118 A92-56034
Response of helicopter blades to a sharp collective increase p 1084 A92-56282
Research on measurement and control of helicopter rotor response using blade-mounted accelerometers 1990-91 p 1057 A92-56316
On the calculation of the response of helicopters to control inputs
[NASA-CR-190812] p 1088 N92-33536
Dynamic response of induced pressures, suckdown, and temperatures for two tandem jet STOVL configurations
[NASA-TM-103934] p 1039 N92-33581
The dynamics of flexible multibody systems: A finite segment approach p 1128 N92-34036
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter
[NASA-TM-104211] p 1042 N92-34147

DYNAMIC STABILITY
Dynamic derivative data for high angle of attack simulation
[AIAA PAPER 92-4355] p 1079 A92-55341
Gust response and cross wind performance of a hovercraft with vertical wings p 1118 A92-56034

DYNAMIC STRUCTURAL ANALYSIS
FREPS - A forced response prediction system for turbomachinery blade rows
[AIAA PAPER 92-3072] p 1130 A92-54006
Rotary wing structural dynamics and aeroelasticity --- Book
[ISBN 1-56347-031-4] p 1052 A92-54550
Getting up to speed in hypersonic structures
p 1117 A92-55127
DAMVIBS looks at rotorcraft vibration
p 1052 A92-55128
Dynamic analysis of rotor blades with root retention design variations p 1054 A92-56156
Finite-element analysis and multibody dynamics issues in rotorcraft dynamic analysis p 1055 A92-56286
Influence of cross section variations on the structural behaviour of composite rotor blades
p 1121 A92-56320
A dynamic stiffness technique for the vibration analysis of stiffened shell structures p 1123 A92-56866
Use of SEA to predict structure-borne noise in aircraft
p 1137 N92-32955
Active vibrations and noise control for turboprop application research program activities
p 1138 N92-32962
The dynamics of flexible multibody systems: A finite segment approach p 1128 N92-34036
Introduction to Flutter of Winged Aircraft, volume 2
[VKI-LS-1992-01-VOL-2] p 1088 N92-34161
Elementary flutter analysis p 1088 N92-34162
Aeroelasticity of bluff bodies p 1089 N92-34165

DYNAMIC TESTS
Preliminary dynamic tests of a flight-type ejector
[AIAA PAPER 92-3261] p 1066 A92-54020
On improvements of three-dimensional position measuring system for dynamic wind tunnel testing
p 1093 A92-56012

DYNAMICAL SYSTEMS
A general approach to optimal real-time guidance of dynamic systems based on nonlinear programming
[AIAA PAPER 92-4378] p 1131 A92-55182

E

EAR
Exposures from headset interference tones
[AD-A247175] p 1136 N92-32697

EARPHONES
Exposures from headset interference tones
[AD-A247175] p 1136 N92-32697

EARTH ATMOSPHERE
Flowpath and sensitivity analyses of high speed propulsion systems
[AIAA PAPER 92-3806] p 1069 A92-54178

EARTH ORBITAL ENVIRONMENTS
HOPE re-entry experimental vehicle
p 1103 A92-55098

EARTH ORBITS
Issues in developing control zones for international space operations p 1141 A92-56602

EARTH SCIENCES
Research and technology, 1990
[NASA-TM-107967] p 1143 N92-33948

EARTH TERMINALS
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG
p 1050 N92-33356

ECONOMIC ANALYSIS
Cost/benefit analysis of the AH-64 (Apache) helicopter Automated Test Equipment (ATE)
[AD-A252909] p 1101 N92-33398

EDDY CURRENTS
Inspection of fabricated fuselage panels using electronic shearography
[DOT/FAA/CT-TN92/26] p 1127 N92-33627

EDUCATION
Improvements in teaching aircraft engine design
[AIAA PAPER 92-3758] p 1141 A92-54152
Applications of robust control theory - Educational implications
[AIAA PAPER 92-4559] p 1131 A92-55271
Aerodynamics laboratory education at Purdue University - Ground testing facilities
[AIAA PAPER 92-4018] p 1100 A92-56840
The trisonic wind tunnel Muenchen and its involvement in the German SAeNGER-programme
[AIAA PAPER 92-4019] p 1100 A92-56841
Development and integration of modern laboratories in aerospace education
[AIAA PAPER 92-4022] p 1141 A92-56844

EFFECTS
Effects of bleed air extraction of thrust levels on the F404-GE-400 turbofan engine
[AIAA PAPER 92-3092] p 1066 A92-54009

EIGENVALUES
Aeroelastic modal characteristics of mistuned blade assemblies - Mode localization and loss of eigenstructure p 1117 A92-54921
Design of helicopter flight control systems for hover and low speed using eigenstructure assignment
p 1061 N92-33952

EIGENVECTORS
Robust sampled data eigenstructure assignment using the delta operator
[AIAA PAPER 92-4400] p 1075 A92-55200
Design of helicopter flight control systems for hover and low speed using eigenstructure assignment
p 1061 N92-33952

EJECTORS
Preliminary dynamic tests of a flight-type ejector
[AIAA PAPER 92-3261] p 1066 A92-54020
Experimental investigation of an ejector-powered free-jet facility
[AIAA PAPER 92-3569] p 1090 A92-54058
Flow induction by pressure forces
[AIAA PAPER 92-3571] p 1067 A92-54060
Use of an approximate similarity principle for the thermal scaling of a full-scale thrust augmenting ejector
[AIAA PAPER 92-3792] p 1069 A92-54171

ELASTIC BODIES
Stability and dynamic coupling of elastic vehicles with unsteady aerodynamic forces considered
p 1102 A92-53545

ELASTIC DAMPING
Safety provision against 'ground resonance' free vibration of a coaxial helicopter p 1056 A92-56289

ELASTIC DEFORMATION
An integrated development of the equations of motion for elastic hypersonic flight vehicles
[AIAA PAPER 92-4605] p 1077 A92-55283

ELASTIC PROPERTIES
Oscillations of an anisotropic rotor on an elastic anisotropic support p 1057 A92-56311
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-34019

ELECTRIC DISCHARGES
Mechanisms of high-current pulses in lightning and long-spark stepped leaders p 1116 A92-54678

ELECTRIC EQUIPMENT TESTS
Automatic function testing in the aircraft production
p 1015 A92-56083

ELECTRIC GENERATORS
Design of the Boeing 777 electric system
p 1070 A92-55902

ELECTRIC POWER SUPPLIES
Design of the Boeing 777 electric system
p 1070 A92-55902

ELECTRICAL FAULTS
Optimal control of helicopters following power failure
[AIAA PAPER 92-4471] p 1076 A92-55231
Optimal control of tiltrotor aircraft following power failure p 1085 A92-56303

ELECTRO-OPTICS
Electro optical system to measure strains at high temperature
[NASA-CR-190450] p 1127 N92-33696

ELECTROLYTES
Evaluation of electrolytic tilt sensors for wind tunnel model angle-of-attack (AOA) measurements
p 1116 A92-54344

ELECTROMAGNETIC INTERFERENCE
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778

ELECTROMAGNETIC NOISE
Feasibility of measuring transverse electric noise at VLF and LF on an ice cap
[AD-A252280] p 1129 N92-33220

ELECTRONIC EQUIPMENT
Application of electronically scanned pressure measurement system for engine simulation tests in the German-Dutch Wind Tunnel
[AIAA PAPER 92-4003] p 1122 A92-56826

ELECTRONIC EQUIPMENT TESTS
Field test of an advanced maintenance-system
p 1016 A92-56221
A module-level testing environment for safety-critical software systems p 1132 A92-56293
Cost/benefit analysis of the AH-64 (Apache) helicopter Automated Test Equipment (ATE)
[AD-A252909] p 1101 N92-33398

ELECTRONIC TRANSDUCERS
The use of silicon microsensors in smart skins for aerodynamic research p 1116 A92-54348

END PLATES
Contribution of tailplane-mounted twin fins to sideforce, yawing moment, and rolling moment derivatives due to sideslip
[ESDU-92007] p 1086 N92-32487

ENERGY CONVERSION
DoD key technologies plan
[AD-A253692] p 1142 N92-33238

ENERGY METHODS
Further studies of kinetic energy methods in high speed ramjet cycle analysis
[AIAA PAPER 92-3805] p 1069 A92-54177
Use of SEA to predict structure-borne noise in aircraft
p 1137 N92-32955

ENERGY STORAGE
DoD key technologies plan
[AD-A253692] p 1142 N92-33238

ENERGY TRANSFER
Rarefied gas research at Berkeley - Current studies and future potentials
[AIAA PAPER 92-3971] p 1098 A92-56797

ENGINE AIRFRAME INTEGRATION
Propulsion system performance resulting from an Integrated Flight/Propulsion Control design
[AIAA PAPER 92-4602] p 1069 A92-55281
Analysis of airframe/engine interactions for a STOVL aircraft with integrated flight/propulsion control
[AIAA PAPER 92-4623] p 1052 A92-55300
Flight simulation modeling in support of engine/airframe integration p 1055 A92-56279
Test description and preliminary pitot-pressure surveys for Langley Test Technique Demonstrator at Mach 6
[AIAA PAPER 92-3940] p 1096 A92-56770
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[NASA-TM-105672] p 1128 N92-34112

ENGINE CONTROL
In-flight optimization of the total propulsion system [AIAA PAPER 92-3744] p 1068 A92-54146
In-flight performance diagnostic capability of an adaptive engine model [AIAA PAPER 92-3746] p 1068 A92-54147
Propulsion system performance resulting from an Integrated Flight/Propulsion Control design [AIAA PAPER 92-4602] p 1069 A92-55281
Flight simulation modeling in support of engine/airframe integration p 1055 A92-56279
Piloted evaluation of an integrated propulsion and flight control simulator [NASA-TM-105797] p 1088 N92-34107
ENGINE DESIGN
The VRT gas turbine combustor - Phase II [AIAA PAPER 92-3471] p 1067 A92-54035
The study of experimental turboramjets [AIAA PAPER 92-3720] p 1067 A92-54135
Improvements in teaching aircraft engine design [AIAA PAPER 92-3758] p 1141 A92-54152
Development of ITS90 small gas turbine engine p 1070 A92-55500
'A new proposal for an old problem' - The right engine for the right helicopter p 1070 A92-56281
V-22 propulsion system design p 1070 A92-56300
Description of a pressure measurement technique for obtaining surface static pressures of a radial turbine [AIAA PAPER 92-4006] p 1123 A92-56829
Re-engining for real stage 3 compliance [PNR-90872] p 1072 N92-33748
The Rolls-Royce Trent [PNR-90875] p 1061 N92-33750
A graphical user-interface for propulsion system analysis [NASA-TM-105696] p 1134 N92-33894
ENGINE FAILURE
Optimal control of helicopters following power failure [AIAA PAPER 92-4471] p 1076 A92-55231
A simulation model for tail rotor failure [AIAA PAPER 92-4633] p 1081 A92-55380
The advantages of digital engine control as compared with traditional systems (hydraulic or pneumatic) p 1070 A92-56338
Smoothing CFM56 engine removal rate at USAir [AIAA PAPER 92-3928] p 1070 A92-56759
Bird ingestion into large turbofan engines [DOT/FAA/CT-91/17] p 1043 N92-33005
Statistics on aircraft gas turbine engine rotor failures that occurred in US commercial aviation during 1988 [DOT/FAA/CT-91/28] p 1071 N92-33105
ENGINE INLETS
Flow measurements in scramjet inlets p 1102 A92-53565
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion [AIAA PAPER 92-3177] p 1020 A92-54013
Results of a perturbation analysis correlating flows entering and exiting an aircraft inlet system [AIAA PAPER 92-3624] p 1021 A92-54091
Comparison between computational and experimental data for a hypersonic laser propelled vehicle [AIAA PAPER 92-3808] p 1023 A92-54179
Development and validation of a freejet technique for inlet-engine compatibility testing [AIAA PAPER 92-3921] p 1033 A92-56752
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion [NASA-TM-105672] p 1128 N92-34112
ENGINE MONITORING INSTRUMENTS
In-flight performance diagnostic capability of an adaptive engine model [AIAA PAPER 92-3746] p 1068 A92-54147
Engine condition monitoring system for B747-400 p 1064 A92-56082
Smoothing CFM56 engine removal rate at USAir [AIAA PAPER 92-3928] p 1070 A92-56759
ENGINE NOISE
The interaction between a high-frequency gust and a blade row p 1135 A92-54484
Experimental study of noise generation and propagation in a turbofan model p 1136 A92-56169
MD-80 aft cabin noise control: A case history p 1137 N92-32950
ENGINE PARTS
Performance analysis of idealized scramjet p 1066 A92-53493
Current repair technologies for jet engine components p 1016 A92-56085
Smoothing CFM56 engine removal rate at USAir [AIAA PAPER 92-3928] p 1070 A92-56759
Turbine engine hot-part temperature measurement techniques [AIAA PAPER 92-3960] p 1122 A92-56788
Advanced nozzle and engine components test facility [AIAA PAPER 92-3993] p 1099 A92-56816
Engine component instrumentation development facility at NASA Lewis Research Center [AIAA PAPER 92-3995] p 1099 A92-56818
Description of a pressure measurement technique for obtaining surface static pressures of a radial turbine [AIAA PAPER 92-4006] p 1123 A92-56829
Life prediction and constitutive models for engine hot section anisotropic materials program [NASA-CR-189223] p 1072 N92-33479
ENGINE TESTING LABORATORIES
A conceptual study for future engine test facility [AIAA PAPER 92-3992] p 1099 A92-56815
ENGINE TESTS
A comparison of the calculated and experimental off-design performance of a radial flow turbine [AIAA PAPER 92-3069] p 1020 A92-54004
Effects of bleed air extraction of thrust levels on the F404-GE-400 turbofan engine [AIAA PAPER 92-3092] p 1066 A92-54009
The study of experimental turboramjets [AIAA PAPER 92-3720] p 1067 A92-54135
Conception of a UHB engine simulator for the essential characteristics of a true-scale engine --- ultrahigh bypass p 1090 A92-54322
Development of local nonintrusive measurements of inlet and exhaust flows for the ground testing of air-breathing engines [AIAA PAPER 92-3899] p 1122 A92-56735
Test data models to characterize turbine engine operation in altitude test facilities [AIAA PAPER 92-3917] p 1095 A92-56749
Development and validation of a freejet technique for inlet-engine compatibility testing [AIAA PAPER 92-3921] p 1033 A92-56752
Thrust stand design principles [AIAA PAPER 92-3976] p 1098 A92-56802
Turbine engine performance test and evaluation techniques [AIAA PAPER 92-3977] p 1071 A92-56803
A model study on diffuser pressure recovery in NAL scramjet test facility with simulated hydrogen combustion [AIAA PAPER 92-3979] p 1071 A92-56805
Small engine components test facility compressor testing cell at NASA Lewis Research Center [AIAA PAPER 92-3980] p 1098 A92-56806
Engine component instrumentation development facility at NASA Lewis Research Center [AIAA PAPER 92-3995] p 1099 A92-56818
Application of electronically scanned pressure measurement system for engine simulation tests in the German-Dutch Wind Tunnel [AIAA PAPER 92-4003] p 1122 A92-56826
Tests results on Air Turbo Ramjet for a future space plane [IAF PAPER 92-0657] p 1071 A92-57098
ENTHALPY
The high enthalpy shock tunnel in Goettingen [AIAA PAPER 92-3942] p 1104 A92-56772
Perspectives on hypersonic viscous and nonequilibrium flow research [NASA-CR-190817] p 1039 N92-33413
ENVIRONMENT EFFECTS
Fluid effects: Thermoset and thermoplastic matrix composites p 1110 N92-33049
Flight service environmental effects on composite materials and structures p 1110 N92-33054
The impact of air transport on the environment [PNR-90876] p 1129 N92-33751
ENVIRONMENT POLLUTION
The impact of air transport on the environment [PNR-90876] p 1129 N92-33751
ENVIRONMENT SIMULATION
Effect of a simulated glaze ice shape on the aerodynamic performance of a rectangular wing [AIAA PAPER 92-4042] p 1035 A92-56861
ENVIRONMENTAL TESTS
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575
Residual strength of repaired graphite/epoxy laminates after 5 years of outdoor exposure p 1108 N92-32577
Evaluation of the effects of the environment on the behavior of the primary structures of composite material aircraft in service: Historic and current situation p 1110 N92-33048
EPHEMERIDES
GPS orbit determination at the National Geodetic Survey p 1049 N92-33354
Precise GPS ephemerides from DMA and NGS tested by time transfer p 1049 N92-33355
EPOXY MATRIX COMPOSITES
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
Processing and environmental effects on mechanical properties of composite repairs [NRC-LTR-ST-1826] p 1109 N92-32791
EQUATIONS OF MOTION
Modal simulation of gearbox vibration with experimental correlation [AIAA PAPER 92-3494] p 1112 A92-54036
Effect of atmospheric disturbances on airplane response [AIAA PAPER 92-4340] p 1078 A92-55329
Robust identification of nonlinear aerodynamic model structure [AIAA PAPER 92-4503] p 1081 A92-55370
Flutter analyses using high speed computers. Part 1: Flutter analyses for large aircraft p 1089 N92-34168
EQUIPMENT SPECIFICATIONS
Cost/benefit analysis of the AH-64 (Apache) helicopter Automated Test Equipment (ATE) [AD-A252909] p 1101 N92-33398
ERROR ANALYSIS
A Kalman filter integrated navigation design for the IAR Twin Otter Atmospheric Research Aircraft [NRC-32148] p 1048 N92-32849
A review and discussion of flight management system incidents reported to the aviation safety reporting system [AD-A252438] p 1043 N92-32941
ESTIMATING
An investigation of switched reluctance rotor position estimation using neural networks [AD-A252846] p 1061 N92-33414
EULER EQUATIONS OF MOTION
Unsteady blade pressures on a propfan - Predicted and measured compressibility effects [AIAA PAPER 92-3774] p 1023 A92-54161
Numerical simulation of supersonic unsteady flow using a panel method p 1030 A92-56048
Improved calculation of transonic potential flow past swept wings p 1031 A92-56179
Sound produced by vortex-airfoil interaction p 1136 A92-56345
EULER-LAGRANGE EQUATION
Estimation of aircraft inertial characteristics using maximum likelihood estimation p 1084 A92-56057
EXHAUST EMISSION
Applied analytical combustion/emissions research at the NASA Lewis Research Center - A progress report [AIAA PAPER 92-3338] p 1067 A92-54025
Development of local nonintrusive measurements of inlet and exhaust flows for the ground testing of air-breathing engines [AIAA PAPER 92-3899] p 1122 A92-56735
The impact of air transport on the environment [PNR-90876] p 1129 N92-33751
EXHAUST GASES
Degenerate four-wave mixing for measurement of NO2 and smoke concentration in jet engine exhaust [AIAA PAPER 92-3658] p 1113 A92-54108
Smoothing CFM56 engine removal rate at USAir [AIAA PAPER 92-3928] p 1070 A92-56759
EXHAUST NOZZLES
Preliminary dynamic tests of a flight-type ejector [AIAA PAPER 92-3261] p 1066 A92-54020
Experimental performance of three design factors for ventral nozzles for SSTOVL aircraft [AIAA PAPER 92-3789] p 1069 A92-54168
EXHAUST SYSTEMS
Internal reversing flow in a tailpipe offtake configuration for SSTOVL aircraft [AIAA PAPER 92-3790] p 1069 A92-54169
Advanced nozzle and engine components test facility [AIAA PAPER 92-3993] p 1099 A92-56816
EXPERT SYSTEMS
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
Discrete event fuzzy airport control p 1046 A92-55973
Flight simulator test of cockpit advisory system p 1054 A92-56115
Field test of an advanced maintenance-system p 1016 A92-56221
Advanced software development workstation: Effectiveness of constraint-checking --- spaceflight simulation and planning [NASA-CR-190712] p 1134 N92-32865
EXPOSURE
Residual strength of repaired graphite/epoxy laminates after 5 years of outdoor exposure p 1108 N92-32577
Fluid effects: Thermoset and thermoplastic matrix composites p 1110 N92-33049
EXTERNAL STORES
Computations of the unsteady flow about a generic wing/pylon/finned-store configuration [AIAA PAPER 92-4568] p 1027 A92-55377
EXTINCTION
Theories of turbulent combustion in high speed flows [AD-A253032] p 1111 N92-33624

F

F-117A AIRCRAFT
Flight management system of the F-117A
p 1082 A92-55910

F-14 AIRCRAFT
Implementation of a personal computer based parameter estimation program
[AD-A252914] p 1061 N92-33502

F-15 AIRCRAFT
Flight testing and simulation of an F-15 airplane using throttles for flight control
[NASA-TM-104255] p 1087 N92-32864

F-18 AIRCRAFT
Full Navier-Stokes calculations on the installed F/A-18 inlet at a high angle of attack
[AIAA PAPER 92-3175] p 1020 A92-54012
Structural assessment of ultralightweight composites
p 1107 N92-32525
The F-18 high alpha research vehicle: A high-angle-of-attack testbed aircraft
[NASA-TM-104253] p 1060 N92-33404
Experience with Ada on the F-18 High Alpha Research Vehicle Flight Test Program
[NASA-TM-104259] p 1062 N92-34039

FABRICATION
Fabrication test and evaluation of graphite/PMR-15 polyimide for HOPE primary structure
p 1105 A92-53516
Design, evaluation and experimental effort toward development of a high strain composite wing for Navy aircraft p 1107 N92-32514
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575
High temperature aircraft research furnace facilities
[NASA-CR-184384] p 1101 N92-33826

FAILURE
Out of plane analysis for composite structures
p 1107 N92-32527

FAILURE ANALYSIS
The application of math-dynamic models to characterise a range of helicopter rotor system faults
p 1056 A92-56297
Damage tolerance analysis for rotorcraft - What the issues are p 1058 A92-56336
Damage tolerant design of critical aircraft structural components
[AIAA PAPER 92-4041] p 1123 A92-56860
Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483
Joint study on the computerisation of in-field aero engines vibration diagnosis
[PNR-90799] p 1072 N92-33815
Stability failure of sandwich structures
[MBB-UD-0613-92-PUB] p 1111 N92-33994

FAILURE MODES
Redundancy design philosophy for catastrophic loss protection p 1119 A92-56202
The Utilization of Advanced Composites in Military Aircraft
[AGARD-R-785] p 1109 N92-33033
Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483
Stability failure of sandwich structures
[MBB-UD-0613-92-PUB] p 1111 N92-33994

FATIGUE (MATERIALS)
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-34019

FATIGUE LIFE
Fatigue cracking threshold prediction of transport airplanes p 1118 A92-56094
Damage tolerance analysis for rotorcraft - What the issues are p 1058 A92-56336

FATIGUE TESTS
Effects of spectrum variations on fatigue crack growth
p 1123 A92-57399

FAULT TOLERANCE
Modular techniques for dynamic fault-tree analysis
p 1120 A92-56241
Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483
Distributed systems: Interconnection and fault tolerance studies
[AD-A252869] p 1135 N92-33920

FAULT TREES
Modular techniques for dynamic fault-tree analysis
p 1120 A92-56241

FEASIBILITY ANALYSIS
Study on international cooperative test facilities for future SST/HST
[AIAA PAPER 92-3945] p 1097 A92-56775
Vision-based range estimation using helicopter flight data
[NASA-TM-103930] p 1047 N92-32424

FEDERAL BUDGETS
Departments of Veterans Affairs and Housing and Urban Development, and independent agencies appropriations for 1993, part 6
[GAO-55-636-PT-6] p 1141 N92-32505

FEEDBACK CONTROL
Identification and control of aircraft dynamics using radial basis function neural networks
[AIAA PAPER 92-4393] p 1074 A92-55194
Robust sampled data eigenstructure assignment using the delta operator
[AIAA PAPER 92-4400] p 1075 A92-55200
Design of robust Quantitative Feedback Theory controllers for pitch attitude hold systems
[AIAA PAPER 92-4409] p 1075 A92-55203
Invertibility and trajectory control for nonlinear maneuvers of aircraft
[AIAA PAPER 92-4410] p 1075 A92-55204
An algorithm for robust eigenstructure assignment using the Linear Quadratic Regulator
[AIAA PAPER 92-4478] p 1131 A92-55237
An framework for robust flight control design using constrained optimization
[AIAA PAPER 92-4603] p 1131 A92-55282
Robust control design of an automatic carrier landing system
[AIAA PAPER 92-4619] p 1077 A92-55296
Nonlinear model-following control application to airplane control (1992 AIAA Controls Design Challenge)
[AIAA PAPER 92-4625] p 1077 A92-55302
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
Multiple delay model approach applied to the AIAA 1922 Controls Design Challenge
[AIAA PAPER 92-4630] p 1078 A92-55305
A guidance law for hypersonic descent to a point
[AIAA PAPER 92-4303] p 1104 A92-55311
Numerical simulations of flutter and its suppression by active control
[AIAA PAPER 92-4652] p 1082 A92-55396
An identification procedure for a system with a choice of feedback structures p 1132 A92-55426
Robust control system design with multiple model approach p 1083 A92-56029
MIMO state-feedback control system considering phase stability by -90 deg phase-locus method
p 1084 A92-56066
Design of a flight control system using a feedback-error-learning-type neural network
p 1132 A92-56067
Control of large cryogenic tunnels
[AIAA PAPER 92-3930] p 1096 A92-56761
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
Design of helicopter flight control systems for hover and low speed using eigenstructure assignment
p 1061 N92-33952

FIBER COMPOSITES
Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, part 1
[NASA-CP-3087-PT-1] p 1106 N92-32513
Design, evaluation and experimental effort toward development of a high strain composite wing for Navy aircraft p 1107 N92-32514
Development of thermoplastic components for structural validation p 1107 N92-32522
Damage tolerance certification methodology for composite structures p 1108 N92-32579
Initial postbuckling response of an unsymmetrically laminated rectangular plate p 1108 N92-32586
Jet fuel absorption and dynamic mechanical analysis of carbon fibre composites p 1110 N92-33050
Advanced airframe structural materials: A primer and cost estimating methodology
[AD-A253371] p 1062 N92-34182

FIBER OPTICS
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778

FIBER ORIENTATION
Continuation of tailored composite structures of ordered staple thermoplastic material
[NASA-CR-189671] p 1110 N92-33613

FIELD OF VIEW
Computational algorithms for increased control of depth-viewing volume for stereo three-dimensional graphic displays
[NASA-TM-4379] p 1065 N92-34109

FIGHTER AIRCRAFT
Results of a perturbation analysis correlating flows entering and exiting an aircraft inlet system
[AIAA PAPER 92-3624] p 1021 A92-54091
In-flight optimization of the total propulsion system
[AIAA PAPER 92-3744] p 1068 A92-54146
Mikoyan's market-buster p 1052 A92-54981
Flight control law synthesis using neural network theory
[AIAA PAPER 92-4390] p 1074 A92-55191
A fuzzy logic based F/A-18 automatic carrier landing system
[AIAA PAPER 92-4392] p 1074 A92-55193
The flow field characteristics about a fighter configuration at high angles of attack
[AIAA PAPER 92-4358] p 1025 A92-55344
Pulsating spanwise blowing on a fighter aircraft
[AIAA PAPER 92-4359] p 1025 A92-55345
Analytical development of an equivalent system mismatch function
[AIAA PAPER 92-4422] p 1080 A92-55346
Understanding and development of a prediction method of transonic limit cycle oscillation characteristics of fighter aircraft
[AIAA PAPER 92-4501] p 1026 A92-55369
Optimization of composite material wing of fighter type aircrafts p 1053 A92-56018
Design of a flight control system using a feedback-error-learning-type neural network
p 1132 A92-56067
Euler/experiment correlation of a generic fighter
p 1031 A92-56164
Development and validation of a freejet technique for inlet-engine compatibility testing
[AIAA PAPER 92-3921] p 1033 A92-56752
A learning enhanced flight control system for high performance aircraft
[AD-A252520] p 1086 N92-32435
Aspects of compression in aerospace composites: Future requirements p 1109 N92-33036
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
Effect of afterbody geometry on aerodynamic characteristics of isolated nonaxisymmetric afterbodies at transonic Mach numbers
[NASA-TP-3236] p 1041 N92-33706

FILM COOLING
Experimental modeling of film-cooled axial turbine tip seals
[AIAA PAPER 92-4058] p 1119 A92-56141

FINITE DIFFERENCE THEORY
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
Motion analysis of 2-dimensional flat plate in ground effect p 1030 A92-56053
Computation and stability analysis of laminar flow over a blunt cone in hypersonic flow p 1041 N92-33839
Finite difference time domain grid generation from AMC helicopter models
[NASA-TM-107679] p 1128 N92-34017

FINITE ELEMENT METHOD
Finite-element analysis and multibody dynamics issues in rotorcraft dynamic analysis p 1055 A92-56286
A finite element method for shear stresses calculation in composite blade models p 1121 A92-56322
Transverse shear effect on flutter of composite panels
p 1122 A92-56607
Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, part 1
[NASA-CP-3087-PT-1] p 1106 N92-32513
Vibro-acoustic FE analyses of the Saab 2000 aircraft
p 1137 N92-32952
Computational methods for global/local analysis
[NASA-TM-107591] p 1125 N92-33104
Computational aspects of helicopter trim analysis and damping levels from Floquet theory
[NASA-CR-190736] p 1087 N92-33107
Development of 3D electromagnetic modeling tools for airborne vehicles
[NASA-CR-190810] p 1126 N92-33307
Stability failure of sandwich structures
[MBB-UD-0613-92-PUB] p 1111 N92-33994
Effects of constraint on crack growth under aircraft spectrum loading
[NASA-TM-107677] p 1128 N92-34178

FINITE VOLUME METHOD
A finite-volume numerical method to calculate fluid forces and rotordynamic coefficients in seals
[AIAA PAPER 92-3712] p 1113 A92-54132
Approximate Riemann solver for hypervelocity flows
p 1117 A92-54934
Euler/experiment correlation of a generic fighter
p 1031 A92-56164

FINNED BODIES
Computations of the unsteady flow about a generic wing/pylon/finned-store configuration
[AIAA PAPER 92-4568] p 1027 A92-55377

FINS
A low speed wind tunnel investigation of a joined-wing aircraft with an overhanging fin p 1030 A92-56078
A low speed wind tunnel investigation of the direct side force control of a joined-wing aircraft with overhanging fin p 1084 A92-56079
Assessment of calculation methods for efficiency of straight fins of rectangular profile p 1121 A92-56374
Contribution of tailplane-mounted twin fins to sideforce, yawing moment, and rolling moment derivatives due to sideslip
[ESDU-92007] p 1086 N92-32487
FIRE CONTROL
Airborne experimental FLIR program p 1064 N92-32447
FIRE EXTINGUISHERS
Spray nozzle for fire control
[CA-PATENT-APPL-SN-2-011-94] p 1125 N92-32856
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301
[AD-A252912] p 1126 N92-33501
FIRE FIGHTING
Spray nozzle for fire control
[CA-PATENT-APPL-SN-2-011-94] p 1125 N92-32856
FIRE PREVENTION
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301
[AD-A252912] p 1126 N92-33501
FIRES
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301
[AD-A252912] p 1126 N92-33501
FIXED WINGS
Numerical investigation of the effects of icing on fixed and rotary wing aircraft
[NASA-CR-190542] p 1044 N92-34105
FLAPPING
Measurements of blade flapping motion on a wind tunnel model p 1093 A92-56023
The identification of coupled flapping/inflow models for hovering flight p 1058 A92-56335
FLAPS (CONTROL SURFACES)
Lift and rolling moment due to spoilers on wings with trailing-edge flaps deflected at subsonic speeds
[ESDU-92002-SUPPL] p 1037 N92-32782
FLAT PLATES
Heat transfer measurements and CFD comparison of swept shock wave/boundary-layer interactions
[AIAA PAPER 92-3665] p 1021 A92-54110
Swept shock/boundary layer interaction experiments in support of CFD code validation
[NASA-CR-190583] p 1036 N92-32494
Leading-edge receptivity for blunt-nose bodies
[NASA-CR-190563] p 1036 N92-32648
Vortex flow visualization using colored and fluorescent dyes on flat plate delta wing with leading edge extension
[AD-A251139] p 1036 N92-32651
FLEXIBILITY
Planning method of skirt systems for small ACVs p 1118 A92-56038
FLEXIBLE BODIES
New literal approximations for the longitudinal dynamic characteristics of flexible flight vehicles
[AIAA PAPER 92-4411] p 1075 A92-55205
The dynamics of flexible multibody systems: A finite *segment approach* *p 1128 N92-34036*
FLEXIBLE SPACECRAFT
Applications of robust control theory - Educational implications
[AIAA PAPER 92-4559] p 1131 A92-55271
FLEXIBLE WINGS
Generalized aerodynamics analysis by the boundary element method p 1030 A92-56050
Unsteady shock-vortex interaction on a flexible delta wing p 1030 A92-56157
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
FLIGHT CHARACTERISTICS
Continuous flying quality improvement - The measure and the payoff
[AIAA PAPER 92-4327] p 1073 A92-55171
Analytical development of an equivalent system mismatch function
[AIAA PAPER 92-4422] p 1080 A92-55346
Flight test results using a low order equivalent systems technique to estimate flying qualities
[AIAA PAPER 92-4425] p 1080 A92-55349
A background to the handling qualities of aircraft
[ESDU-92006] p 1087 N92-32780
Analysis of the flight performance of the 155 mm M864 base burn projectile
[BRL-TR-3083] p 1041 N92-33699
FLIGHT CONDITIONS
User's manual for AeroFcn: A FORTRAN program to compute aerodynamic parameters
[NASA-TM-104237] p 1133 N92-32507
FLIGHT CONTROL
Improvement of atmospheric flight performance of a space vehicle through H infinity-control theory p 1130 A92-53785
Effects of bleed air extraction of thrust levels on the F404-GE-400 turbofan engine
[AIAA PAPER 92-3092] p 1066 A92-54009
Development of the full-envelope Performance Seeking Control algorithm
[AIAA PAPER 92-3748] *p 1068 A92-54148*
Performance benefits of adaptive in-flight propulsion system optimization
[AIAA PAPER 92-3749] p 1068 A92-54149
Preliminary assessment of the robustness of dynamic inversion based flight control laws
[AIAA PAPER 92-4330] p 1074 A92-55174
Flight control law synthesis using neural network theory
[AIAA PAPER 92-4390] p 1074 A92-55191
Flight-determined stability analysis of multiple-input-multiple-output control systems
[AIAA PAPER 92-4396] p 1074 A92-55196
Robustness of a helicopter flight control system designed using eigenstructure assignment
[AIAA PAPER 92-4469] p 1076 A92-55229
Constrained control allocation
[AIAA PAPER 92-4550] p 1131 A92-55262
Applications of robust control theory - Educational implications
[AIAA PAPER 92-4559] p 1131 A92-55271
Enlisting industry support for a flight controls design lab
[AIAA PAPER 92-4560] p 1141 A92-55272
E-6 flutter investigation and experience
[AIAA PAPER 92-4601] p 1077 A92-55280
An framework for robust flight control design using constrained optimization
[AIAA PAPER 92-4603] p 1131 A92-55282
Automated procedures for aircraft aeroservoelastic compensation
[AIAA PAPER 92-4606] p 1077 A92-55284
Analysis of airframe/engine interactions for a STOVL aircraft with integrated flight/propulsion control
[AIAA PAPER 92-4623] p 1052 A92-55300
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
Computer aided evaluation of aircraft handling qualities and flight control system robustness
[AIAA PAPER 92-4423] p 1080 A92-55347
Flight simulator fidelity assessment in a rotorcraft lateral translation maneuver
[AIAA PAPER 92-4424] p 1092 A92-55348
Robust identification of nonlinear aerodynamic model structure
[AIAA PAPER 92-4503] p 1081 A92-55370
C-17 flight control system overview p 1082 A92-55906
On-line identification and control of linearized aircraft dynamics p 1082 A92-55911
Multiaxis control in longitudinal mode of aircraft p 1083 A92-56027
A320 flight control from the pilot's point of view p 1083 A92-56028
Flight control system design using H(infinity) optimal control p 1083 A92-56030
MIMO state-feedback control system considering phase stability by -90 deg phase-locus method p 1084 A92-56066
Design of a flight control system using a feedback-error-learning-type neural network p 1132 A92-56067
Application of restructurable flight control system using nonlinear control to an airliner p 1084 A92-56068
Piloted simulation for the BK117 FBW demonstrator p 1053 A92-56077
An experimental study on variable pressure hydraulic flight control system p 1084 A92-56119
Redundancy design philosophy for catastrophic loss protection p 1119 A92-56202
Field test of an advanced maintenance-system p 1016 A92-56221
Creation of a living specification for an experimental helicopter active flight control system through incremental simulation p 1057 A92-56312
Helicopter nonlinear flight control system development p 1085 A92-56317
A study of helicopter rotor/fuselage response in low-speed manoeuvres - Comparison of theory with flight p 1086 A92-56334
Issues in developing control zones for international *space operations* *p 1141 A92-56602*
A learning enhanced flight control system for high performance aircraft
[AD-A252520] p 1086 N92-32435
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
Collaborative research on V/STOL control system/cockpit display tradeoffs under the NASA/MOD joint aeronautical program
[NASA-TM-103910] p 1087 N92-32788
An evaluation of decelerating IFR approaches utilizing a helicopter flight simulator
[CTN-92-60348] p 1048 N92-32845
Flight testing and simulation of an F-15 airplane using throttles for flight control
[NASA-TM-104255] p 1087 N92-32864
Investigation of the flight control requirements of a half-scale ducted fan unmanned aerial vehicle
[AD-A252730] p 1087 N92-32988
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
The F-18 high alpha research vehicle: A high-angle-of-attack testbed aircraft
[NASA-TM-104253] p 1060 N92-33404
Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483
A workstation-based evaluation of a far-field route planner for helicopters
[NASA-TM-102882] p 1051 N92-33609
Design of helicopter flight control systems for hover and low speed using eigenstructure assignment p 1061 N92-33952
Nonlinear dynamic-inversion flight control of supermaneuverable aircraft p 1062 N92-33953
Experience with Ada on the F-18 High Alpha Research Vehicle Flight Test Program
[NASA-TM-104259] p 1062 N92-34039
Piloted evaluation of an integrated propulsion and flight control simulator
[NASA-TM-105797] p 1088 N92-34107
FLIGHT CREWS
Using the simulation modeling method to estimate the reliability of the crew-flight vehicle system p 1133 A92-57444
An experimental study of organismic principles of the functioning of the crew-transport aircraft system p 1133 A92-57446
A review and discussion of flight management system incidents reported to the aviation safety reporting system
[AD-A252438] p 1043 N92-32941
Development of rating instruments and procedures for aviation mishap investigation
[AD-A253072] *p 1044 N92-33288*
Workshop on Aeronautical Decision Making (ADM). Volume 1: Executive summary
[DOT/FAA/RD-92/14-VOL-1] p 1142 N92-33305
FLIGHT ENVELOPES
Development of the full-envelope Performance Seeking Control algorithm
[AIAA PAPER 92-3748] p 1068 A92-54148
Gain scheduled linear PID autopilot for the AIAA Controls Design Challenge aircraft
[AIAA PAPER 92-4629] p 1078 A92-55304
FLIGHT HAZARDS
Modified Doppler detects wind shear more reliably p 1015 A92-55099
Escape strategies for turboprop aircraft in microburst windshear p 1084 A92-56151
FLIGHT INSTRUMENTS
The utility of analog vertical velocity information during instrument flight with a Head-Up Display (HUD)
[AD-A252863] p 1065 N92-33277
FLIGHT MANAGEMENT SYSTEMS
Flight management system of the F-117A p 1082 A92-55910
A review and discussion of flight management system incidents reported to the aviation safety reporting system
[AD-A252438] p 1043 N92-32941
CTAS: Computer intelligence for air traffic control in the terminal area
[NASA-TM-103959] p 1044 N92-33080
FLIGHT MECHANICS
AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pts. 1-2 p 1078 A92-55326
Analysis of spacecraft entry into Mars atmosphere p 1105 N92-33763
FLIGHT OPERATIONS
Development of new flight procedures for the Microwave Landing System (MLS)
[NLR-TP-91156-U] p 1047 N92-32830
Federal aviation regulations. Part 91: General operating and flight rules
[PB92-197334] p 1017 N92-33176

FLIGHT OPTIMIZATION
The application of direct transcription to commercial aircraft trajectory optimization
[AIAA PAPER 92-4528] p 1077 A92-55246
FLIGHT PATHS
An efficient algorithm for optimal aircraft trajectories
[AIAA PAPER 92-4412] p 1076 A92-55206
Optimal recovery from microburst wind shear
[AIAA PAPER 92-4338] p 1078 A92-55327
A Lie Bracket solution of the optimal thrust magnitude on a singular arc in atmospheric flight
[AIAA PAPER 92-4345] p 1079 A92-55334
Multiaxis control in longitudinal mode of aircraft
p 1083 A92-56027
A320 flight control from the pilot's point of view
p 1083 A92-56028
Robust control system design with multiple model approach p 1083 A92-56029
Selection of sampling rate for nonlinear flight trajectory controller of aircraft p 1084 A92-56070
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of MLS
p 1047 A92-56117
Optimization of two stage reusable space transportation systems with rocket and airbreathing propulsion concepts
[IAF PAPER 92-0863] p 1104 A92-57254
A workstation-based evaluation of a far-field route planner for helicopters
[NASA-TM-102882] p 1051 N92-33609
FLIGHT RECORDERS
Severe turbulence and maneuvering from airline flight records
[AIAA PAPER 92-4341] p 1078 A92-55330
FLIGHT SAFETY
The advantages of digital engine control as compared with traditional systems (hydraulic or pneumatic)
p 1070 A92-56338
Safety study of TCAS 2 for logic version 6.04
[DOT/FAA/RD-92/22] p 1047 N92-32537
Statistics on aircraft gas turbine engine rotor failures that occurred in US commercial aviation during 1988
[DOT/FAA/CT-91/28] p 1071 N92-33105
FLIGHT SIMULATION
Space plane navigation simulation
p 1103 A92-53603
Pre-flight physical simulation test of HIMES reentry test vehicle p 1103 A92-53640
A data fusion algorithm for multi-sensor microburst hazard assessment
[AIAA PAPER 92-4339] p 1063 A92-55328
ATTAS flight test and simulation results of the advanced gust management system LARS
[AIAA PAPER 92-4343] p 1079 A92-55332
A simulation model for tail rotor failure
[AIAA PAPER 92-4633] p 1081 A92-55380
Synthesis of a MLS automatic landing control law for the NAL experimental research aircraft Do-228
p 1084 A92-56062
Piloted simulation for the BK117 FBW demonstrator
p 1053 A92-56077
Flight simulator test of cockpit advisory system
p 1054 A92-56115
Escape strategies for turboprop aircraft in microburst windshear p 1084 A92-56151
Flight simulation modeling in support of engine/airframe integration p 1055 A92-56279
A generic harmonic rotor model for helicopter flight simulation p 1086 A92-56333
Mission oriented investigation of handling qualities through simulation p 1059 A92-56353
Collaborative research on V/STOL control system/cockpit display tradeoffs under the NASA/MOD joint aeronautical program
[NASA-TM-103910] p 1087 N92-32788
Development of new flight procedures for the Microwave Landing System (MLS)
[NLR-TP-91156-U] p 1047 N92-32830
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
FLIGHT SIMULATORS
Design of robust Quantitative Feedback Theory controllers for pitch attitude hold systems
[AIAA PAPER 92-4409] p 1075 A92-55203
Flight simulator fidelity assessment in a rotorcraft lateral translation maneuver
[AIAA PAPER 92-4424] p 1092 A92-55348
Parameter identification of AV-8B wingborne aerodynamics for flight simulator model updates
[AIAA PAPER 92-4506] p 1027 A92-55373
Real-time helicopter simulation using the blade element method p 1132 A92-56278
HEPO mission simulator - Development and usage for NH90 helicopter p 1094 A92-56313
Mission oriented investigation of handling qualities through simulation p 1059 A92-56353
An evaluation of decelerating IFR approaches utilizing a helicopter flight simulator
[CTN-92-60348] p 1048 N92-32845
Flight testing and simulation of an F-15 airplane using throttles for flight control
[NASA-TM-104255] p 1087 N92-32864
Advanced software development workstation: Effectiveness of constraint-checking --- spaceflight simulation and planning
[NASA-CR-190712] p 1134 N92-32865
Piloted evaluation of an integrated propulsion and flight control simulator
[NASA-TM-105797] p 1088 N92-34107
FLIGHT STABILITY TESTS
Flight-determined stability analysis of multiple-input-multiple-output control systems
[AIAA PAPER 92-4396] p 1074 A92-55196
FLIGHT TESTS
Scramjet engine and its flying test bed
p 1066 A92-53492
In-flight performance diagnostic capability of an adaptive engine model
[AIAA PAPER 92-3746] p 1068 A92-54147
Some important factors in turbulence in flight measurement p 1063 A92-54324
Modified Doppler detects wind shear more reliably
p 1015 A92-55099
Gain scheduled linear PID autopilot for the AIAA Controls Design Challenge aircraft
[AIAA PAPER 92-4629] p 1078 A92-55304
ATTAS flight test and simulation results of the advanced gust management system LARS
[AIAA PAPER 92-4343] p 1079 A92-55332
Flight test results using a low order equivalent systems technique to estimate flying qualities
[AIAA PAPER 92-4425] p 1080 A92-55349
A physical approach to the estimation of aerodynamic characteristics from flight data p 1030 A92-56058
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
A calculation method to predict helicopter noise and its verification p 1135 A92-56074
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS
p 1047 A92-56118
Model flight tests of a spin-resistant trainer configuration p 1054 A92-56158
High angle-of-attack flush airdata sensing system
p 1064 A92-56172
Flight measurements of downwash on the Ball-Bartoe Jetwing powered lift aircraft p 1054 A92-56174
Short takeoff optimization for the XV-15 tiltrotor aircraft p 1056 A92-56302
The achievement of aerodynamic goals on the EH101 project through the 'single site' concept
p 1058 A92-56342
Correlation of flight, tunnel and prediction data on a helicopter main rotor p 1059 A92-56350
Integrated test and evaluation for hypervelocity systems
[AIAA PAPER 92-3901] p 1017 A92-56736
Vision-based range estimation using helicopter flight data
[NASA-TM-103930] p 1047 N92-32424
A learning enhanced flight control system for high performance aircraft
[AD-A252520] p 1086 N92-32435
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
An evaluation of decelerating IFR approaches utilizing a helicopter flight simulator
[CTN-92-60348] p 1048 N92-32845
The use of Kalman filtering techniques to improve the accuracy of flight test data
[NRC-32139] p 1064 N92-32850
The design and development of a portable, DSP micro-processor based, high-accuracy data acquisition system
[NRC-32146] p 1134 N92-32851
Flight testing and simulation of an F-15 airplane using throttles for flight control
[NASA-TM-104255] p 1087 N92-32864
The development of an airborne information management system for flight test
[NASA-TM-104251] p 1065 N92-32866
MD-80 aft cabin noise control: A case history
p 1137 N92-32950
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
Pilots noise exposure during a Boeing 747-400 round trip: Ambient noise and acoustic-head recording and analysis of data p 1137 N92-32960
Flight service environmental effects on composite materials and structures p 1110 N92-33054
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
The F-18 high alpha research vehicle: A high-angle-of-attack testbed aircraft
[NASA-TM-104253] p 1060 N92-33404
Implementation of a personal computer based parameter estimation program
[AD-A252914] p 1061 N92-33502
On the calculation of the response of helicopters to control inputs
[NASA-CR-190812] p 1088 N92-33536
Lateral spread of sonic boom measurements from US Air Force boomfile flight tests p 1140 N92-33883
Experience with Ada on the F-18 High Alpha Research Vehicle Flight Test Program
[NASA-TM-104259] p 1062 N92-34039
Piloted evaluation of an integrated propulsion and flight control simulator
[NASA-TM-105797] p 1088 N92-34107
Flight flutter testing p 1089 N92-34163
FLIGHT VEHICLES
An integrated development of the equations of motion for elastic hypersonic flight vehicles
[AIAA PAPER 92-4605] p 1077 A92-55283
Parameter identification of unsteady aerodynamic forces for elastic vehicles
[AIAA PAPER 92-4505] p 1027 A92-55372
FLIR DETECTORS
Airborne experimental FLIR program
p 1064 N92-32447
FLOQUET THEOREM
Computational aspects of helicopter trim analysis and damping levels from Floquet theory
[NASA-CR-190736] p 1087 N92-33107
FLOW CHARACTERISTICS
Flow characterization in the NASA Ames 16-inch Shock Tunnel
[AIAA PAPER 92-3810] p 1090 A92-54180
The flow field characteristics about a fighter configuration at high angles of attack
[AIAA PAPER 92-4358] p 1025 A92-55344
Surface heat transfer and flow properties of vortex arrays induced artificially and from centrifugal instabilities
p 1121 A92-56371
Numerical prediction of the flow characteristics in an arc wind tunnel
[AIAA PAPER 92-4016] p 1100 A92-56838
Vaporizing particle velocimeter
[NASA-CASE-LAR-14685-1] p 1042 N92-34172
FLOW DISTORTION
An acceptance process for the evaluation of inlet distortion
[AIAA PAPER 92-3918] p 1032 A92-56750
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[NASA-TM-105672] p 1128 N92-34112
FLOW DISTRIBUTION
Flow measurements in scramjet inlets
p 1102 A92-53565
Full Navier-Stokes analysis of a two-dimensional mixer/ejector nozzle for noise suppression
[AIAA PAPER 92-3570] p 1067 A92-54059
Structure of crossing-shock wave/turbulent boundary-layer interactions
[AIAA PAPER 92-3670] p 1022 A92-54113
Comparison of turbulence models for powered-lift flow fields
[AIAA PAPER 92-3674] p 1022 A92-54117
Numerical study of the 3-D flowfield for a supersonic jet exiting into a hypersonic stream from a conical surface
[AIAA PAPER 92-3675] p 1022 A92-54118
Use of an approximate similarity principle for the thermal scaling of a full-scale thrust augmenting ejector
[AIAA PAPER 92-3792] p 1069 A92-54171
Signal processing schemes for Doppler global velocimetry p 1115 A92-54338
Efficient methods for inviscid non-equilibrium hypersonic flow fields p 1024 A92-54571
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
Approximate Riemann solver for hypervelocity flows
p 1117 A92-54934
The flow field characteristics about a fighter configuration at high angles of attack
[AIAA PAPER 92-4358] p 1025 A92-55344

Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance p 1029 A92-56009
Experimental results for a hypersonic nozzle/afterbody flow field
[AIAA PAPER 92-3915] p 1032 A92-56747
Flow quality studies of the NASA Lewis Research Center 8- by 6-foot supersonic/9- by 15-foot Low Speed Wind Tunnel
[AIAA PAPER 92-3916] p 1095 A92-56748
Engine component instrumentation development facility at NASA Lewis Research Center
[AIAA PAPER 92-3995] p 1099 A92-56818
Numerical prediction of the flow characteristics in an arc wind tunnel
[AIAA PAPER 92-4016] p 1100 A92-56838
Study on supersonic combustion in a hypersonic flight
[IAF PAPER 92-0661] p 1106 A92-57101
An examination of several high resolution schemes applied to complex problems in high speed flows
[AD-A250814] p 1124 N92-32632
New concepts for multi-block grid generation for flow domains around complex aerodynamic configurations
[NLR-TP-91046-U] p 1037 N92-32730
An experimental study of the flow over a sharp-edged delta wing at subsonic and transonic speeds
[NLR-TP-91117-U] p 1037 N92-32732
Integration of wall interference assessment and wall adaptation
[NLR-TP-91119-U] p 1101 N92-32734
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
A nozzle internal performance prediction method
[NASA-TP-3221] p 1040 N92-33625
Static and dynamic flow visualization studies of two double-delta wing models at high angles of attack
[AD-A252878] p 1040 N92-33678
An approximate viscous shock layer technique for calculating chemically reacting hypersonic flows about blunt-nosed bodies p 1041 N92-33837
Influence of the swirl producing construction in the flow and reaction field of turbulent diffusion flames
[ETN-92-92103] p 1127 N92-33916
Investigation of advancing front method for generating unstructured grid
[NASA-CR-190902] p 1128 N92-34043

FLOW EQUATIONS
Modeling and numerical simulation of vortex flow in aerodynamics
[NLR-TP-91154-U] p 1037 N92-32673

FLOW GEOMETRY
A new look at surface flow visualization to provide insight into complex fluid dynamic behavior p 1090 A92-54307
The vortical structure in the wake during dynamic stall
[AIAA PAPER 92-4496] p 1026 A92-55364
Flight measurements of downwash on the Ball-Bartoe Jetwing powered lift aircraft p 1054 A92-56174

FLOW MEASUREMENT
Flow measurements in scramjet inlets p 1102 A92-53565
ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record
[ISBN 0-0783-0123-4] p 1114 A92-54301
Detecting 3-D, turbulent separation regions using unsteady computerized thermographic technique p 1023 A92-54308
Nonintrusive measurements in fluid dynamic flows from Mach .0005 to 14 p 1090 A92-54311
Rayleigh imaging and flow tagging in ground test facilities p 1115 A92-54330
A simple three component velocity measurement *method using a rotated split-film sensor* p 1115 A92-54333
A laser fluorescence anemometer system for the Langley 16- by 24-inch water tunnel p 1092 A92-54347
Flight measurements of downwash on the Ball-Bartoe Jetwing powered lift aircraft p 1054 A92-56174
Development of local nonintrusive measurements of inlet and exhaust flows for the ground testing of air-breathing engines
[AIAA PAPER 92-3899] p 1122 A92-56735
Flow quality studies of the NASA Lewis Research Center 8- by 6-foot supersonic/9- by 15-foot Low Speed Wind Tunnel
[AIAA PAPER 92-3916] p 1095 A92-56748
The SR3 low density wind tunnel - Facility capabilities and research development
[AIAA PAPER 92-3972] p 1098 A92-56798
Advanced nozzle and engine components test facility
[AIAA PAPER 92-3993] p 1099 A92-56816
Radial inflow turbine study
[AD-A252783] p 1127 N92-33538

FLOW REGULATORS
Automatic control of test parameters for intake measurements in a low-speed wind tunnel p 1091 A92-54341

FLOW STABILITY
Mixed flow compressor surge margin gain using a manifolded diffuser system
[AIAA PAPER 92-3753] p 1068 A92-54151
Perspectives on hypersonic viscous and nonequilibrium flow research
[NASA-CR-190817] p 1039 N92-33413
Computation and stability analysis of laminar flow over a blunt cone in hypersonic flow p 1041 N92-33839

FLOW VELOCITY
Flowpath and sensitivity analyses of high speed propulsion systems
[AIAA PAPER 92-3806] p 1069 A92-54178
A simple three component velocity measurement method using a rotated split-film sensor p 1115 A92-54333
An analysis of boundary layer for droplet aerodynamic stripped in high speed gas flow p 1116 A92-54563
Unsteady response of the leading-edge vortices on a pitching delta wing p 1041 N92-33851
Vaporizing particle velocimeter
[NASA-CASE-LAR-14685-1] p 1042 N92-34172

FLOW VISUALIZATION
Experimental and numerical investigation of a supersonic free jet impinging on a perpendicular surface p 1018 A92-53555
Experimental investigation of an ejector-powered free-jet facility
[AIAA PAPER 92-3569] p 1090 A92-54058
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
A new look at surface flow visualization to provide insight *into complex fluid dynamic behavior* p 1090 A92-54307
Rayleigh imaging and flow tagging in ground test facilities p 1115 A92-54330
BGK1 airfoil oilflow tests in the NAL two-dimensional wind tunnel. II p 1029 A92-56044
Holographic and PLIF measurements of free-flight hypervelocity flows in the AEDC Range G facility
[AIAA PAPER 92-3935] p 1122 A92-56765
Advanced nozzle and engine components test facility
[AIAA PAPER 92-3993] p 1099 A92-56816
Vortex flow visualization using colored and fluorescent dyes on flat plate delta wing with leading edge extension
[AD-A251139] p 1036 N92-32651
An experimental study of the flow over a sharp-edged delta wing at subsonic and transonic speeds
[NLR-TP-91117-U] p 1037 N92-32732
Static and dynamic flow visualization studies of two double-delta wing models at high angles of attack
[AD-A252878] p 1040 N92-33678

FLUID DYNAMICS
Image processing in the undergraduate fluid dynamics laboratory
[AIAA PAPER 92-4020] p 1141 A92-56842
High speed transition prediction
[NASA-CR-190836] p 1039 N92-33424

FLUID INJECTION
Structure and penetration of a transverse fluid jet injected at supercritical pressure in supersonic flow
[AIAA PAPER 92-3652] p 1113 A92-54105
Numerical simulation of slot injection into a turbulent supersonic stream p 1024 A92-54914

FLUID MECHANICS
Flow induction by pressure forces
[AIAA PAPER 92-3571] p 1067 A92-54060
Active control of compressor surge and stall
[AD-A252771] p 1126 N92-33498

FLUID-SOLID INTERACTIONS
The interaction between a high-frequency gust and a blade row p 1135 A92-54484
The Utilization of Advanced Composites in Military Aircraft
[AGARD-R-785] p 1109 N92-33033
Jet fuel absorption and dynamic mechanical analysis *of carbon fibre composites* p 1110 N92-33050

FLUTTER
Numerical simulations of flutter and its suppression by active control
[AIAA PAPER 92-4652] p 1082 A92-55396
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
Introduction to Flutter of Winged Aircraft, volume 2
[VKI-LS-1992-01-VOL-2] p 1088 N92-34161
Flight flutter testing p 1089 N92-34163
Flutter models: Their design, manufacture, and ground testing p 1089 N92-34164
Flutter in the transonic flight regime p 1089 N92-34167
Flutter analyses using high speed computers. Part 1: Flutter analyses for large aircraft p 1089 N92-34168
Flutter analyses using high speed computers. Part 2: *Aerodynamic procedures* p 1089 N92-34169

FLUTTER ANALYSIS
FREPS - A forced response prediction system for *turbomachinery blade rows*
[AIAA PAPER 92-3072] p 1130 A92-54006
E-6 flutter investigation and experience
[AIAA PAPER 92-4601] p 1077 A92-55280
Flutter analysis and wind tunnel test with respect to a low-aspect-ratio wing with free-rotational control surface p 1052 A92-56014
An example of whirl flutter analysis p 1052 A92-56015
Propeller-nacelle whirl flutter analysis and wind tunnel test p 1052 A92-56016
Whirl flutter analysis and application to aircraft design p 1053 A92-56017
Research on aeroelastic tailoring at NAL p 1053 A92-56019
Synthesis of gust load alleviation with flutter margin *augmentation* p 1082 A92-56021
Multidisciplinary optimization of aeroservoelastic systems using reduced-size models p 1054 A92-56176
Flutter and stall response of a helicopter blade with structural nonlinearity p 1055 A92-56178
Helicopter tail rotor stall flutter p 1056 A92-56290
Aeroelasticity of a coaxial helicopter rotor p 1057 A92-56309
Transverse shear effect on flutter of composite panels p 1122 A92-56607
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter
[NASA-TM-104211] p 1042 N92-34147
Introduction to Flutter of Winged Aircraft, volume 2
[VKI-LS-1992-01-VOL-2] p 1088 N92-34161
Elementary flutter analysis p 1088 N92-34162
Flight flutter testing p 1089 N92-34163
Flutter models: Their design, manufacture, and ground *testing* p 1089 N92-34164
Unsteady wind tunnel tests p 1089 N92-34166
Flutter in the transonic flight regime p 1089 N92-34167
Flutter analyses using high speed computers. Part 1: Flutter analyses for large aircraft p 1089 N92-34168
Flutter analyses using high speed computers. Part 2: Aerodynamic procedures p 1089 N92-34169

FLUX VECTOR SPLITTING
An examination of several high resolution schemes applied to complex problems in high speed flows
[AD-A250814] p 1124 N92-32632

FLY BY WIRE CONTROL
A simulator evaluation of various manual control concepts for fly-by-wire transport aircraft
[AIAA PAPER 92-4328] p 1073 A92-55172
A320 flight control from the pilot's point of view p 1083 A92-56028
Piloted simulation for the BK117 FBW demonstrator p 1053 A92-56077
HEPO mission simulator - Development and usage for NH90 helicopter p 1094 A92-56313

FOKKER AIRCRAFT
Active synchrophasing of propeller unbalance p 1138 N92-32963
Activities report of the National Aerospace Laboratory
[ETN-92-92053] p 1143 N92-33694

FOREBODIES
Reduction of the side force on pointed forebodies through add-on tip devices p 1024 A92-54918
Vortical flow control on a wing-body combination using tangential blowing
[AIAA PAPER 92-4430] p 1081 A92-55354
Assessment of passive porosity with free and fixed separation on a tangent ogive forebody
[AIAA PAPER 92-4494] p 1081 A92-55363
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations p 1127 N92-33968

FORECASTING
Developing robust support structures for high-technology subsystems: The AH-64 Apache helicopter
[AD-A252773] p 1017 N92-33499

FORMING TECHNIQUES
Examples of advanced near-net shape manufacturing techniques for aerospace
[MBB-Z-0399-91-PUB] p 1125 N92-32742

FOUR-WAVE MIXING
Degenerate four-wave mixing for measurement of NO2 and smoke concentration in jet engine exhaust
[AIAA PAPER 92-3658] p 1113 A92-54108

FRACTURE MECHANICS
Damage tolerant design of critical aircraft structural components
[AIAA PAPER 92-4041] p 1123 A92-56860
FREE FLOW
Increased heat transfer to elliptical leading edges due to spanwise variations in the freestream momentum - Numerical and experimental results
[AIAA PAPER 92-3070] p 1020 A92-54005
Assessment of compressibility corrections to the k-epsilon model in high-speed shear layers p 1024 A92-54905
Swept shock/boundary layer interaction experiments in support of CFD code validation
[NASA-CR-190583] p 1036 N92-32494
An examination of several high resolution schemes applied to complex problems in high speed flows
[AD-A250814] p 1124 N92-32632
Leading-edge receptivity for blunt-nose bodies
[NASA-CR-190563] p 1036 N92-32648
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations p 1127 N92-33968
FREE JETS
Experimental and numerical investigation of a supersonic free jet impinging on a perpendicular surface p 1018 A92-53555
Experimental investigation of an ejector-powered free-jet facility
[AIAA PAPER 92-3569] p 1090 A92-54058
The design of a subsonic low-noise, low-turbulence wind tunnel for acoustic measurements
[AIAA PAPER 92-3883] p 1094 A92-56726
An acceptance process for the evaluation of inlet distortion
[AIAA PAPER 92-3918] p 1032 A92-56750
Development and validation of a freejet technique for inlet-engine compatibility testing
[AIAA PAPER 92-3921] p 1033 A92-56752
FREE RADICALS
Free-radicals aided combustion with scramjet applications
[IAF PAPER 92-0659] p 1106 A92-57100
FREE VIBRATION
Estimation of aircraft inertial characteristics using maximum likelihood estimation p 1084 A92-56057
Safety provision against 'ground resonance' free vibration of a coaxial helicopter p 1056 A92-56289
FREE-PISTON ENGINES
The G-range impulse facility - A high-performance free-piston shock tunnel
[AIAA PAPER 92-3946] p 1097 A92-56774
FREQUENCY RANGES
On the calculation of the response of helicopters to control inputs
[NASA-CR-190812] p 1088 N92-33536
FREQUENCY STANDARDS
The need for GPS standardization p 1049 N92-33351
FRICTION MEASUREMENT
Skin friction measurements in 3-D boundary layers p 1092 A92-54351
FROST
Performance of insulated pavements at Newton Fields, Jackman, Maine
[CRREL-92-9] p 1101 N92-32903
FUEL COMBUSTION
Free-radicals aided combustion with scramjet applications
[IAF PAPER 92-0659] p 1106 A92-57100
FUEL CONTAMINATION
Flow contamination and flow quality in arc heaters used for hypersonic testing
[AIAA PAPER 92-4028] p 1100 A92-56850
FUEL FLOW
Fault diagnostics on jet engine starting p 1116 A92-54345
FUEL INJECTION
Computational and experimental investigation of annulus heat transfer with swirl
[AIAA PAPER 92-4060] p 1119 A92-56143
FUEL-AIR RATIO
Computational and experimental studies of flow in multi-lobed forced mixers
[AIAA PAPER 92-3568] p 1112 A92-54057
FULL SCALE TESTS
Experimental investigation of an ejector-powered free-jet facility
[AIAA PAPER 92-3569] p 1090 A92-54058
Helicopter rotor testing using scaled model p 1093 A92-56076
FUNCTIONAL DESIGN SPECIFICATIONS
A multivariable control concept for a gas turbine engine
[ETN-92-92104] p 1072 N92-33645
FURNACES
High temperature aircraft research furnace facilities
[NASA-CR-184384] p 1101 N92-33826
FUSELAGES
Coupled rotor-fuselage vibration reduction with multiple frequency blade pitch control p 1085 A92-56315
Analysis of helicopter rotor-fuselage interference with time averaged pressure distribution p 1032 A92-56331
A study of helicopter rotor/fuselage response in low-speed manoeuvres - Comparison of theory with flight p 1086 A92-56334
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951
Active control of sound transmission through stiff lightweight composite fuselage constructions p 1137 N92-32957
CFRP stiffened panels under compression p 1109 N92-33044
FUSION (MELTING)
Notes on the use of fusible temperature indicators to bound the temperature of hot graphite in the NAVSWC hypervelocity wind tunnel facility p 1090 A92-54315
FUZZY SYSTEMS
A fuzzy logic based F/A-18 automatic carrier landing system
[AIAA PAPER 92-4392] p 1074 A92-55193
Discrete event fuzzy airport control p 1046 A92-55973
An autorotation-entry control for a helicopter with a fuzzy controller p 1083 A92-56032
Application of fuzzy control to aircraft guidance p 1083 A92-56033

G

GALERKIN METHOD
Development of 3D electromagnetic modeling tools for airborne vehicles
[NASA-CR-190810] p 1126 N92-33307
GAS DISSOCIATION
Effects of oxygen dissociation on hypervelocity combustion experiments
[AIAA PAPER 92-3964] p 1098 A92-56791
GAS DYNAMICS
The study of experimental turboramjets
[AIAA PAPER 92-3720] p 1067 A92-54135
TSNIIMASH capabilities for aerogasdynamical and thermal testing of hypersonic vehicles
[AIAA PAPER 92-3962] p 1097 A92-56789
Swept shock/boundary layer interaction experiments in support of CFD code validation
[NASA-CR-190583] p 1036 N92-32494
Perspectives on hypersonic viscous and nonequilibrium flow research
[NASA-CR-190817] p 1039 N92-33413
GAS FLOW
Rarefied gas numerical wind tunnel p 1017 A92-53552
An analysis of boundary layer for droplet aerodynamic stripped in high speed gas flow p 1116 A92-54563
GAS GENERATORS
Detonation duct gas generator demonstration program
[AIAA PAPER 92-3174] p 1066 A92-54011
Analysis of the flight performance of the 155 mm M864 base burn projectile
[BRL-TR-3083] p 1041 N92-33699
GAS INJECTION
Numerical study on the secondary jet into a supersonic flow p 1018 A92-53556
Active control of asymmetric vortical flows around cones using injection and heating
[AIAA PAPER 92-4426] p 1025 A92-55350
GAS JETS
Dynamic response of induced pressures, suckdown, and temperatures for two tandem jet STOVL configurations
[NASA-TM-103934] p 1039 N92-33581
GAS MIXTURES
Experimental and computational investigation of scaling phenomena in a large caliber ram accelerator
[AIAA PAPER 92-3245] p 1103 A92-54019
GAS TUNGSTEN ARC WELDING
High temperature aircraft research furnace facilities
[NASA-CR-184384] p 1101 N92-33826
GAS TURBINE ENGINES
High-temperature metal matrix composite p 1105 A92-53878
Applied analytical combustion/emissions research at the NASA Lewis Research Center - A progress report
[AIAA PAPER 92-3338] p 1067 A92-54025
The VRT gas turbine combustor - Phase II
[AIAA PAPER 92-3471] p 1067 A92-54035
In-flight performance diagnostic capability of an adaptive engine model
[AIAA PAPER 92-3746] p 1068 A92-54147
Improvements in teaching aircraft engine design
[AIAA PAPER 92-3758] p 1141 A92-54152
CIS engines - The range revealed. II p 1069 A92-54546
Development of ITS90 small gas turbine engine p 1070 A92-55500
State-of-the-art materials for future gas turbine engines p 1070 A92-56122
Computational and experimental investigation of annulus heat transfer with swirl
[AIAA PAPER 92-4060] p 1119 A92-56143
Small engine components test facility compressor testing cell at NASA Lewis Research Center
[AIAA PAPER 92-3980] p 1098 A92-56806
Statistics on aircraft gas turbine engine rotor failures that occurred in US commercial aviation during 1988
[DOT/FAA/CT-91/28] p 1071 N92-33105
Life prediction and constitutive models for engine hot section anisotropic materials program
[NASA-CR-189223] p 1072 N92-33479
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480
A multivariable control concept for a gas turbine engine
[ETN-92-92104] p 1072 N92-33645
A graphical user-interface for propulsion system analysis
[NASA-TM-105696] p 1134 N92-33894
Cooled high-temperature radial turbine program 2
[NASA-CR-189122] p 1073 N92-34236
GAS TURBINES
Detonation duct gas generator demonstration program
[AIAA PAPER 92-3174] p 1066 A92-54011
Radial inflow turbine study
[AD-A252783] p 1127 N92-33538
GAS-LIQUID INTERACTIONS
An analysis of boundary layer for droplet aerodynamic stripped in high speed gas flow p 1116 A92-54563
GEAR TEETH
Monitoring fatigue cracks in gears p 1116 A92-54496
GEARS
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
GEODETIC SURVEYS
GPS orbit determination at the National Geodetic Survey p 1049 N92-33354
Precise GPS ephemerides from DMA and NGS tested by time transfer p 1049 N92-33355
GEOMETRIC DILUTION OF PRECISION
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS p 1047 A92-56118
GEOMETRICAL ACOUSTICS
Wave equations and computational models for sonic boom propagation through a turbulent atmosphere p 1139 N92-33877
Simulations of sonic boom ray tube area fluctuations for propagation through atmospheric turbulence including caustics via a Monte Carlo method p 1139 N92-33878
GEOPOTENTIAL
User's manual for AeroFcn: A FORTRAN program to compute aerodynamic parameters
[NASA-TM-104237] p 1133 N92-32507
GERMAN SPACE PROGRAM
The German Hypersonics Technology Programme - Status report 1992
[IAF PAPER 92-0867] p 1105 A92-57258
GLASS FIBER REINFORCED PLASTICS
Development of aircraft bonded structure and the NDI method p 1016 A92-56100
Computed tomography (CT) as a nondestructive test method used for composite helicopter components p 1121 A92-56276
Processing and environmental effects on mechanical properties of composite repairs
[NRC-LTR-ST-1826] p 1109 N92-32791
GLIDE PATHS
ILS mathematical modeling study of an ILS localizer and glide slope proposed for runway 32R, Moffett Field Airport, California
[DOT/FAA/CT-TN92/28] p 1048 N92-33308
GLIDERS
A guidance law for hypersonic descent to a point
[AIAA PAPER 92-4303] p 1104 A92-55311
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063

GLOBAL POSITIONING SYSTEM
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS p 1047 A92-56118
The need for GPS standardization p 1049 N92-33351
US Coast Guard GPS Information Center (GPSIC) and its function within the Civil GPS Service (CGS) p 1049 N92-33352
Evaluation of GPS/UTC steering performance p 1049 N92-33353
GPS orbit determination at the National Geodetic Survey p 1049 N92-33354
Precise GPS ephemerides from DMA and NGS tested by time transfer p 1049 N92-33355
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG p 1050 N92-33356
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
Calibration of GPS antennas [ETN-92-92034] p 1051 N92-33693

GRAPHIC ARTS
Computational algorithms for increased control of depth-viewing volume for stereo three-dimensional graphic displays [NASA-TM-4379] p 1065 N92-34109

GRAPHITE
Notes on the use of fusible temperature indicators to bound the temperature of hot graphite in the NAVSWC hypervelocity wind tunnel facility p 1090 A92-54315

GRAPHITE-EPOXY COMPOSITES
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
Global/local methods research using the CSM testbed p 1107 N92-32528
Residual strength of repaired graphite/epoxy laminates after 5 years of outdoor exposure p 1108 N92-32577
Initial postbuckling response of an unsymmetrically laminated rectangular plate p 1108 N92-32586
Advanced airframe structural materials: A primer and cost estimating methodology [AD-A253371] p 1062 N92-34182

GREEN'S FUNCTIONS
Application of a wall pressure method in a wind tunnel test section with adjustable longitudinal slots p 1091 A92-54336

GRID GENERATION (MATHEMATICS)
A finite element method for shear stresses calculation in composite blade models p 1121 A92-56322
New concepts for multi-block grid generation for flow domains around complex aerodynamic configurations [NLR-TP-91046-U] p 1037 N92-32730
Finite difference time domain grid generation from AMC helicopter models [NASA-TM-107679] p 1128 N92-34017

GROOVING
Grooved runway surface texture before and after rubber removal p 1093 A92-56111

GROUND BASED CONTROL
Application of fuzzy control to aircraft guidance p 1083 A92-56033
Controller response to conflict resolution advisory prototype [PB92-190032] p 1050 N92-33596

GROUND EFFECT (AERODYNAMICS)
Motion analysis of 2-dimensional flat plate in ground effect p 1030 A92-56053
On the anomalies in single-jet hover suckdown data [NASA-TM-102261] p 1038 N92-33306
On the estimation of jet-induced fountain lift and additional suckdown in hover for two-jet configurations [NASA-TM-102268] p 1040 N92-33618

GROUND EFFECT MACHINES
Gust response and cross wind performance of a hovercraft with vertical wings p 1118 A92-56034
On the maneuvering tests of an ACV model p 1118 A92-56035
Configuration of flexible-skirts for an ACV and its CAD p 1118 A92-56036
Planning method of skirt systems for small ACVs p 1118 A92-56038
A potential flow theory of two-dimensional bifurcated curtain jets. II p 1118 A92-56039
Three-dimensional numerical analysis of impinging circular jet - Discrete vortex method p 1029 A92-56040

GROUND RESONANCE
Safety provision against 'ground resonance' free vibration of a coaxial helicopter p 1056 A92-56289

GROUND STATIONS
Aircraft satellite communication systems p 1046 A92-56091
GPS orbit determination at the National Geodetic Survey p 1049 N92-33354
LORAN-C data reduction at the US Naval Observatory p 1050 N92-33358

GROUND TESTS
Development of local nonintrusive measurements of inlet and exhaust flows for the ground testing of air-breathing engines [AIAA PAPER 92-3899] p 1122 A92-56735
Turbine engine hot-part temperature measurement techniques [AIAA PAPER 92-3960] p 1122 A92-56788
A multi-diagnostic approach to testing V/STOL craft [AIAA PAPER 92-4008] p 1099 A92-56831
Aerodynamics laboratory education at Purdue University - Ground testing facilities [AIAA PAPER 92-4018] p 1100 A92-56840
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575
MD-80 aft cabin noise control: A case history p 1137 N92-32950
Advanced Study for Active Noise Control in Aircraft (ASANCA) [AIAA PAPER 92-2092] p 1137 N92-32956
Flight service environmental effects on composite materials and structures p 1110 N92-33054

GUIDANCE (MOTION)
AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pts. 1-3 p 1130 A92-55151

GUIDANCE SENSORS
Talons 95 GHz radar sensor for autonomous landing guidance p 1063 A92-55908

GUST ALLEVIATORS
Analysis and wind tunnel test of low aspect wing gust load alleviation p 1053 A92-56020
Synthesis of gust load alleviation with flutter margin augmentation p 1082 A92-56021
Optimization of aeroelastic system with active control p 1083 A92-56022

GUST LOADS
The interaction between a high-frequency gust and a blade row p 1135 A92-54484
Effect of atmospheric disturbances on airplane response [AIAA PAPER 92-4340] p 1078 A92-55329
Stability, control and gust response characteristics of an ultralight freewing airplane [AIAA PAPER 92-4342] p 1079 A92-55331
ATTAS flight test and simulation results of the advanced gust management system LARS [AIAA PAPER 92-4343] p 1079 A92-55332
Gust response and cross wind performance of a hovercraft with vertical wings p 1118 A92-56034

GUSTS
Implementation of a personal computer based parameter estimation program [AD-A252914] p 1061 N92-33502

GYROCOMPASSES
The effect of gyro nonorthogonality error on gyrocompassing p 1045 A92-55955

H

H-53 HELICOPTER
On the calculation of the response of helicopters to control inputs [NASA-CR-190812] p 1088 N92-33536

H-60 HELICOPTER
Control design of a UH-60 rotorcraft via CLTR and direct optimization [AIAA PAPER 92-4470] p 1076 A92-55230

HALOGENS
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301 [AD-A252912] p 1126 N92-33501

HAMILTONIAN FUNCTIONS
A dynamic stiffness technique for the vibration analysis of stiffened shell structures p 1123 A92-56866

HANGARS
ILS mathematical modeling study of an ILS localizer and glide slope proposed for runway 32R, Moffett Field Airport, California [DOT/FAA/CT-TN92/28] p 1048 N92-33308

HARDWARE
Test and integration concept for complex helicopter avionic systems p 1064 A92-56292

HARMONIC CONTROL
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344

HARMONICS
A generic harmonic rotor model for helicopter flight simulation p 1086 A92-56333

HARRIER AIRCRAFT
Collaborative research on V/STOL control system/cockpit display tradeoffs under the NASA/MOD joint aeronautical program [NASA-TM-103910] p 1087 N92-32788

HAZARDS
Pilot noise exposure during a Boeing 747-400 round trip: Judgement of noise and analysis in respect to hearing impairment of pilots p 1138 N92-32961

HEAD-UP DISPLAYS
The utility of analog vertical velocity information during instrument flight with a Head-Up Display (HUD) [AD-A252863] p 1065 N92-33277

HEARING
Exposures from headset interference tones [AD-A247175] p 1136 N92-32697

HEAT EXCHANGERS
Assessment of calculation methods for efficiency of straight fins of rectangular profile p 1121 A92-56374
Study of potassium turbine electric generator system p 1129 N92-33794

HEAT MEASUREMENT
Thermal mechanical analysis of sprag clutches [NASA-CR-190686] p 1128 N92-34207

HEAT PUMPS
Proof of concept of a magnetically coupled Stirling engine-driven heat pump [DE92-017129] p 1129 N92-33271

HEAT RADIATORS
Study of potassium turbine electric generator system p 1129 N92-33794

HEAT RESISTANT ALLOYS
High-temperature metal matrix composite p 1105 A92-53878
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy [PNR-90860] p 1111 N92-34019

HEAT TRANSFER
Three-dimensional Navier-Stokes heat transfer predictions for turbine blade rows [AIAA PAPER 92-3068] p 1020 A92-54003
Increased heat transfer to elliptical leading edges due to spanwise variations in the freestream momentum - Numerical and experimental results [AIAA PAPER 92-3070] p 1020 A92-54005
Heat transfer measurements and CFD comparison of swept shock wave/boundary-layer interactions [AIAA PAPER 92-3665] p 1021 A92-54110
Problems and solutions for transition detection in cryogenic wind tunnels by infrared imaging p 1090 A92-54319
Computational and experimental investigation of annulus heat transfer with swirl [AIAA PAPER 92-4060] p 1119 A92-56143
Surface heat transfer and flow properties of vortex arrays induced artificially and from centrifugal instabilities p 1121 A92-56371
TSNIIMASH capabilities for aerogasdynamical and thermal testing of hypersonic vehicles [AIAA PAPER 92-3962] p 1097 A92-56789
Transonic turbine blade cascade testing facility [AIAA PAPER 92-4034] p 1101 A92-56856
Turbine disk cavity aerodynamics and heat transfer p 1124 N92-32265
Swept shock/boundary layer interaction experiments in support of CFD code validation [NASA-CR-190583] p 1036 N92-32494

HEAVING
Performance of insulated pavements at Newton Fields, Jackman, Maine [CRREL-92-9] p 1101 N92-32903

HEAVY LIFT AIRSHIPS
C-17 flight control system overview p 1082 A92-55906

HELICOPTER CONTROL
Vision-based stereo ranging as an optimal control problem [AIAA PAPER 92-4418] p 1045 A92-55211
Robustness of a helicopter flight control system designed using eigenstructure assignment [AIAA PAPER 92-4469] p 1076 A92-55229
Control design of a UH-60 rotorcraft via CLTR and direct optimization [AIAA PAPER 92-4470] p 1076 A92-55230
Optimal control of helicopters following power failure [AIAA PAPER 92-4471] p 1076 A92-55231
Concepts for pilot interaction with an automated NOE obstacle-avoidance system [AIAA PAPER 92-4472] p 1076 A92-55232
A simulation model for tail rotor failure [AIAA PAPER 92-4633] p 1081 A92-55380
Optimization approach for helicopter maneuverability with a point mass model p 1083 A92-56025
An investigation of the automation of emergency landings for helicopters p 1083 A92-56026

An autorotation-entry control for a helicopter with a fuzzy controller p 1083 A92-56032
Flight simulation modeling in support of engine/airframe integration p 1055 A92-56279
Trimming rotor blades with periodically deflecting trailing edge flaps p 1085 A92-56283
The solution of the helicopter flight dynamics tasks by the methods of optimal control theory p 1085 A92-56284
A module-level testing environment for safety-critical software systems p 1132 A92-56293
Modern helicopter technologies at MBB and the application in future programmes p 1016 A92-56304
Creation of a living specification for an experimental helicopter active flight control system through incremental simulation p 1057 A92-56312
Helicopter nonlinear flight control system development p 1085 A92-56317
Experimental investigation of helicopter coupled rotor/body control p 1086 A92-56318
A high speed edgewise rotor using circulation control only in the reversed flow area p 1059 A92-56347
Mission oriented investigation of handling qualities through simulation p 1059 A92-56353
Computational aspects of helicopter trim analysis and damping levels from Floquet theory
[NASA-CR-190736] p 1087 N92-33107
On the calculation of the response of helicopters to control inputs
[NASA-CR-190812] p 1088 N92-33536
A workstation-based evaluation of a far-field route planner for helicopters
[NASA-TM-102882] p 1051 N92-33609
Design of helicopter flight control systems for hover and low speed using eigenstructure assignment p 1061 N92-33952

HELICOPTER DESIGN
Summary highlights of the Advanced Rotorcraft Transmission (ART) program
[AIAA PAPER 92-3362] p 1051 A92-54026
DAMVIBS looks at rotorcraft vibration p 1052 A92-55128
Measurements of blade flapping motion on a wind tunnel model p 1093 A92-56023
Efficiency and accuracy in helicopter hovering performance calculation p 1053 A92-56072
Repair procedures for advanced composites for helicopters p 1016 A92-56277
Safety provision against 'ground resonance' free vibration of a coaxial helicopter p 1056 A92-56289
Test and integration concept for complex helicopter avionic systems p 1064 A92-56292
The application of math-dynamic models to characterise a range of helicopter rotor system faults p 1056 A92-56297
Organization and technical status of the NH90 European helicopter programme p 1016 A92-56306
Lynx - A 50 year product? p 1056 A92-56307
Aeroelasticity of a coaxial helicopter rotor p 1057 A92-56309
Influence of cross section variations on the structural behaviour of composite rotor blades p 1121 A92-56320
Composite blades for helicopter main and tail rotors developed by Mil Design Bureau p 1057 A92-56325
Current European research activities in helicopter interactional aerodynamics p 1058 A92-56330
Current European rotorcraft research activities on development of advanced CFD methods for the design of rotor blades (BRITE/EURAM 'DACRO' project) p 1032 A92-56332
Damage tolerance analysis for rotorcraft - What the issues are p 1058 A92-56336
Design method of a helicopter cockpit p 1058 A92-56337
First level release of 2GCHAS for comprehensive helicopter analysis p 1133 A92-56339
Development of a conceptual design method for rotary-wing aircraft using digital computers p 1058 A92-56340
The compound helicopter - A concept revisited p 1058 A92-56341
The achievement of aerodynamic goals on the EH101 project through the 'single site' concept p 1058 A92-56342
AS 332 MKII - Development and certification p 1059 A92-56343
A high speed edgewise rotor using circulation control only in the reversed flow area p 1059 A92-56347
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575

HELICOPTER ENGINES
'A new proposal for an old problem' - The right engine for the right helicopter p 1070 A92-56281
Lynx - A 50 year product? p 1056 A92-56307

HELICOPTER PERFORMANCE
Optimal control of helicopters following power failure
[AIAA PAPER 92-4471] p 1076 A92-55231
Efficiency and accuracy in helicopter hovering performance calculation p 1053 A92-56072
Piloted simulation for the BK117 FBW demonstrator p 1053 A92-56077
Automatic function testing in the aircraft production p 1015 A92-56083
The solution of the helicopter flight dynamics tasks by the methods of optimal control theory p 1085 A92-56284
The computation and validation of hovering rotor performance p 1055 A92-56285

HELICOPTER PROPELLER DRIVE
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
Path identification in structural acoustics p 1059 A92-56346

HELICOPTER TAIL ROTORS
A simulation model for tail rotor failure
[AIAA PAPER 92-4633] p 1081 A92-55380
A calculation method to predict helicopter noise and its verification p 1135 A92-56074
Computed tomography (CT) as a nondestructive test method used for composite helicopter components p 1121 A92-56276
Helicopter tail rotor stall flutter p 1056 A92-56290

HELICOPTER WAKES
The computation and validation of hovering rotor performance p 1055 A92-56285

HELICOPTERS
Real-time helicopter simulation using the blade element method p 1132 A92-56278
Dynamics of helicopters with dissimilar blades in forward flight p 1056 A92-56288
Laser-radar based obstacle avoidance system for helicopters p 1064 A92-56295
Modern helicopter technologies at MBB and the application in future programmes p 1016 A92-56304
HEPO mission simulator - Development and usage for NH90 helicopter p 1094 A92-56313
Research on measurement and control of helicopter rotor response using blade-mounted accelerometers 1990-91 p 1057 A92-56316
Aluminium-lithium alloys - Application on helicopters p 1106 A92-56326
Analysis of helicopter rotor-fuselage interference with time averaged pressure distribution p 1032 A92-56331
Vision-based range estimation using helicopter flight data
[NASA-TM-103930] p 1047 N92-32424
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575
An evaluation of decelerating IFR approaches utilizing a helicopter flight simulator
[CTN-92-60348] p 1048 N92-32845
Flight service environmental effects on composite materials and structures p 1110 N92-33054
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers
[NASA-TM-104170] p 1138 N92-33160
Development of rating instruments and procedures for aviation mishap investigation
[AD-A253072] p 1044 N92-33288
Workshop on Aeronautical Decision Making (ADM). Volume 1: Executive summary
[DOT/FAA/RD-92/14-VOL-1] p 1142 N92-33305
On the calculation of the response of helicopters to control inputs
[NASA-CR-190812] p 1088 N92-33536
A workstation-based evaluation of a far-field route planner for helicopters
[NASA-TM-102882] p 1051 N92-33609
Finite difference time domain grid generation from AMC helicopter models
[NASA-TM-107679] p 1128 N92-34017
Experimental study of performance degradation of a rotating system in the NASA Lewis RC icing tunnel
[NASA-CR-190684] p 1102 N92-34141
Thermal mechanical analysis of sprag clutches
[NASA-CR-190686] p 1128 N92-34207

HELIOTRONS
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743

HIGH ALTITUDE
Design and wind tunnel test of low-Reynolds-number airfoil p 1029 A92-56047

HIGH CURRENT
Mechanisms of high-current pulses in lightning and long-spark stepped leaders p 1116 A92-54678

HIGH REYNOLDS NUMBER
High Reynolds number testing in support of transport airplane development
[AIAA PAPER 92-3982] p 1099 A92-56807
High-lift testing at high Reynolds numbers
[AIAA PAPER 92-3986] p 1033 A92-56810
An approach for increasing aeroelastic divergence dynamic pressure of wind-tunnel models
[AIAA PAPER 92-4002] p 1099 A92-56825

HIGH SPEED
An examination of several high resolution schemes applied to complex problems in high speed flows
[AD-A250814] p 1124 N92-32632
High speed transition prediction
[NASA-CR-190836] p 1039 N92-33424

HIGH TEMPERATURE
Electro optical system to measure strains at high temperature
[NASA-CR-190450] p 1127 N92-33696

HIGH TEMPERATURE AIR
Numerical study on the secondary jet into a supersonic flow p 1018 A92-53556

HIGH TEMPERATURE ENVIRONMENTS
The Langley 15-inch Mach 6 High Temperature Tunnel
[AIAA PAPER 92-3938] p 1096 A92-56768
Life prediction and constitutive models for engine hot section anisotropic materials program
[NASA-CR-189223] p 1072 N92-33479
Cooled high-temperature radial turbine program 2
[NASA-CR-189122] p 1073 N92-34236

HIGH TEMPERATURE GASES
Dynamic response of induced pressures, suckdown, and temperatures for two tandem jet STOVL configurations
[NASA-TM-103934] p 1039 N92-33581

HIGH TEMPERATURE LUBRICANTS
Liquid lubricants for advanced aircraft engines
[NASA-TM-104531] p 1109 N92-32863

HIGH TEMPERATURE RESEARCH
Electro optical system to measure strains at high temperature
[NASA-CR-190450] p 1127 N92-33696
High temperature aircraft research furnace facilities
[NASA-CR-184384] p 1101 N92-33826

HIGH TEMPERATURE TESTS
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729

HIGHLY MANEUVERABLE AIRCRAFT
Force production mechanisms of a tangential jet on bodies at high alpha
[AIAA PAPER 92-4648] p 1082 A92-55393

HISTORIES
Test facilities and instrumentation for research in rarefied gas dynamics - An historical perspective
[AIAA PAPER 92-3969] p 1098 A92-56795

HOLOGRAPHIC INTERFEROMETRY
Holographic and PLIF measurements of free-flight hypervelocity flows in the AEDC Range G facility
[AIAA PAPER 92-3935] p 1122 A92-56765
Electro optical system to measure strains at high temperature
[NASA-CR-190450] p 1127 N92-33696

HOLOGRAPHY
Holographic and PLIF measurements of free-flight hypervelocity flows in the AEDC Range G facility
[AIAA PAPER 92-3935] p 1122 A92-56765
Electro optical system to measure strains at high temperature
[NASA-CR-190450] p 1127 N92-33696

HONEYCOMB STRUCTURES
Development of aircraft bonded structure and the NDI method p 1016 A92-56100
Flow quality studies of the NASA Lewis Research Center 8- by 6-foot supersonic/9- by 15-foot Low Speed Wind Tunnel
[AIAA PAPER 92-3916] p 1095 A92-56748
Detection of honeycomb damage using hexagonal grid discontinuities
[DREP-89-9] p 1109 N92-32846
Active control of sound transmission through stiff lightweight composite fuselage constructions p 1137 N92-32957

HORIZONTAL FLIGHT
Optimal trajectories for an unmanned air-vehicle in the horizontal plane
[AIAA PAPER 92-4344] p 1079 A92-55333
Investigation of the flight control requirements of a half-scale ducted fan unmanned aerial vehicle
[AD-A252730] p 1087 N92-32988

HORIZONTAL TAIL SURFACES
Contribution of tailplane-mounted twin fins to sideforce, yawing moment, and rolling moment derivatives due to sideslip
[ESDU-92007] p 1086 N92-32487

HOT ISOSTATIC PRESSING
Titanium alloy casting for aerospace
p 1106 A92-56103
HOT SURFACES
Experimental investigation of the reflection of a shock wave on a heated surface in presence of a turbulent boundary layer p 1023 A92-54569
HOT-FILM ANEMOMETERS
Shock detection on airfoils by means of piezo foil- and hot film arrays p 1115 A92-54334
HOT-WIRE ANEMOMETERS
The use of silicon microsensors in smart skins for aerodynamic research p 1116 A92-54348
Measurements of turbulence in hypersonic flow
p 1092 A92-56005
HOVERING
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
Efficiency and accuracy in helicopter hovering performance calculation p 1053 A92-56072
Response of helicopter blades to a sharp collective increase p 1084 A92-56282
The computation and validation of hovering rotor performance p 1055 A92-56285
A time-dependent tip loss formula for rotor blade dynamic analysis p 1057 A92-56310
The identification of coupled flapping/inflow models for hovering flight p 1058 A92-56335
On the anomalies in single-jet hover suckdown data [NASA-TM-102261] p 1038 N92-33306
On the calculation of the response of helicopters to control inputs
[NASA-CR-190812] p 1088 N92-33536
On the estimation of jet-induced fountain lift and additional suckdown in hover for two-jet configurations
[NASA-TM-102268] p 1040 N92-33618
Design of helicopter flight control systems for hover and low speed using eigenstructure assignment
p 1061 N92-33952
HUBS
Design and testing of a composite hingeless hub for rotary-wing aircraft p 1053 A92-56075
HUMAN FACTORS ENGINEERING
Flight simulator test of cockpit advisory system
p 1054 A92-56115
Human factors issues in the use of artificial intelligence in air traffic control. October 1990 Workshop
[NASA-CR-190925] p 1051 N92-34203
HUMAN REACTIONS
Application of magnitude estimation scaling to the assessment of subjective loudness response to simulated sonic booms
[NASA-TM-107657] p 1138 N92-33719
HUMAN TOLERANCES
Exposures from headset interference tones
[AD-A247175] p 1136 N92-32697
Application of magnitude estimation scaling to the assessment of subjective loudness response to simulated sonic booms
[NASA-TM-107657] p 1138 N92-33719
HYDRAULIC CONTROL
An experimental study on variable pressure hydraulic flight control system p 1084 A92-56119
HYDRAULIC EQUIPMENT
An experimental study on variable pressure hydraulic flight control system p 1084 A92-56119
HYDRAULIC TEST TUNNELS
A laser fluorescence anemometer system for the Langley 16- by 24-inch water tunnel
p 1092 A92-54347
Aerodynamics laboratory education at Purdue University - Ground testing facilities
[AIAA PAPER 92-4018] p 1100 A92-56840
Static and dynamic flow visualization studies of two double-delta wing models at high angles of attack
[AD-A252878] p 1040 N92-33678
HYDRODYNAMICS
On the origin and acoustical behaviour of cloud cavitation
[ISBN-90-9004317-9] p 1125 N92-33066
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131
HYDROGEN
Numerical study on the secondary jet into a supersonic flow p 1018 A92-53556
H-N2 interaction energies, transport cross sections, and collision integrals p 1135 A92-54660
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301
[AD-A252912] p 1126 N92-33501
HYDROGEN ENGINES
Interaction between chemical reaction and turbulence in supersonic nonpremixed H2-air combustion
p 1117 A92-54931
HYDROGEN FUELS
A model study on diffuser pressure recovery in NAL scramjet test facility with simulated hydrogen combustion
[AIAA PAPER 92-3979] p 1071 A92-56805
HYPERSONIC AIRCRAFT
Japan pushes high speed research
p 1015 A92-53434
Current status of R&D on materials for super/hypersonic transports p 1106 A92-56002
Study on international cooperative test facilities for future SST/HST
[AIAA PAPER 92-3945] p 1097 A92-56775
A conceptual study for future engine test facility
[AIAA PAPER 92-3992] p 1099 A92-56815
HYPERSONIC COMBUSTION
Instrumentation key to NASP combustor tests
p 1092 A92-55100
HYPERSONIC FLIGHT
Some thermodynamical aspects in the optimization of supersonic combustors p 1065 A92-53486
Performance analysis of idealized scramjet
p 1066 A92-53493
Radiative heat transfer from nonequilibrium shock layer to a hypersonic reentry body p 1019 A92-53579
Concepts of flight experiments for HOPE development
p 1103 A92-53635
Aerodynamic studies on space plane configuration at hypersonic speed p 1019 A92-53641
Lateral control of spaceplane at hypersonic flight
p 1104 A92-56069
Integrated test and evaluation for hypervelocity systems
[AIAA PAPER 92-3901] p 1017 A92-56736
The trisonic wind tunnel Muenchen and its involvement in the German SAeNGER-programme
[AIAA PAPER 92-4019] p 1100 A92-56841
Study on supersonic combustion in a hypersonic flight
[IAF PAPER 92-0661] p 1106 A92-57101
Technologies for the National Aero-Space Plane
[IAF PAPER 92-0868] p 1105 A92-57259
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
Perspectives on hypersonic viscous and nonequilibrium flow research
[NASA-CR-190817] p 1039 N92-33413
Thermal-structural test facilities at NASA Dryden
[NASA-TM-104249] p 1062 N92-34202
HYPERSONIC FLOW
Hypersonic flows with air chemistry over a reentry vehicle at high altitudes p 1017 A92-53549
Calculations for aerodynamic characteristics of HOPE type vehicle in subsonic and hypersonic flow
p 1018 A92-53560
Thermally and chemically nonequilibrium hypersonic flow in three-dimensional geometry
p 1019 A92-53580
Numerical study of the 3-D flowfield for a supersonic jet exiting into a hypersonic stream from a conical surface
[AIAA PAPER 92-3675] p 1022 A92-54118
A fine-wire thermocouple probe for measurement of stagnation temperatures in real gas hypersonic flows of nitrogen p 1114 A92-54317
Efficient methods for inviscid non-equilibrium hypersonic flow fields p 1024 A92-54571
Application of a parallel direct simulation Monte Carlo method to hypersonic rarefied flows
p 1024 A92-54916
Measurements of turbulence in hypersonic flow
p 1092 A92-56005
A code validation strategy and facility for nonequilibrium, reacting flows
[AIAA PAPER 92-3970] p 1098 A92-56796
The SR3 low density wind tunnel - Facility capabilities and research development
[AIAA PAPER 92-3972] p 1098 A92-56798
Computational and numerical analysis of hypersonic nozzle flows with comparisons to wind tunnel calibration data
[AIAA PAPER 92-4011] p 1033 A92-56834
Hypersonic shock tunnel testing for undergraduate laboratory instruction
[AIAA PAPER 92-4021] p 1100 A92-56843
A database of aerothermal measurements in hypersonic flow for CFD validation
[AIAA PAPER 92-4023] p 1034 A92-56845
CFD validation experiments for hypersonic flows
[AIAA PAPER 92-4024] p 1034 A92-56846
Flow contamination and flow quality in arc heaters used for hypersonic testing
[AIAA PAPER 92-4028] p 1100 A92-56850
Numerical simulation of unsteady flow in a hypersonic shock tunnel facility
[AIAA PAPER 92-4029] p 1034 A92-56851
Perspectives on hypersonic viscous and nonequilibrium flow research
[NASA-CR-190817] p 1039 N92-33413
An approximate viscous shock layer technique for calculating chemically reacting hypersonic flows about blunt-nosed bodies p 1041 N92-33837
Computation and stability analysis of laminar flow over a blunt cone in hypersonic flow p 1041 N92-33839
HYPERSONIC INLETS
Comparison between computational and experimental data for a hypersonic laser propelled vehicle
[AIAA PAPER 92-3808] p 1023 A92-54179
HYPERSONIC NOZZLES
Unsteady shock propagation in a steady flow nozzle expansion p 1023 A92-54489
Experimental results for a hypersonic nozzle/afterbody flow field
[AIAA PAPER 92-3915] p 1032 A92-56747
Computational and numerical analysis of hypersonic nozzle flows with comparisons to wind tunnel calibration data
[AIAA PAPER 92-4011] p 1033 A92-56834
Hypersonic wind tunnel nozzle study
[AIAA PAPER 92-4012] p 1033 A92-56835
Boundary layer study on nozzle wall at hypersonic velocities
[AIAA PAPER 92-4013] p 1034 A92-56836
HYPERSONIC REENTRY
Analysis of spacecraft entry into Mars atmosphere
p 1105 N92-33763
HYPERSONIC SHOCK
Three-dimensional calculation of radiative field in hypersonic air shock layers p 1023 A92-54498
HYPERSONIC SPEED
Conceptual design of scramjet engine
p 1065 A92-53490
Key design considerations for scramjet powered space plane p 1066 A92-53491
Flow characterization in the NASA Ames 16-inch Shock Tunnel
[AIAA PAPER 92-3810] p 1090 A92-54180
New 1.27-m leg of the National Aerospace Laboratory hypersonic wind tunnel p 1092 A92-56003
HYPERSONIC TEST APPARATUS
Laser-driven hypersonic air-breathing propulsion simulator
[AIAA PAPER 92-3922] p 1095 A92-56753
Hypersonic aerodynamic/aerothermodynamic testing capabilities at Langley Research Center
[AIAA PAPER 92-3937] p 1096 A92-56767
HYPERSONIC VEHICLES
The study of experimental turboramjets
[AIAA PAPER 92-3720] p 1067 A92-54135
Getting up to speed in hypersonic structures
p 1117 A92-55127
Dynamics and control of hypersonic aeropropulsive/aeroelastic vehicles
[AIAA PAPER 92-4326] p 1073 A92-55170
An integrated development of the equations of motion for elastic hypersonic flight vehicles
[AIAA PAPER 92-4605] p 1077 A92-55283
Optimal launch trajectory of a hypersonic research vehicle
[AIAA PAPER 92-4302] p 1103 A92-55310
A guidance law for hypersonic descent to a point
[AIAA PAPER 92-4303] p 1104 A92-55311
PAYCOS, a multidisciplinary sizing code for hypersonic vehicles
[AIAA PAPER 92-4564] p 1132 A92-55376
Application of advanced multidisciplinary analysis and optimization methods to vehicle design synthesis
p 1054 A92-56160
The G-range impulse facility - A high-performance free-piston shock tunnel
[AIAA PAPER 92-3946] p 1097 A92-56774
TSNIIMASH capabilities for aerogasdynamical and thermal testing of hypersonic vehicles
[AIAA PAPER 92-3962] p 1097 A92-56789
CFD validation experiments for hypersonic flows
[AIAA PAPER 92-4024] p 1034 A92-56846
An integrated analytical aeropropulsive/aeroelastic model for the dynamic analysis of hypersonic vehicles
[AIAA PAPER 92-4567] p 1035 A92-57034
Combined exo/endoatmospheric transport alternatives
[IAF PAPER 92-0663] p 1104 A92-57102
The German Hypersonics Technology Programme - Status report 1992
[IAF PAPER 92-0867] p 1105 A92-57258
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
HYPERSONIC WIND TUNNELS
Aerodynamic heating characteristics of space planes tested by NAL hypersonic wind tunnel
p 1017 A92-53547

Nonintrusive measurements in fluid dynamic flows from Mach .0005 to 14 p 1090 A92-54311
Quantitative heat transfer measurements in hypersonic wind tunnels by means of infrared thermography p 1115 A92-54321
New 1.27-m leg of the National Aerospace Laboratory hypersonic wind tunnel p 1092 A92-56003
A hypersonic wind tunnel test of a mixed-compression air inlet model p 1028 A92-56007
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043
Future requirements for hypersonic aerodynamic and aerothermodynamic facilities
[AIAA PAPER 92-3903] p 1094 A92-56738
Supersonic and hypersonic quiet tunnel technology at NASA Langley
[AIAA PAPER 92-3908] p 1094 A92-56743
Experimental results for a hypersonic nozzle/afterbody flow field
[AIAA PAPER 92-3915] p 1032 A92-56747
Hypersonic aerodynamic/aerothermodynamic testing capabilities at Langley Research Center
[AIAA PAPER 92-3937] p 1096 A92-56767
The Langley 15-inch Mach 6 High Temperature Tunnel
[AIAA PAPER 92-3938] p 1096 A92-56768
Test description and preliminary pitot-pressure surveys for Langley Test Technique Demonstrator at Mach 6
[AIAA PAPER 92-3940] p 1096 A92-56770
A code validation strategy and facility for nonequilibrium, reacting flows
[AIAA PAPER 92-3970] p 1098 A92-56796
Rarefied gas research at Berkeley - Current studies and future potentials
[AIAA PAPER 92-3971] p 1098 A92-56797
CAN-DO, CFD-based Aerodynamic Nozzle Design and Optimization program for supersonic/hypersonic wind tunnels
[AIAA PAPER 92-4009] p 1033 A92-56832
Hypersonic wind tunnel nozzle study
[AIAA PAPER 92-4012] p 1033 A92-56835
Pilot-pressure probe for measuring pressure in a hypersonic wind tunnel
[NASA-CASE-LAR-14232-1] p 1102 N92-34213

HYPERVELOCITY FLOW
Nonintrusive measurements in fluid dynamic flows from Mach .0005 to 14 p 1090 A92-54311
Approximate Riemann solver for hypervelocity flows p 1117 A92-54934
Holographic and PLIF measurements of free-flight hypervelocity flows in the AEDC Range G facility
[AIAA PAPER 92-3935] p 1122 A92-56765
The high enthalpy shock tunnel in Goettingen
[AIAA PAPER 92-3942] p 1104 A92-56772
Millisecond aerodynamic force measurement with side-jet model in the ISL shock tunnel
[AIAA PAPER 92-3963] p 1097 A92-56790
Effects of oxygen dissociation on hypervelocity combustion experiments
[AIAA PAPER 92-3964] p 1098 A92-56791

HYPERVELOCITY GUNS
Experimental and computational investigation of scaling phenomena in a large caliber ram accelerator
[AIAA PAPER 92-3245] p 1103 A92-54019

HYPERVELOCITY PROJECTILES
Experimental and computational investigation of scaling phenomena in a large caliber ram accelerator
[AIAA PAPER 92-3245] p 1103 A92-54019
Holographic and PLIF measurements of free-flight hypervelocity flows in the AEDC Range G facility
[AIAA PAPER 92-3935] p 1122 A92-56765

HYPERVELOCITY WIND TUNNELS
Notes on the use of fusible temperature indicators to bound the temperature of hot graphite in the NAVSWC hypervelocity wind tunnel facility p 1090 A92-54315
A new system for recording unstable aerodynamic phenomena in NAVSWC Hypervelocity Wind Tunnel No. 9 p 1091 A92-54325
Hypervelocity Wind Tunnel 9 control system p 1092 A92-54343
Hypersonic aerodynamic/aerothermodynamic testing capabilities at Langley Research Center
[AIAA PAPER 92-3937] p 1096 A92-56767
Boundary layer study on nozzle wall at hypersonic velocities
[AIAA PAPER 92-4013] p 1034 A92-56836

I

ICE
Feasibility of measuring transverse electric noise at VLF and LF on an ice cap
[AD-A252280] p 1129 N92-33220
Experimental study of performance degradation of a rotating system in the NASA Lewis RC icing tunnel
[NASA-CR-190684] p 1102 N92-34141
Analysis of iced wings
[NASA-TM-105773] p 1042 N92-34144

ICE CLOUDS
Predicting droplet impingement on yawed wings p 1043 A92-56180

ICE FORMATION
Effect of a simulated glaze ice shape on the aerodynamic performance of a rectangular wing
[AIAA PAPER 92-4042] p 1035 A92-56861
Numerical investigation of the effects of icing on fixed and rotary wing aircraft
[NASA-CR-190542] p 1044 N92-34105
Experimental study of performance degradation of a rotating system in the NASA Lewis RC icing tunnel
[NASA-CR-190684] p 1102 N92-34141
Analysis of iced wings
[NASA-TM-105773] p 1042 N92-34144

IDEAL FLUIDS
A potential flow theory of two-dimensional bifurcated curtain jets. II p 1118 A92-56039

IDEAL GAS
Comparison between computational and experimental data for a hypersonic laser propelled vehicle
[AIAA PAPER 92-3808] p 1023 A92-54179

IMAGE ANALYSIS
Image processing in the undergraduate fluid dynamics laboratory
[AIAA PAPER 92-4020] p 1141 A92-56842

IMAGE ENHANCEMENT
The C-17 Multifunction Display - A building block for avionic systems p 1063 A92-55907

IMAGE PROCESSING
Quantitative heat transfer measurements in hypersonic wind tunnels by means of infrared thermography p 1115 A92-54321
Analysis of image-based navigation system for rotorcraft low-altitude flight p 1046 A92-55968
Image processing in the undergraduate fluid dynamics laboratory
[AIAA PAPER 92-4020] p 1141 A92-56842
Detection of honeycomb damage using hexagonal grid discontinuities
[DREP-89-9] p 1109 N92-32846

IMAGE VELOCITY SENSORS
Particle image velocimetry measurements of the aerodynamics of a wind turbine p 1115 A92-54337

IMPACT DAMAGE
Damage tolerance certification methodology for composite structures p 1108 N92-32579
CFRP stiffened panels under compression p 1109 N92-33044

IMPACT TESTS
Design, evaluation and experimental effort toward development of a high strain composite wing for Navy aircraft p 1107 N92-32514

IMPELLERS
Effects of curvature and rotation on turbulence in the NASA low-speed centrifugal compressor impeller p 1124 N92-32292

IMPROVEMENT
Accomplishments under the Airport Improvement Program, FY 1991
[AD-A253046] p 1101 N92-33434

IN-FLIGHT MONITORING
In-flight optimization of the total propulsion system
[AIAA PAPER 92-3744] p 1068 A92-54146
In-flight performance diagnostic capability of an adaptive engine model
[AIAA PAPER 92-3746] p 1068 A92-54147

INDUCED DRAG
Aerodynamic calculation of an elliptic ring wing
[AIAA PAPER 91-0068] p 1035 A92-57035
Applications of a direct/iterative design method to complex transonic configurations
[NASA-TP-3234] p 1039 N92-33484

INERTIAL NAVIGATION
A Kalman filter integrated navigation design for the IAR Twin Otter Atmospheric Research Aircraft
[NRC-32148] p 1048 N92-32849
The use of Kalman filtering techniques to improve the accuracy of flight test data
[NRC-32139] p 1064 N92-32850

INERTIAL PLATFORMS
The effect of gyro nonorthogonality error on gyrocompassing p 1045 A92-55955
Evaluation of a IMU with optical fiber gyros in dynamic windtunnel tests p 1104 A92-56121

INFORMATION DISSEMINATION
US Coast Guard GPS Information Center (GPSIC) and its function within the Civil GPS Service (CGS) p 1049 N92-33352

INFORMATION MANAGEMENT
The development of an airborne information management system for flight test
[NASA-TM-104251] p 1065 N92-32866
An international aerospace information system: A cooperative opportunity
[NASA-TM-108171] p 1142 N92-33237

INFORMATION SYSTEMS
A development of hypermedia type database system for instruction of aircraft conceptual design p 1132 A92-56113
An international aerospace information system: A cooperative opportunity
[NASA-TM-108171] p 1142 N92-33237
US Coast Guard GPS Information Center (GPSIC) and its function within the Civil GPS Service (CGS) p 1049 N92-33352
LORAN-C data reduction at the US Naval Observatory p 1050 N92-33358

INFRARED IMAGERY
Problems and solutions for transition detection in cryogenic wind tunnels by infrared imaging p 1090 A92-54319

INFRARED RADIOMETERS
Quantitative heat transfer measurements in hypersonic wind tunnels by means of infrared thermography p 1115 A92-54321

INGESTION (ENGINES)
Bird ingestion into large turbofan engines
[DOT/FAA/CT-91/17] p 1043 N92-33005

INLET FLOW
Full Navier-Stokes calculations on the installed F/A-18 inlet at a high angle of attack
[AIAA PAPER 92-3175] p 1020 A92-54012
Results of a perturbation analysis correlating flows entering and exiting an aircraft inlet system
[AIAA PAPER 92-3624] p 1021 A92-54091
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
Thermal paints for shock/boundary layer interaction in inlet flows
[AIAA PAPER 92-3626] p 1113 A92-54093
Methodology for calculating aerodynamic sensitivity derivatives p 1024 A92-54911
A hypersonic wind tunnel test of a mixed-compression air inlet model p 1028 A92-56007
Development of local nonintrusive measurements of inlet and exhaust flows for the ground testing of air-breathing engines
[AIAA PAPER 92-3899] p 1122 A92-56735
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[NASA-TM-105672] p 1128 N92-34112

INLET PRESSURE
Results of a perturbation analysis correlating flows entering and exiting an aircraft inlet system
[AIAA PAPER 92-3624] p 1021 A92-54091
An acceptance process for the evaluation of inlet distortion
[AIAA PAPER 92-3918] p 1032 A92-56750

INLET TEMPERATURE
Development of the full-envelope Performance Seeking Control algorithm
[AIAA PAPER 92-3748] p 1068 A92-54148
Cooled high-temperature radial turbine program 2
[NASA-CR-189122] p 1073 N92-34236

INSPECTION
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480
Inspection of fabricated fuselage panels using electronic shearography
[DOT/FAA/CT-TN92/26] p 1127 N92-33627

INSTRUMENT COMPENSATION
Computational and numerical analysis of hypersonic nozzle flows with comparisons to wind tunnel calibration data
[AIAA PAPER 92-4011] p 1033 A92-56834

INSTRUMENT ERRORS
The effect of gyro nonorthogonality error on gyrocompassing p 1045 A92-55955
Development of an uncertainty methodology for multiple-channel instrumentation systems
[AIAA PAPER 92-3953] p 1133 A92-56781
A Kalman filter integrated navigation design for the IAR Twin Otter Atmospheric Research Aircraft
[NRC-32148] p 1048 N92-32849

INSTRUMENT FLIGHT RULES
An evaluation of decelerating IFR approaches utilizing a helicopter flight simulator
[CTN-92-60348] p 1048 N92-32845
Federal aviation regulations. Part 91: General operating and flight rules
[PB92-197334] p 1017 N92-33176

Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081
INSTRUMENT LANDING SYSTEMS
Aircraft accident report: L'Express Airlines, Inc., Flight 508, Beech C99, N7217L weather encounter and crash near Birmingham, Alabama, July 10, 1991
[PB92-910401] p 1043 N92-32455
ILS mathematical modeling study of an ILS localizer and glide slope proposed for runway 32R, Moffett Field Airport, California
[DOT/FAA/CT-TN92/28] p 1048 N92-33308
INSTRUMENT PACKAGES
Development of an uncertainty methodology for multiple-channel instrumentation systems
[AIAA PAPER 92-3953] p 1133 A92-56781
INTEGRATED CIRCUITS
The use of silicon microsensors in smart skins for aerodynamic research p 1116 A92-54348
INTEGRATED MISSION CONTROL CENTER
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
INTERACTIONAL AERODYNAMICS
Experimental investigation on turbulent phenomena in three-dimensional shock wave/turbulent boundary layer interaction induced by blunt fin p 1018 A92-53557
Interaction between a body flying at a supersonic velocity and a point explosion p 1019 A92-53867
Experimental study on three-dimensional shock wave-turbulent boundary layer interaction induced by protuberance p 1019 A92-53997
Thermal paints for shock/boundary layer interaction in inlet flows
[AIAA PAPER 92-3626] p 1113 A92-54093
An experimental examination of the effects of incoming boundary layer modifications on the dynamics of a turbulent compression corner interaction
[AIAA PAPER 92-3667] p 1022 A92-54111
A laser fluorescence anemometer system for the Langley 16- by 24-inch water tunnel p 1092 A92-54347
The interaction between a high-frequency gust and a blade row p 1135 A92-54484
Active control of asymmetric vortical flows around cones using injection and heating
[AIAA PAPER 92-4426] p 1025 A92-55350
Navier-Stokes prediction of large-amplitude delta-wing roll oscillations characterizing wing rock
[AIAA PAPER 92-4428] p 1080 A92-55352
Vortical flow control on a wing-body combination using tangential blowing
[AIAA PAPER 92-4430] p 1081 A92-55354
Tow-tank study of nonlinear aerodynamics of a 2-D airfoil
[AIAA PAPER 92-4499] p 1026 A92-55367
Robust identification of nonlinear aerodynamic model structure
[AIAA PAPER 92-4503] p 1081 A92-55370
Approximate aerodynamic analysis of jet interaction
[AIAA PAPER 92-4640] p 1027 A92-55387
Force production mechanisms of a tangential jet on bodies at high alpha
[AIAA PAPER 92-4648] p 1082 A92-55393
Unsteady shock-vortex interaction on a flexible delta wing p 1030 A92-56157
Euler/experiment correlation of a generic fighter p 1031 A92-56164
Trimming rotor blades with periodically deflecting trailing edge flaps p 1085 A92-56283
Current European research activities in helicopter interactional aerodynamics p 1058 A92-56330
Wind tunnel blockage effects on slender wings undergoing large amplitude motions
[AIAA PAPER 92-3926] p 1096 A92-56757
A multi-diagnostic approach to testing V/STOL craft
[AIAA PAPER 92-4008] p 1099 A92-56831
Numerical modeling of transonic juncture flow
[AIAA PAPER 92-4036] p 1035 A92-56858
Increasing the accuracy of the Godunov scheme for calculating steady-state supersonic gas flows by solving the generalized Riemann problem p 1035 A92-57499
Further development of the CANAERO computer code to include propulsor modelling
[DREA-CR-90-425] p 1038 N92-32811
Effect of afterbody geometry on aerodynamic characteristics of isolated nonaxisymmetric afterbodies at transonic Mach numbers
[NASA-TP-3236] p 1041 N92-33706
INTERFACIAL TENSION
Fundamental studies on Marangoni convection related to Bridgman crystal growth p 1111 A92-53758
Flow induction by pressure forces
[AIAA PAPER 92-3571] p 1067 A92-54060
Stokes flows in superposed immiscible liquids with horizontal heating
[IAF PAPER 92-0909] p 1123 A92-57288
INTERFERENCE
Exposures from headset interference tones
[AD-A247175] p 1136 N92-32697
INTERFERENCE DRAG
Applications of a direct/iterative design method to complex transonic configurations
[NASA-TP-3234] p 1039 N92-33484
INTERFEROMETERS
Electro optical system to measure strains at high temperature
[NASA-CR-190450] p 1127 N92-33696
INTERNATIONAL COOPERATION
Study on international cooperative test facilities for future SST/HST
[AIAA PAPER 92-3945] p 1097 A92-56775
An international aerospace information system: A cooperative opportunity
[NASA-TM-108171] p 1142 N92-33237
INTERPOLATION
Global/local methods research using the CSM testbed p 1107 N92-32528
INVENTORIES
Developing robust support structures for high-technology subsystems: The AH-64 Apache *helicopter*
[AD-A252773] p 1017 N92-33499
INVERSIONS
Nonlinear dynamic-inversion flight control of supermaneuverable aircraft p 1062 N92-33953
INVISCID FLOW
The behaviour of the pressure temperature and density in an inviscid unsteady transonic axisymmetric flow with shock waves p 1018 A92-53553
A comparison of the calculated and experimental off-design performance of a radial flow turbine
[AIAA PAPER 92-3069] p 1020 A92-54004
Efficient methods for inviscid non-equilibrium hypersonic flow fields p 1024 A92-54571
Methodology for calculating aerodynamic sensitivity derivatives p 1024 A92-54911
Investigation of advancing front method for generating unstructured grid
[NASA-CR-190902] p 1128 N92-34043
Analysis of iced wings
[NASA-TM-105773] p 1042 N92-34144
IRON ALLOYS
Diffusion bonding a creep-resistant Fe-ODS alloy p 1117 A92-54868
ISOTHERMAL PROCESSES
Isothermal aging of IM7/8320 and IM7/5260
[NASA-TM-107666] p 1110 N92-33423
ITERATIVE SOLUTION
Efficient iterative methods for the transonic small disturbance equation p 1025 A92-54933

J

JAPANESE SPACE PROGRAM
Japan pushes high speed research p 1015 A92-53434
Concepts of flight experiments for HOPE development p 1103 A92-53635
JAPANESE SPACECRAFT
Calculations for aerodynamic characteristics of HOPE type vehicle in subsonic and hypersonic flow p 1018 A92-53560
Study of potassium turbine electric generator system p 1129 N92-33794
JET AIRCRAFT
On the estimation of jet-induced fountain lift and additional suckdown in hover for two-jet configurations
[NASA-TM-102268] p 1040 N92-33618
JET AIRCRAFT NOISE
Full Navier-Stokes analysis of a two-dimensional mixer/ejector nozzle for noise suppression
[AIAA PAPER 92-3570] p 1067 A92-54059
Broadband shock associated noise from supersonic jets measured by a ground observer p 1135 A92-54909
Acoustic loads prediction on jet aircraft p 1136 N92-32949
MD-80 aft cabin noise control: A case history p 1137 N92-32950
Pilots noise exposure during a Boeing 747-400 round trip: Ambient noise and acoustic-head recording and analysis of data p 1137 N92-32960
Pilot noise exposure during a Boeing 747-400 round trip: Judgement of noise and analysis in respect to hearing impairment of pilots p 1138 N92-32961
JET ENGINE FUELS
Jet fuel absorption and dynamic mechanical analysis of carbon fibre composites p 1110 N92-33050
JET ENGINES
Degenerate four-wave mixing for measurement of NO2 and smoke concentration in jet engine exhaust
[AIAA PAPER 92-3658] p 1113 A92-54108
Fault diagnostics on jet engine starting p 1116 A92-54345
Current repair technologies for jet engine components p 1016 A92-56085
JET FLOW
Structure and penetration of a transverse fluid jet injected at supercritical pressure in supersonic flow
[AIAA PAPER 92-3652] p 1113 A92-54105
Experimental observations of instability modes in a rectangular jet p 1135 A92-54908
Approximate aerodynamic analysis of jet interaction
[AIAA PAPER 92-4640] p 1027 A92-55387
Force production mechanisms of a tangential jet on bodies at high alpha
[AIAA PAPER 92-4648] p 1082 A92-55393
A potential flow theory of two-dimensional bifurcated curtain jets. II p 1118 A92-56039
Numerical simulation of turbulence at the back of the airplane
[ETN-92-91664] p 1037 N92-32769
On the anomalies in single-jet hover suckdown data
[NASA-TM-102261] p 1038 N92-33306
JET IMPINGEMENT
Experimental and numerical investigation of a supersonic free jet impinging on a perpendicular surface p 1018 A92-53555
Three-dimensional numerical analysis of impinging circular jet - Discrete vortex method p 1029 A92-56040
On the anomalies in single-jet hover suckdown data
[NASA-TM-102261] p 1038 N92-33306
JET MIXING FLOW
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
Acoustic control of combustor primary zone air-jet mixing
[AIAA PAPER 92-3651] p 1067 A92-54104
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
Acoustic loads prediction on jet aircraft p 1136 N92-32949
JET NOZZLES
Full Navier-Stokes analysis of a two-dimensional mixer/ejector nozzle for noise suppression
[AIAA PAPER 92-3570] p 1067 A92-54059
JET PROPULSION
Flow induction by pressure forces
[AIAA PAPER 92-3571] p 1067 A92-54060
JET THRUST
Lateral control of spaceplane at hypersonic flight p 1104 A92-56069
JOINED WINGS
A low speed wind tunnel investigation of a joined-wing aircraft with an overhanging fin p 1030 A92-56078
A low speed wind tunnel investigation of the direct side force control of a joined-wing aircraft with overhanging fin p 1084 A92-56079
JOINTS (JUNCTIONS)
Out of plane analysis for composite structures p 1107 N92-32527
JP-4 JET FUEL
Fluid effects: Thermoset and thermoplastic matrix composites p 1110 N92-33049
JP-5 JET FUEL
The VRT gas turbine combustor - Phase II
[AIAA PAPER 92-3471] p 1067 A92-54035

K

K-EPSILON TURBULENCE MODEL
Assessment of compressibility corrections to the k-epsilon model in high-speed shear layers p 1024 A92-54905
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
Navier-Stokes analysis and experimental data comparison of compressible flow in a diffusing S-duct
[NASA-TM-105683] p 1072 N92-33746
KALMAN FILTERS
Integration of radar altimeter, precision navigation, and digital terrain data for low-altitude flight
[AIAA PAPER 92-4420] p 1063 A92-55212
A data fusion algorithm for multi-sensor microburst hazard assessment
[AIAA PAPER 92-4339] p 1063 A92-55328
Vision-based range estimation using helicopter flight data
[NASA-TM-103930] p 1047 N92-32424

The use of Kalman filtering techniques to improve the accuracy of flight test data
[NRC-32139] p 1064 N92-32850
KALMAN-SCHMIDT FILTERING
A Kalman filter integrated navigation design for the IAR Twin Otter Atmospheric Research Aircraft
[NRC-32148] p 1048 N92-32849
The use of Kalman filtering techniques to improve the accuracy of flight test data
[NRC-32139] p 1064 N92-32850
KEVLAR (TRADEMARK)
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
KINEMATIC EQUATIONS
An integrated development of the equations of motion for elastic hypersonic flight vehicles
[AIAA PAPER 92-4605] p 1077 A92-55283
KINETIC ENERGY
Further studies of kinetic energy methods in high speed ramjet cycle analysis
[AIAA PAPER 92-3805] p 1069 A92-54177
Synthesis of gust load alleviation with flutter margin augmentation p 1082 A92-56021
KNOWLEDGE REPRESENTATION
Discrete event fuzzy airport control
p 1046 A92-55973

L

LABORATORIES
Development and integration of modern laboratories in aerospace education
[AIAA PAPER 92-4022] p 1141 A92-56844
LAMINAR BOUNDARY LAYER
Enhancement of laminar boundary layer heat transfer by a vortex generator p 1118 A92-55453
Method of reducing drag in aerodynamic systems
[NASA-CASE-LEW-14791-1] p 1043 N92-34243
LAMINAR FLOW
High subsonic wind tunnel test of a two-dimensional hybrid-laminar-flow-control airfoil with slotted surface
p 1029 A92-56045
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063
Computation and stability analysis of laminar flow over a blunt cone in hypersonic flow p 1041 N92-33839
LAMINATES
Mechanical properties of laminate aluminum matrix composites p 1106 A92-56102
Repair procedures for advanced composites for helicopters p 1016 A92-56277
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
Out of plane analysis for composite structures
p 1107 N92-32527
Global/local methods research using the CSM testbed
p 1107 N92-32528
Residual strength of repaired graphite/epoxy laminates after 5 years of outdoor exposure p 1108 N92-32577
Damage tolerance certification methodology for composite structures p 1108 N92-32579
Initial postbuckling response of an unsymmetrically laminated rectangular plate p 1108 N92-32586
CFRP stiffened panels under compression
p 1109 N92-33044
Global/local interlaminar stress analysis of a grid-stiffened composite panel
[NASA-CR-190822] p 1125 N92-33139
Isothermal aging of IM7/8320 and IM7/5260
[NASA-TM-107666] p 1110 N92-33423
Continuation of tailored composite structures of ordered staple thermoplastic material
[NASA-CR-189671] p 1110 N92-33613
LANDING AIDS
Robust control design of an automatic carrier landing system
[AIAA PAPER 92-4619] p 1077 A92-55296
LANDING GEAR
Structural design and testing results of composite landing gear components p 1057 A92-56328
Landing gear mechanism including runway-roughness restrictor assembly
[CA-PATENT-1-257-618] p 1061 N92-33585
LANDING RADAR
Talons 95 GHz radar sensor for autonomous landing guidance p 1063 A92-55908
LASER ANEMOMETERS
A laser fluorescence anemometer system for the Langley 16- by 24-inch water tunnel
p 1092 A92-54347
LASER APPLICATIONS
Measurement of position and attitude using laser and retro-reflectors p 1047 A92-56120
Inspection of fabricated fuselage panels using electronic shearography
[DOT/FAA/CT-TN92/26] p 1127 N92-33627
LASER DOPPLER VELOCIMETERS
Nonintrusive measurements in fluid dynamic flows from Mach .0005 to 14 p 1090 A92-54311
Comparison of frequency domain and time domain laser velocimeter signal processors p 1114 A92-54314
Signal processing schemes for Doppler global velocimetry p 1115 A92-54338
Investigation of a plate-ramp-configuration by means of laser Doppler anemometry at Mach 2.95
[AIAA PAPER 92-3956] p 1097 A92-56784
Vaporizing particle velocimeter
[NASA-CASE-LAR-14685-1] p 1042 N92-34172
LASER HEATING
Laser-driven hypersonic air-breathing propulsion simulator
[AIAA PAPER 92-3922] p 1095 A92-56753
LASER INDUCED FLUORESCENCE
A laser fluorescence anemometer system for the Langley 16- by 24-inch water tunnel
p 1092 A92-54347
Holographic and PLIF measurements of free-flight hypervelocity flows in the AEDC Range G facility
[AIAA PAPER 92-3935] p 1122 A92-56765
LASER PUMPING
Degenerate four-wave mixing for measurement of NO2 and smoke concentration in jet engine exhaust
[AIAA PAPER 92-3658] p 1113 A92-54108
LATERAL CONTROL
Gain scheduled linear PID autopilot for the AIAA Controls Design Challenge aircraft
[AIAA PAPER 92-4629] p 1078 A92-55304
Lateral control of spaceplane at hypersonic flight
p 1104 A92-56069
LATTICES (MATHEMATICS)
Flutter analyses using high speed computers. Part 2: Aerodynamic procedures p 1089 N92-34169
LEADING EDGES
Increased heat transfer to elliptical leading edges due to spanwise variations in the freestream momentum - Numerical and experimental results
[AIAA PAPER 92-3070] p 1020 A92-54005
Analysis of the onset of dynamic stall
p 1024 A92-54919
Pulsating spanwise blowing on a fighter aircraft
[AIAA PAPER 92-4359] p 1025 A92-55345
Model flight tests of a spin-resistant trainer configuration p 1054 A92-56158
Forcing level effects of internal acoustic excitation on the improvement of airfoil performance
p 1136 A92-56162
Predicting droplet impingement on yawed wings
p 1043 A92-56180
Experimental unsteady pressures on an oscillating cascade with supersonic leading edge locus
[AIAA PAPER 92-4035] p 1035 A92-56857
Vortex flow visualization using colored and fluorescent dyes on flat plate delta wing with leading edge extension
[AD-A251139] p 1036 N92-32651
Unsteady response of the leading-edge vortices on a pitching delta wing p 1041 N92-33851
LEAKAGE
Effects of material choices on brush seal performance
p 1116 A92-54650
LEAST SQUARES METHOD
Application of recursive partially unknown system identification to aerodynamic coefficients estimation
[AIAA PAPER 92-4504] p 1081 A92-55371
LIFE (DURABILITY)
Cost/benefit analysis of the AH-64 (Apache) helicopter Automated Test Equipment (ATE)
[AD-A252909] p 1101 N92-33398
Life prediction and constitutive models for engine hot section anisotropic materials program
[NASA-CR-189223] p 1072 N92-33479
LIFE CYCLE COSTS
Cost/benefit analysis of the AH-64 (Apache) helicopter Automated Test Equipment (ATE)
[AD-A252909] p 1101 N92-33398
LIFT
Use of an approximate similarity principle for the thermal scaling of a full-scale thrust augmenting ejector
[AIAA PAPER 92-3792] p 1069 A92-54171
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
Two-fence concept for efficient trapping of vortices on airfoils p 1031 A92-56165
High Reynolds number testing in support of transport airplane development
[AIAA PAPER 92-3982] p 1099 A92-56807
High-lift testing at high Reynolds numbers
[AIAA PAPER 92-3986] p 1033 A92-56810
Lift and rolling moment due to spoilers on wings with trailing-edge flaps deflected at subsonic speeds
[ESDU-92002-SUPPL] p 1037 N92-32782
On the estimation of jet-induced fountain lift and additional suckdown in hover for two-jet configurations
[NASA-TM-102268] p 1040 N92-33618
LIFT DRAG RATIO
Grid studies for thin-layer Navier-Stokes computations of airfoil flowfields p 1025 A92-54935
LIFTING BODIES
Small two-dimensional surface excrescences on aircraft wings approaching separation p 1031 A92-56170
Predicted aerodynamic characteristics for HL-20 lifting-body using the aerodynamic preliminary analysis system (APAS)
[AIAA PAPER 92-3941] p 1033 A92-56771
Aerodynamic centre of wing-body combinations
[ESDU-92024] p 1036 N92-32479
LIFTING ROTORS
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
LIGHTNING
Mechanisms of high-current pulses in lightning and long-spark stepped leaders p 1116 A92-54678
Lightning strike tests of composite connectors
[AD-A252281] p 1044 N92-33249
LINEAR QUADRATIC GAUSSIAN CONTROL
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
LINEAR QUADRATIC REGULATOR
An algorithm for robust eigenstructure assignment using the Linear Quadratic Regulator
[AIAA PAPER 92-4478] p 1131 A92-55237
Gain scheduled linear PID autopilot for the AIAA Controls Design Challenge aircraft
[AIAA PAPER 92-4629] p 1078 A92-55304
Synthesis of gust load alleviation with flutter margin augmentation p 1082 A92-56021
Robust control system design with multiple model approach p 1083 A92-56029
LINEAR TRANSFORMATIONS
Computational algorithms for increased control of depth-viewing volume for stereo three-dimensional graphic displays
[NASA-TM-4379] p 1065 N92-34109
LIQUID NITROGEN
Structure and penetration of a transverse fluid jet injected at supercritical pressure in supersonic flow
[AIAA PAPER 92-3652] p 1113 A92-54105
LIQUID-LIQUID INTERFACES
Stokes flows in superposed immiscible liquids with horizontal heating
[IAF PAPER 92-0909] p 1123 A92-57288
LIQUID-SOLID INTERFACES
Experimental study of convection effects around the phase charge interface p 1111 A92-53755
LOAD DISTRIBUTION (FORCES)
Force production mechanisms of a tangential jet on bodies at high alpha
[AIAA PAPER 92-4648] p 1082 A92-55393
Effects of spectrum variations on fatigue crack growth
p 1123 A92-57399
LOADS (FORCES)
Landing gear mechanism including runway-roughness restrictor assembly
[CA-PATENT-1-257-618] p 1061 N92-33585
LOGIC DESIGN
Safety study of TCAS 2 for logic version 6.04
[DOT/FAA/RD-92/22] p 1047 N92-32537
LOGISTICS
Developing robust support structures for high-technology subsystems: The AH-64 Apache helicopter
[AD-A252773] p 1017 N92-33499
LONGITUDE MEASUREMENT
Measurements of longitudinal static aerodynamic coefficients with cable mount system
p 1093 A92-56013
LONGITUDINAL CONTROL
Gain scheduled linear PID autopilot for the AIAA Controls Design Challenge aircraft
[AIAA PAPER 92-4629] p 1078 A92-55304
Multiaxis control in longitudinal mode of aircraft
p 1083 A92-56027
Robust control system design with multiple model approach p 1083 A92-56029
Flight control system design using H(infinity) optimal control p 1083 A92-56030
LONGITUDINAL STABILITY
Stability and dynamic coupling of elastic vehicles with unsteady aerodynamic forces considered
p 1102 A92-53545
Multiple delay model approach applied to the AIAA 1922 Controls Design Challenge
[AIAA PAPER 92-4630] p 1078 A92-55305

LOOP ANTENNAS
Transfer function between airborne VLF transmit and receive loop antenna p 1045 A92-54754
LORAN
A Kalman filter integrated navigation design for the IAR Twin Otter Atmospheric Research Aircraft
[NRC-32148] p 1048 N92-32849
LORAN C
LORAN-C data reduction at the US Naval Observatory p 1050 N92-33358
LOSSES
An improved compressor performance prediction model
[PNR-90873] p 1072 N92-33749
LOUDNESS
Application of magnitude estimation scaling to the assessment of subjective loudness response to simulated sonic booms
[NASA-TM-107657] p 1138 N92-33719
The effect of turbulence on the loudness of minimized sonic boom signatures p 1139 N92-33880
Subjective loudness response to simulated sonic booms p 1140 N92-33885
LOUDSPEAKERS
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964
LOW ALTITUDE
Analysis of image-based navigation system for rotorcraft low-altitude flight p 1046 A92-55968
LOW ASPECT RATIO
Experimental observations of instability modes in a rectangular jet p 1135 A92-54908
Formation and sustainment of a very low aspect ratio tokamak using coaxial helicity injection: Helicity Injected Torus (HIT) experiment
[DE92-014311] p 1136 N92-32595
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
LOW ASPECT RATIO WINGS
Flutter analysis and wind tunnel test with respect to a low-aspect-ratio wing with free-rotational control surface p 1052 A92-56014
Analysis and wind tunnel test of low aspect wing gust load alleviation p 1053 A92-56020
Aeroelastic effects of spoiler surfaces on a low-aspect-ratio rectangular wing p 1030 A92-56154
Numerical modeling of transonic juncture flow
[AIAA PAPER 92-4036] p 1035 A92-56858
LOW DENSITY FLOW
Direct simulation of low-density flow over airfoils p 1030 A92-56159
LOW FREQUENCIES
Feasibility of measuring transverse electric noise at VLF and LF on an ice cap
[AD-A252280] p 1129 N92-33220
LOW NOISE
The design of a subsonic low-noise, low-turbulence wind tunnel for acoustic measurements
[AIAA PAPER 92-3883] p 1094 A92-56726
LOW REYNOLDS NUMBER
Design and wind tunnel test of low-Reynolds-number airfoil p 1029 A92-56047
A quiet-flow Ludwieg tube for experimental study of high speed boundary layer transition
[AIAA PAPER 92-3885] p 1094 A92-56727
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
LOW SPEED
Effects of curvature and rotation on turbulence in the NASA low-speed centrifugal compressor impeller p 1124 N92-32292
LOW SPEED WIND TUNNELS
Automatic control of test parameters for intake measurements in a low-speed wind tunnel p 1091 A92-54341
Effects of the roll angle on cruciform wing-body configurations at high incidences
[AIAA PAPER 92-4356] p 1079 A92-55342
Low-speed wind tunnel testing for the high-speed propeller at high shaft angle of attack p 1030 A92-56054
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055
A low speed wind tunnel investigation of a joined-wing aircraft with an overhanging fin p 1030 A92-56078
A low speed wind tunnel investigation of the direct side force control of a joined-wing aircraft with overhanging fin p 1084 A92-56079
Flow quality studies of the NASA Lewis Research Center 8- by 6-foot supersonic/9- by 15-foot Low Speed Wind Tunnel
[AIAA PAPER 92-3916] p 1095 A92-56748
An overview of the planned aerospace test facilities at Capua, Italy
[AIAA PAPER 92-3944] p 1097 A92-56773
LOW TEMPERATURE
Viscosity characteristics of synthetic aviation oils at low temperatures p 1105 A92-53875
LOW TURBULENCE
The design of a subsonic low-noise, low-turbulence wind tunnel for acoustic measurements
[AIAA PAPER 92-3883] p 1094 A92-56726
LUBRICANT TESTS
Liquid lubricants for advanced aircraft engines
[NASA-TM-104531] p 1109 N92-32863
LUBRICATING OILS
Viscosity characteristics of synthetic aviation oils at low temperatures p 1105 A92-53875
Liquid lubricants for advanced aircraft engines
[NASA-TM-104531] p 1109 N92-32863
LUBRICATION SYSTEMS
Liquid lubricants for advanced aircraft engines
[NASA-TM-104531] p 1109 N92-32863

M

MACH NUMBER
Conceptual design of scramjet engine p 1065 A92-53490
Aerodynamic heating characteristics of space planes tested by NAL hypersonic wind tunnel p 1017 A92-53547
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
Direct simulation of low-density flow over airfoils p 1030 A92-56159
An approach for increasing aeroelastic divergence dynamic pressure of wind-tunnel models
[AIAA PAPER 92-4002] p 1099 A92-56825
Numerical simulation of turbulence at the back of the airplane
[ETN-92-91664] p 1037 N92-32769
Experimental study of a generic high-speed civil transport
[NASA-TM-4382] p 1040 N92-33631
Lateral spread of sonic boom measurements from US Air Force boomfile flight tests p 1140 N92-33883
Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193
MACH REFLECTION
Numerical simulations of shock reflections by a TVD scheme p 1018 A92-53558
MACHINE LEARNING
Design of a flight control system using a feedback-error-learning-type neural network p 1132 A92-56067
A learning enhanced flight control system for high performance aircraft
[AD-A252520] p 1086 N92-32435
MAGNETIC EFFECTS
Proof of concept of a magnetically coupled Stirling engine-driven heat pump
[DE92-017129] p 1129 N92-33271
MAGNETIC SUSPENSION
Dynamics and control of a five degree-of-freedom magnetic suspension system
[NASA-CR-191259] p 1102 N92-34222
MAGNETOHYDRODYNAMIC FLOW
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
MAGNETOHYDRODYNAMICS
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
MAINTAINABILITY
Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings
[ISBN 0-7803-0521-3] p 1119 A92-56201
Improving reliability and maintainability through process management p 1141 A92-56212
Solutions to supportability concerns related to reduced-signature aircraft p 1055 A92-56220
Field test of an advanced maintenance-system p 1016 A92-56221
A testability-dependent maintainability-prediction technique p 1120 A92-56222
Engineering reliability and maintainability review - A regimen for discovering production deficiencies p 1120 A92-56254
MAINTENANCE
Effective maintenance practices to manage system aging p 1119 A92-56215
A testability-dependent maintainability-prediction technique p 1120 A92-56222
Repair procedures for advanced composites for helicopters p 1016 A92-56277
Processing and environmental effects on mechanical properties of composite repairs
[NRC-LTR-ST-1826] p 1109 N92-32791
Criteria for use of seal coats on airport pavements
[DOT/FAA/RD-92/18] p 1102 N92-34247
MAN MACHINE SYSTEMS
Concepts for pilot interaction with an automated NOE obstacle-avoidance system
[AIAA PAPER 92-4472] p 1076 A92-55232
HEPO mission simulator - Development and usage for NH90 helicopter p 1094 A92-56313
Using the simulation modeling method to estimate the reliability of the crew-flight vehicle system p 1133 A92-57444
An approach to the organization of an adaptive man-machine system for flight vehicle control p 1133 A92-57445
An experimental study of organismic principles of the functioning of the crew-transport aircraft system p 1133 A92-57446
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
MAN-COMPUTER INTERFACE
Advanced software development workstation: Effectiveness of constraint-checking --- spaceflight simulation and planning
[NASA-CR-190712] p 1134 N92-32865
A graphical user-interface for propulsion system analysis
[NASA-TM-105696] p 1134 N92-33894
MANAGEMENT INFORMATION SYSTEMS
The development of an airborne information management system for flight test
[NASA-TM-104251] p 1065 N92-32866
MANAGEMENT PLANNING
DoD key technologies plan
[AD-A253692] p 1142 N92-33238
MANEUVERABILITY
Optimization approach for helicopter maneuverability with a point mass model p 1083 A92-56025
On the maneuvering tests of an ACV model p 1118 A92-56035
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
Nonlinear dynamic-inversion flight control of supermaneuverable aircraft p 1062 N92-33953
MANIFOLDS
Mixed flow compressor surge margin gain using a manifolded diffuser system
[AIAA PAPER 92-3753] p 1068 A92-54151
MANIPULATORS
Flow quality studies of the NASA Lewis Research Center 8- by 6-foot supersonic/9- by 15-foot Low Speed Wind Tunnel
[AIAA PAPER 92-3916] p 1095 A92-56748
MANUAL CONTROL
A simulator evaluation of various manual control concepts for fly-by-wire transport aircraft
[AIAA PAPER 92-4328] p 1073 A92-55172
Multiaxis control in longitudinal mode of aircraft p 1083 A92-56027
An approach to the organization of an adaptive man-machine system for flight vehicle control p 1133 A92-57445
Flight testing and simulation of an F-15 airplane using throttles for flight control
[NASA-TM-104255] p 1087 N92-32864
Human factors issues in the use of artificial intelligence in air traffic control. October 1990 Workshop
[NASA-CR-190925] p 1051 N92-34203
MANUFACTURING
Development of an automatic drilling system. II p 1118 A92-56107
Flutter models: Their design, manufacture, and ground testing p 1089 N92-34164
MAP MATCHING GUIDANCE
Talons 95 GHz radar sensor for autonomous landing guidance p 1063 A92-55908
MARANGONI CONVECTION
Fundamental studies on Marangoni convection related to Bridgman crystal growth p 1111 A92-53758
MARITIME SATELLITES
Evaluation report of an experimental Satcom operation by a Japan Airline's B747 passenger plane p 1046 A92-56092
MARS (PLANET)
Analysis of spacecraft entry into Mars atmosphere p 1105 N92-33763
MARS ATMOSPHERE
Flowpath and sensitivity analyses of high speed propulsion systems
[AIAA PAPER 92-3806] p 1069 A92-54178
Analysis of spacecraft entry into Mars atmosphere p 1105 N92-33763

MARS LANDING
Analysis of spacecraft entry into Mars atmosphere p 1105 N92-33763
MARS PROBES
Analysis of spacecraft entry into Mars atmosphere p 1105 N92-33763
MASS DISTRIBUTION
Wing mass formula for twin fuselage aircraft p 1054 A92-56171
MASS FLOW
Analysis of the flight performance of the 155 mm M864 base burn projectile
[BRL-TR-3083] p 1041 N92-33699
Cooled high-temperature radial turbine program 2
[NASA-CR-189122] p 1073 N92-34236
MASS SPECTROSCOPY
Rarefied gas research at Berkeley - Current studies and future potentials
[AIAA PAPER 92-3971] p 1098 A92-56797
MATERIALS HANDLING
Fire bombing and fire bombers
[CA-PATENT-1-268-164] p 1061 N92-33582
MATERIALS TESTS
Evaluation of the effects of the environment on the behavior of the primary structures of composite material aircraft in service: Historic and current situation p 1110 N92-33048
Fluid effects: Thermoset and thermoplastic matrix composites p 1110 N92-33049
Jet fuel absorption and dynamic mechanical analysis of carbon fibre composites p 1110 N92-33050
Flight service environmental effects on composite materials and structures p 1110 N92-33054
MATHEMATICAL MODELS
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
Multidisciplinary optimization of aeroservoelastic systems using reduced-size models p 1054 A92-56176
The G-range impulse facility - A high-performance free-piston shock tunnel
[AIAA PAPER 92-3946] p 1097 A92-56774
Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, part 1
[NASA-CP-3087-PT-1] p 1106 N92-32513
Modeling and numerical simulation of vortex flow in aerodynamics
[NLR-TP-91154-U] p 1037 N92-32673
Vibro-acoustic FE analyses of the Saab 2000 aircraft p 1137 N92-32952
Active control of sound transmission through stiff lightweight composite fuselage constructions p 1137 N92-32957
On the origin and acoustical behaviour of cloud cavitation
[ISBN-90-9004317-9] p 1125 N92-33066
Ideal efficiency of propellers based on Theodorsen's theory: A review and computer study, with extended plus simplified charts
[UTIAS-TN-271] p 1071 N92-33102
ILS mathematical modeling study of an ILS localizer and glide slope proposed for runway 32R, Moffett Field Airport, California
[DOT/FAA/CT-TN92/28] p 1048 N92-33308
Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483
Active control of compressor surge and stall
[AD-A252771] p 1126 N92-33498
Simulation model of a twin-tail, high performance airplane
[NASA-TM-107601] p 1088 N92-33537
A numerical model for sonic boom propagation through an inhomogeneous, windy atmosphere p 1138 N92-33876
Wave equations and computational models for sonic boom propagation through a turbulent atmosphere p 1139 N92-33877
Design of helicopter flight control systems for hover and low speed using eigenstructure assignment p 1061 N92-33952
Finite difference time domain grid generation from AMC helicopter models
[NASA-TM-107679] p 1128 N92-34017
Effects of constraint on crack growth under aircraft spectrum loading
[NASA-TM-107677] p 1128 N92-34178
MAXIMUM LIKELIHOOD ESTIMATES
Estimation of aircraft inertial characteristics using maximum likelihood estimation p 1084 A92-56057
Implementation of a personal computer based parameter estimation program
[AD-A252914] p 1061 N92-33502
MEASURING INSTRUMENTS
Flow quality studies of the NASA Lewis Research Center 8- by 6-foot supersonic/9- by 15-foot Low Speed Wind Tunnel
[AIAA PAPER 92-3916] p 1095 A92-56748
MECHANICAL ENGINEERING
Repair procedures for advanced composites for helicopters p 1016 A92-56277
United States Air Force summer research program 1991. Volume 1: Program management report
[AD-A248763] p 1142 N92-32338
MECHANICAL PROPERTIES
Mechanical properties of laminate aluminum matrix composites p 1106 A92-56102
Titanium alloy casting for aerospace p 1106 A92-56103
Present status of Al-Li alloys p 1106 A92-56105
State-of-the-art materials for future gas turbine engines p 1070 A92-56122
Aluminium-lithium alloys - Application on helicopters p 1106 A92-56326
Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, part 1
[NASA-CP-3087-PT-1] p 1106 N92-32513
Fluid effects: Thermoset and thermoplastic matrix composites p 1110 N92-33049
Jet fuel absorption and dynamic mechanical analysis of carbon fibre composites p 1110 N92-33050
METAL FATIGUE
Monitoring fatigue cracks in gears p 1116 A92-54496
METAL MATRIX COMPOSITES
High-temperature metal matrix composite p 1105 A92-53878
Mechanical properties of laminate aluminum matrix composites p 1106 A92-56102
METAL PLATES
The ASU Transition Research Facility
[AIAA PAPER 92-3910] p 1094 A92-56744
METAL SHEETS
Effects of constraint on crack growth under aircraft spectrum loading
[NASA-TM-107677] p 1128 N92-34178
METEOROLOGICAL PARAMETERS
Analysis of sonic boom data to quantify distortions of shock profiles p 1139 N92-33879
METEOROLOGICAL RADAR
Airport Surveillance Radar (ASR-9) wind shear processor: 1991 test at Orlando, Florida
[AD-A252246] p 1124 N92-32686
METHODOLOGY
Development of an uncertainty methodology for multiple-channel instrumentation systems
[AIAA PAPER 92-3953] p 1133 A92-56781
METROLOGY
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
MICROBURSTS (METEOROLOGY)
Optimal recovery from microburst wind shear
[AIAA PAPER 92-4338] p 1078 A92-55327
A data fusion algorithm for multi-sensor microburst hazard assessment
[AIAA PAPER 92-4339] p 1063 A92-55328
Escape strategies for turboprop aircraft in microburst windshear p 1084 A92-56151
MICROPROCESSORS
The design and development of a portable, DSP micro-processor based, high-accuracy data acquisition system
[NRC-32146] p 1134 N92-32851
The development of an airborne information management system for flight test
[NASA-TM-104251] p 1065 N92-32866
MICROWAVE LANDING SYSTEMS
Synthesis of a MLS automatic landing control law for the NAL experimental research aircraft Do-228 p 1084 A92-56062
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of MLS p 1047 A92-56117
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS p 1047 A92-56118
Development of new flight procedures for the Microwave Landing System (MLS)
[NLR-TP-91156-U] p 1047 N92-32830
MIDAIR COLLISIONS
Safety study of TCAS 2 for logic version 6.04
[DOT/FAA/RD-92/22] p 1047 N92-32537
MIG AIRCRAFT
Mikoyan's market-buster p 1052 A92-54981
MILITARY AIRCRAFT
The Utilization of Advanced Composites in Military Aircraft
[AGARD-R-785] p 1109 N92-33033
MILITARY HELICOPTERS
Response of helicopter blades to a sharp collective increase p 1084 A92-56282
Lynx - A 50 year product? p 1056 A92-56307
AS 332 MKII - Development and certification p 1059 A92-56343
MILITARY TECHNOLOGY
Integrated test and evaluation for hypervelocity systems
[AIAA PAPER 92-3901] p 1017 A92-56736
MILLIMETER WAVES
Laser-radar based obstacle avoidance system for helicopters p 1064 A92-56295
MIMO (CONTROL SYSTEMS)
Flight-determined stability analysis of multiple-input-multiple-output control systems
[AIAA PAPER 92-4396] p 1074 A92-55196
MIMO state-feedback control system considering phase stability by -90 deg phase-locus method p 1084 A92-56066
Dynamics and control of a five degree-of-freedom magnetic suspension system
[NASA-CR-191259] p 1102 N92-34222
MINIMUM DRAG
Optimal design of wing shape by use of neural-network p 1054 A92-56112
MISSILE RANGES
Preliminary results from the White Sands Missile Range sonic boom propagation experiment p 1140 N92-33884
MISSION PLANNING
Issues in developing control zones for international space operations p 1141 A92-56602
Advanced software development workstation: Effectiveness of constraint-checking --- spaceflight simulation and planning
[NASA-CR-190712] p 1134 N92-32865
MIXING LAYERS (FLUIDS)
High-speed cinematography of supersonic mixing layers
[AIAA PAPER 92-3545] p 1112 A92-54044
Mixed flow compressor surge margin gain using a manifolded diffuser system
[AIAA PAPER 92-3753] p 1068 A92-54151
Effect of streamwise pressure gradient on the supersonic mixing layer p 1025 A92-54936
MIXING LENGTH FLOW THEORY
Effects of curvature and rotation on turbulence in the NASA low-speed centrifugal compressor impeller p 1124 N92-32292
MIXTURES
Criteria for use of seal coats on airport pavements
[DOT/FAA/RD-92/18] p 1102 N92-34247
MODAL RESPONSE
Linear stability of supersonic cone boundary layers p 1024 A92-54910
Aeroelastic modal characteristics of mistuned blade assemblies - Mode localization and loss of eigenstructure p 1117 A92-54921
Flight flutter testing p 1089 N92-34163
MOLECULAR RELAXATION
A numerical model for sonic boom propagation through an inhomogeneous, windy atmosphere p 1138 N92-33876
Analysis of sonic boom data to quantify distortions of shock profiles p 1139 N92-33879
Model experiment to study the effect of turbulence on risetime and waveform of N waves p 1139 N92-33881
MOMENTS OF INERTIA
Estimation of aircraft inertial characteristics using maximum likelihood estimation p 1084 A92-56057
MOMENTUM TRANSFER
Rarefied gas research at Berkeley - Current studies and future potentials
[AIAA PAPER 92-3971] p 1098 A92-56797
MONTE CARLO METHOD
Application of a parallel direct simulation Monte Carlo method to hypersonic rarefied flows p 1024 A92-54916
Direct simulation of low-density flow over airfoils p 1030 A92-56159
Simulations of sonic boom ray tube area fluctuations for propagation through atmospheric turbulence including caustics via a Monte Carlo method p 1139 N92-33878
MOTION STABILITY
Multiple delay model approach applied to the AIAA 1922 Controls Design Challenge
[AIAA PAPER 92-4630] p 1078 A92-55305

MOUNTAINS
Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081
MRCA AIRCRAFT
Airborne experimental FLIR program
p 1064 N92-32447
MULTIGRID METHODS
Evaluation of a multigrid-based Navier-Stokes solver for aerothermodynamic computations
[AIAA PAPER 92-4563] p 1027 A92-55375
New concepts for multi-block grid generation for flow domains around complex aerodynamic configurations
[NLR-TP-91046-U] p 1037 N92-32730
MULTISTAGE ROCKET VEHICLES
Optimization of two stage reusable space transportation systems with rocket and airbreathing propulsion concepts
[IAF PAPER 92-0863] p 1104 A92-57254

N

NACELLES
Propeller-nacelle whirl flutter analysis and wind tunnel test p 1052 A92-56016
Whirl flutter analysis and application to aircraft design
p 1053 A92-56017
Applications of a direct/iterative design method to complex transonic configurations
[NASA-TP-3234] p 1039 N92-33484
NAP-OF-THE-EARTH NAVIGATION
Vision-based stereo ranging as an optimal control problem
[AIAA PAPER 92-4418] p 1045 A92-55211
Concepts for pilot interaction with an automated NOE obstacle-avoidance system
[AIAA PAPER 92-4472] p 1076 A92-55232
Analysis of image-based navigation system for rotorcraft low-altitude flight p 1046 A92-55968
A workstation-based evaluation of a far-field route planner for helicopters
[NASA-TM-102882] p 1051 N92-33609
NASA PROGRAMS
Departments of Veterans Affairs and Housing and Urban Development, and independent agencies appropriations for 1993, part 6
[GAO-55-636-PT-6] p 1141 N92-32505
NASA authorization, 1993, volume 1
[GPO-55-260-VOL-1] p 1142 N92-33147
NASTRAN
FREPS - A forced response prediction system for turbomachinery blade rows
[AIAA PAPER 92-3072] p 1130 A92-54006
NATIONAL AEROSPACE PLANE PROGRAM
Some thermodynamical aspects in the optimization of supersonic combustors p 1065 A92-53486
Instrumentation key to NASP combustor tests
p 1092 A92-55100
The Langley 15-inch Mach 6 High Temperature Tunnel
[AIAA PAPER 92-3938] p 1096 A92-56768
An integrated analytical aeropropulsive/aeroelastic model for the dynamic analysis of hypersonic vehicles
[AIAA PAPER 92-4567] p 1035 A92-57034
Technologies for the National Aero-Space Plane
[IAF PAPER 92-0868] p 1105 A92-57259
Thermal-structural test facilities at NASA Dryden
[NASA-TM-104249] p 1062 N92-34202
NATIONAL AIRSPACE SYSTEM
A review and discussion of flight management system incidents reported to the aviation safety reporting system
[AD-A252438] p 1043 N92-32941
Impacts of technology on the capacity needs of the US national airspace system
[NASA-CR-4470] p 1045 N92-34192
NAVIER-STOKES EQUATION
Navier-Stokes simulation for the winged space vehicle 'HOPE' at subsonic, transonic, and supersonic regimes
p 1018 A92-53559
Three-dimensional Navier-Stokes heat transfer predictions for turbine blade rows
[AIAA PAPER 92-3068] p 1020 A92-54003
Increased heat transfer to elliptical leading edges due to spanwise variations in the freestream momentum - Numerical and experimental results
[AIAA PAPER 92-3070] p 1020 A92-54005
Full Navier-Stokes calculations on the installed F/A-18 inlet at a high angle of attack
[AIAA PAPER 92-3175] p 1020 A92-54012
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[AIAA PAPER 92-3177] p 1020 A92-54013
Navier-Stokes analysis of three-dimensional unsteady flows inside turbine stages
[AIAA PAPER 92-3211] p 1021 A92-54016
The enhancement of the mixing and combustion processes in supersonic flow applied to scramjet engine
[AIAA PAPER 92-3428] p 1112 A92-54029
Full Navier-Stokes analysis of a two-dimensional mixer/ejector nozzle for noise suppression
[AIAA PAPER 92-3570] p 1067 A92-54059
A finite-volume numerical method to calculate fluid forces and rotordynamic coefficients in seals
[AIAA PAPER 92-3712] p 1113 A92-54132
Assessment of compressibility corrections to the k-epsilon model in high-speed shear layers
p 1024 A92-54905
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
Approximate Riemann solver for hypervelocity flows
p 1117 A92-54934
Grid studies for thin-layer Navier-Stokes computations of airfoil flowfields p 1025 A92-54935
Navier-Stokes prediction of large-amplitude delta-wing roll oscillations characterizing wing rock
[AIAA PAPER 92-4428] p 1080 A92-55352
Navier-Stokes computations for oscillating control surfaces
[AIAA PAPER 92-4431] p 1026 A92-55355
Evaluation of a multigrid-based Navier-Stokes solver for aerothermodynamic computations
[AIAA PAPER 92-4563] p 1027 A92-55375
Wind tunnel test of M = 2.5 mixed compression inlet
p 1028 A92-56008
Navier-Stokes simulation of a close-coupled canard-wing-body configuration p 1031 A92-56163
Application of computational fluid dynamics to sonic boom near- and mid-field prediction
p 1031 A92-56173
Improved calculation of transonic potential flow past swept wings p 1031 A92-56179
Hypersonic wind tunnel nozzle study
[AIAA PAPER 92-4012] p 1033 A92-56835
Boundary layer study on nozzle wall at hypersonic velocities
[AIAA PAPER 92-4013] p 1034 A92-56836
Numerical prediction of the flow characteristics in an arc wind tunnel
[AIAA PAPER 92-4016] p 1100 A92-56838
A critical evaluation of a three-dimensional Navier-Stokes CFD as a tool to design supersonic turbine stages p 1124 N92-32268
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
Research on some centered implicit methods for calculating transonic flows by solving Navier-Stokes equations
[ONERA-RSF-24/1408-AY-150A] p 1037 N92-32773
High speed transition prediction
[NASA-CR-190836] p 1039 N92-33424
A nozzle internal performance prediction method
[NASA-TP-3221] p 1040 N92-33625
Navier-Stokes analysis and experimental data comparison of compressible flow in a diffusing S-duct
[NASA-TM-105683] p 1072 N92-33746
An approximate viscous shock layer technique for calculating chemically reacting hypersonic flows about blunt-nosed bodies p 1041 N92-33837
Computation and stability analysis of laminar flow over a blunt cone in hypersonic flow p 1041 N92-33839
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations
p 1127 N92-33968
Numerical investigation of the effects of icing on fixed and rotary wing aircraft
[NASA-CR-190542] p 1044 N92-34105
NAVIGATION
Space plane navigation simulation
p 1103 A92-53603
AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pts. 1-3 p 1130 A92-55151
Airborne experimental FLIR program
p 1064 N92-32447
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
NAVIGATION AIDS
Analysis of image-based navigation system for rotorcraft low-altitude flight p 1046 A92-55968
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of MLS
p 1047 A92-56117
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS
p 1047 A92-56118
US Coast Guard GPS Information Center (GPSIC) and its function within the Civil GPS Service (CGS)
p 1049 N92-33352
A workstation-based evaluation of a far-field route planner for helicopters
[NASA-TM-102882] p 1051 N92-33609
Integrated Russian VLF/Omega receiver design
[PB92-193390] p 1051 N92-33809
NAVIGATION SATELLITES
US Coast Guard GPS Information Center (GPSIC) and its function within the Civil GPS Service (CGS)
p 1049 N92-33352
GPS orbit determination at the National Geodetic Survey p 1049 N92-33354
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG
p 1050 N92-33356
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
NEAR WAKES
The vortical structure in the wake during dynamic stall
[AIAA PAPER 92-4496] p 1026 A92-55364
NEURAL NETS
Flight control law synthesis using neural network theory
[AIAA PAPER 92-4390] p 1074 A92-55191
Neural networks for feedback linearization in aircraft control
[AIAA PAPER 92-4391] p 1074 A92-55192
Identification and control of aircraft dynamics using radial basis function neural networks
[AIAA PAPER 92-4393] p 1074 A92-55194
Design of a flight control system using a feedback-error-learning-type neural network
p 1132 A92-56067
Optimal design of wing shape by use of neural-network p 1054 A92-56112
An investigation of switched reluctance rotor position estimation using neural networks
[AD-A252846] p 1061 N92-33414
NEUTRAL BEAMS
Formation and sustainment of a very low aspect ratio tokamak using coaxial helicity injection: Helicity Injected Torus (HIT) experiment
[DE92-014311] p 1136 N92-32595
NICKEL ALLOYS
Joining a Ni-based creep-resistant (ODS) alloy by brazing p 1116 A92-54867
NITRIC OXIDE
Effects of oxygen dissociation on hypervelocity combustion experiments
[AIAA PAPER 92-3964] p 1098 A92-56791
NITROGEN
A fine-wire thermocouple probe for measurement of stagnation temperatures in real gas hypersonic flows of nitrogen p 1114 A92-54317
H-N2 interaction energies, transport cross sections, and collision integrals p 1135 A92-54660
NITROGEN DIOXIDE
Degenerate four-wave mixing for measurement of NO2 and smoke concentration in jet engine exhaust
[AIAA PAPER 92-3658] p 1113 A92-54108
NOISE INTENSITY
Pilot noise exposure during a Boeing 747-400 round trip: Judgement of noise and analysis in respect to hearing impairment of pilots p 1138 N92-32961
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers
[NASA-TM-104170] p 1138 N92-33160
Application of magnitude estimation scaling to the assessment of subjective loudness response to simulated sonic booms
[NASA-TM-107657] p 1138 N92-33719
Advanced subsonic transport approach noise: The relative contribution of airframe noise
[NASA-TM-104112] p 1140 N92-34148
NOISE MEASUREMENT
Fourth Aircraft Interior Noise Workshop
[NASA-CP-10103] p 1136 N92-32948
Use of SEA to predict structure-borne noise in aircraft
p 1137 N92-32955
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
Pilots noise exposure during a Boeing 747-400 round trip: Ambient noise and acoustic-head recording and analysis of data p 1137 N92-32960
Pilot noise exposure during a Boeing 747-400 round trip: Judgement of noise and analysis in respect to hearing impairment of pilots p 1138 N92-32961
Feasibility of measuring transverse electric noise at VLF and LF on an ice cap
[AD-A252280] p 1129 N92-33220

Implementation of a personal computer based parameter estimation program
[AD-A252914] p 1061 N92-33502
NOISE PREDICTION
Fourth Aircraft Interior Noise Workshop
[NASA-CP-10103] p 1136 N92-32948
NOISE PREDICTION (AIRCRAFT)
Broadband shock associated noise from supersonic jets measured by a ground observer p 1135 A92-54909
A calculation method to predict helicopter noise and its verification p 1135 A92-56074
Path identification in structural acoustics p 1059 A92-56346
Acoustic loads prediction on jet aircraft p 1136 N92-32949
MD-80 aft cabin noise control: A case history p 1137 N92-32950
Vibro-acoustic FE analyses of the Saab 2000 aircraft p 1137 N92-32952
Use of SEA to predict structure-borne noise in aircraft p 1137 N92-32955
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
Advanced subsonic transport approach noise: The relative contribution of airframe noise
[NASA-TM-104112] p 1140 N92-34148
NOISE PROPAGATION
Path identification in structural acoustics p 1059 A92-56346
Use of SEA to predict structure-borne noise in aircraft p 1137 N92-32955
NOISE REDUCTION
Summary highlights of the Advanced Rotorcraft Transmission (ART) program
[AIAA PAPER 92-3362] p 1051 A92-54026
Full Navier-Stokes analysis of a two-dimensional mixer/ejector nozzle for noise suppression
[AIAA PAPER 92-3570] p 1067 A92-54059
Experimental study of noise generation and propagation in a turbofan model p 1136 A92-56169
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344
A quiet-flow Ludwieg tube for experimental study of high speed boundary layer transition
[AIAA PAPER 92-3885] p 1094 A92-56727
Fourth Aircraft Interior Noise Workshop
[NASA-CP-10103] p 1136 N92-32948
MD-80 aft cabin noise control: A case history p 1137 N92-32950
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951
Vibro-acoustic FE analyses of the Saab 2000 aircraft p 1137 N92-32952
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
Active control of interior noise in a large scale cylinder using piezoelectric actuators p 1137 N92-32958
Pilots noise exposure during a Boeing 747-400 round trip: Ambient noise and acoustic-head recording and analysis of data p 1137 N92-32960
Pilot noise exposure during a Boeing 747-400 round trip: Judgement of noise and analysis in respect to hearing impairment of pilots p 1138 N92-32961
Active vibrations and noise control for turboprop application research program activities p 1138 N92-32962
Active synchrophasing of propeller unbalance p 1138 N92-32963
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964
Re-engining for real stage 3 compliance
[PNR-90872] p 1072 N92-33748
Impacts of technology on the capacity needs of the US national airspace system
[NASA-CR-4470] p 1045 N92-34192
NOISE TOLERANCE
Application of magnitude estimation scaling to the assessment of subjective loudness response to simulated sonic booms
[NASA-TM-107657] p 1138 N92-33719
NONDESTRUCTIVE TESTS
Application of X-ray image radiography system for aircraft p 1118 A92-56084
Development of aircraft bonded structure and the NDI method p 1016 A92-56100
Computed tomography (CT) as a nondestructive test method used for composite helicopter components p 1121 A92-56276
Repair procedures for advanced composites for helicopters p 1016 A92-56277
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480
Inspection of fabricated fuselage panels using electronic shearography
[DOT/FAA/CT-TN92/26] p 1127 N92-33627
NONEQUILIBRIUM FLOW
Thermally and chemically nonequilibrium hypersonic flow in three-dimensional geometry p 1019 A92-53580
A code validation strategy and facility for nonequilibrium, reacting flows
[AIAA PAPER 92-3970] p 1098 A92-56796
Perspectives on hypersonic viscous and nonequilibrium flow research
[NASA-CR-190817] p 1039 N92-33413
NONLINEAR EQUATIONS
Application of restructurable flight control system using nonlinear control to an airliner p 1084 A92-56068
User's manual for AeroFcn: A FORTRAN program to compute aerodynamic parameters
[NASA-TM-104237] p 1133 N92-32507
NONLINEAR FEEDBACK
Nonlinear model-following control application to airplane control (1992 AIAA Controls Design Challenge)
[AIAA PAPER 92-4625] p 1077 A92-55302
NONLINEAR PROGRAMMING
A general approach to optimal real-time guidance of dynamic systems based on nonlinear programming
[AIAA PAPER 92-4378] p 1131 A92-55182
NONLINEAR SYSTEMS
Preliminary assessment of the robustness of dynamic inversion based flight control laws
[AIAA PAPER 92-4330] p 1074 A92-55174
G-Field Control of nonlinear systems
[AIAA PAPER 92-4555] p 1131 A92-55267
Helicopter nonlinear flight control system development p 1085 A92-56317
Thermal mechanical analysis of sprag clutches
[NASA-CR-190686] p 1128 N92-34207
NONLINEARITY
Nonlinear dynamic-inversion flight control of supermaneuverable aircraft p 1062 N92-33953
NOSE FINS
Experimental investigation on turbulent phenomena in three-dimensional shock wave/turbulent boundary layer interaction induced by blunt fin p 1018 A92-53557
NOTCHES
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-34019
NOZZLE DESIGN
CAN-DO, CFD-based Aerodynamic Nozzle Design and Optimization program for supersonic/hypersonic wind tunnels
[AIAA PAPER 92-4009] p 1033 A92-56832
Hypersonic wind tunnel nozzle study
[AIAA PAPER 92-4012] p 1033 A92-56835
A nozzle internal performance prediction method
[NASA-TP-3221] p 1040 N92-33625
Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193
NOZZLE EFFICIENCY
A nozzle internal performance prediction method
[NASA-TP-3221] p 1040 N92-33625
NOZZLE FLOW
Pulsation characteristics of one-phase and two-phase steam flows in Laval nozzles under off-design conditions p 1019 A92-53882
Preliminary dynamic tests of a flight-type ejector
[AIAA PAPER 92-3261] p 1066 A92-54020
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
Methodology for calculating aerodynamic sensitivity derivatives p 1024 A92-54911
Computational and numerical analysis of hypersonic nozzle flows with comparisons to wind tunnel calibration data
[AIAA PAPER 92-4011] p 1033 A92-56834
Flow contamination and flow quality in arc heaters used for hypersonic testing
[AIAA PAPER 92-4028] p 1100 A92-56850
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
A nozzle internal performance prediction method
[NASA-TP-3221] p 1040 N92-33625
Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193
NOZZLE GEOMETRY
The behaviour of the pressure temperature and density in an inviscid unsteady transonic axisymmetric flow with shock waves p 1018 A92-53553
Broadband shock associated noise from supersonic jets measured by a ground observer p 1135 A92-54909
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
NOZZLE THRUST COEFFICIENTS
A nozzle internal performance prediction method
[NASA-TP-3221] p 1040 N92-33625
NUMERICAL ANALYSIS
Three-dimensional numerical analysis of impinging circular jet - Discrete vortex method p 1029 A92-56040
Ideal efficiency of propellers based on Theodorsen's theory: A review and computer study, with extended plus simplified charts
[UTIAS-TN-271] p 1071 N92-33102
Computational aspects of helicopter trim analysis and damping levels from Floquet theory
[NASA-CR-190736] p 1087 N92-33107
NUMERICAL CONTROL
Air traffic control: FAA's advanced automation system contract
[GAO/IMTEC-91-25] p 1048 N92-32861
NUMERICAL FLOW VISUALIZATION
Numerical prediction of the flow characteristics in an arc wind tunnel
[AIAA PAPER 92-4016] p 1100 A92-56838

O

OBJECT-ORIENTED PROGRAMMING
Modular techniques for dynamic fault-tree analysis p 1120 A92-56241
OBLIQUE SHOCK WAVES
Detailed numerical analysis of standing oblique detonation p 1111 A92-53550
OBSTACLE AVOIDANCE
Concepts for pilot interaction with an automated NOE obstacle-avoidance system
[AIAA PAPER 92-4472] p 1076 A92-55232
Analysis of image-based navigation system for rotorcraft low-altitude flight p 1046 A92-55968
Laser-radar based obstacle avoidance system for helicopters p 1064 A92-56295
OMEGA NAVIGATION SYSTEM
Integrated Russian VLF/Omega receiver design
[PB92-193390] p 1051 N92-33809
ON-LINE SYSTEMS
Hypervelocity Wind Tunnel 9 control system p 1092 A92-54343
Neural networks for feedback linearization in aircraft control
[AIAA PAPER 92-4391] p 1074 A92-55192
On-line identification and control of linearized aircraft dynamics p 1082 A92-55911
ONBOARD EQUIPMENT
Some important factors in turbulence in flight measurement p 1063 A92-54324
OPERATING SYSTEMS (COMPUTERS)
Distributed systems: Interconnection and fault tolerance studies
[AD-A252869] p 1135 N92-33920
OPERATING TEMPERATURE
Notes on the use of fusible temperature indicators to bound the temperature of hot graphite in the NAVSWC hypervelocity wind tunnel facility p 1090 A92-54315
OPERATIONAL PROBLEMS
Simulation test and evaluation of TCAS 2 logic version 6.04
[DOT/FAA/RD-92/23] p 1048 N92-33098
OPTICAL FIBERS
Evaluation of a IMU with optical fiber gyros in dynamic windtunnel tests p 1104 A92-56121
OPTICAL GYROSCOPES
Evaluation of a IMU with optical fiber gyros in dynamic windtunnel tests p 1104 A92-56121
OPTICAL MEASURING INSTRUMENTS
ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record
[ISBN 0-0783-0123-4] p 1114 A92-54301
Aerodynamic assessment of an optical pressure measurement system (OPMS) by comparison with conventional pressure measurements in a high speed wind tunnel p 1114 A92-54304
OPTICAL PROPERTIES
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
OPTICAL RADAR
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
Laser-radar based obstacle avoidance system for helicopters p 1064 A92-56295
Time Resolved Lidar Fluorosensor operating from helicopter p 1121 A92-56296

OPTIMAL CONTROL
Improvement of atmospheric flight performance of a space vehicle through H infinity-control theory p 1130 A92-53785
A general approach to optimal real-time guidance of dynamic systems based on nonlinear programming [AIAA PAPER 92-4378] p 1131 A92-55182
An efficient algorithm for optimal aircraft trajectories [AIAA PAPER 92-4412] p 1076 A92-55206
Vision-based stereo ranging as an optimal control problem [AIAA PAPER 92-4418] p 1045 A92-55211
Optimal control of helicopters following power failure [AIAA PAPER 92-4471] p 1076 A92-55231
The application of direct transcription to commercial aircraft trajectory optimization [AIAA PAPER 92-4528] p 1077 A92-55246
A robust gain scheduler interpolated into multiple models by membership functions [AIAA PAPER 92-4553] p 1131 A92-55265
Robust control design of an automatic carrier landing system [AIAA PAPER 92-4619] p 1077 A92-55296
A Lie Bracket solution of the optimal thrust magnitude on a singular arc in atmospheric flight [AIAA PAPER 92-4345] p 1079 A92-55334
Optimization approach for helicopter maneuverability with a point mass model p 1083 A92-56025
An investigation of the automation of emergency landings for helicopters p 1083 A92-56026
Flight control system design using H(infinity) optimal control p 1083 A92-56030
The solution of the helicopter flight dynamics tasks by the methods of optimal control theory p 1085 A92-56284
Optimal control of tiltrotor aircraft following power failure p 1085 A92-56303
OPTIMIZATION
In-flight optimization of the total propulsion system [AIAA PAPER 92-3744] p 1068 A92-54146
Experimental investigation of the stability of a clearance-excited rotor system with optimal parameters p 1114 A92-54223
Control design of a UH-60 rotorcraft via CLTR and direct optimization [AIAA PAPER 92-4470] p 1076 A92-55230
Intelligent control law tuning for AIAA Controls Design Challenge [AIAA PAPER 92-4631] p 1132 A92-55306
On-line identification and control of linearized aircraft dynamics p 1082 A92-55911
Optimization of composite material wing of fighter type aircrafts p 1053 A92-56018
Research on aeroelastic tailoring at NAL p 1053 A92-56019
Optimization of aeroelastic system with active control p 1083 A92-56022
Structural optimization of a cantilevered beam subject to combined static loadings p 1118 A92-56024
Sensitivity analysis for structural optimization of helicopter rotor blades p 1053 A92-56073
Optimal design of wing shape by use of neural-network p 1054 A92-56112
Application of advanced multidisciplinary analysis and optimization methods to vehicle design synthesis p 1054 A92-56160
Multidisciplinary optimization of aeroservoelastic systems using reduced-size models p 1054 A92-56176
Demonstration of structural optimization applied to wind-tunnel model design p 1119 A92-56181
Short takeoff optimization for the XV-15 tiltrotor aircraft p 1056 A92-56302
CAN-DO, CFD-based Aerodynamic Nozzle Design and Optimization program for supersonic/hypersonic wind tunnels [AIAA PAPER 92-4009] p 1033 A92-56832
OPTOELECTRONIC DEVICES
Electro optical system to measure strains at high temperature [NASA-CR-190450] p 1127 N92-33696
ORBIT CALCULATION
GPS orbit determination at the National Geodetic Survey p 1049 N92-33354
OSCILLATING FLOW
Pulsation characteristics of one-phase and two-phase steam flows in Laval nozzles under off-design conditions p 1019 A92-53882
OSCILLATIONS
Oscillations of an anisotropic rotor on an elastic anisotropic support p 1057 A92-56311
OVERPRESSURE
Application of computational fluid dynamics to sonic boom near- and mid-field prediction p 1031 A92-56173
Lateral spread of sonic boom measurements from US Air Force boomfile flight tests p 1140 N92-33883
Preliminary results from the White Sands Missile Range sonic boom propagation experiment p 1140 N92-33884
Subjective loudness response to simulated sonic booms p 1140 N92-33885
OXIDATION RESISTANCE
Joining a Ni-based creep-resistant (ODS) alloy by brazing p 1116 A92-54867
Liquid lubricants for advanced aircraft engines [NASA-TM-104531] p 1109 N92-32863
OXYGEN
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301 [AD-A252912] p 1126 N92-33501
A numerical model for sonic boom propagation through an inhomogeneous, windy atmosphere p 1138 N92-33876
OXYGEN ATOMS
Effects of oxygen dissociation on hypervelocity combustion experiments [AIAA PAPER 92-3964] p 1098 A92-56791

P

PAINTS
Thermal paints for shock/boundary layer interaction in inlet flows [AIAA PAPER 92-3626] p 1113 A92-54093
PANEL METHOD (FLUID DYNAMICS)
Aerodynamic analysis of the Pioneer unmanned air vehicle [AIAA PAPER 92-4635] p 1027 A92-55382
Three-dimensional numerical analysis of impinging circular jet - Discrete vortex method p 1029 A92-56040
Numerical simulation of supersonic unsteady flow using a panel method p 1030 A92-56048
Generalized aerodynamics analysis by the boundary element method p 1030 A92-56050
Analysis of the main wing lift distribution of the STOL research aircraft Asuka p 1053 A92-56051
Potential flow theory and operation guide for the panel code PMARC [NASA-TM-102851] p 1036 N92-32422
Further development of the CANAERO computer code to include propulsor modelling [DREA-CR-90-425] p 1038 N92-32811
PANELS
Global/local methods research using the CSM testbed p 1107 N92-32528
Inspection of fabricated fuselage panels using electronic shearography [DOT/FAA/CT-TN92/26] p 1127 N92-33627
PARACHUTES
Effects of the abrasiveness of test and training site soils on parachute life [AD-A252389] p 1038 N92-32900
PARALLEL FLOW
Linear stability of supersonic cone boundary layers p 1024 A92-54910
PARALLEL PROCESSING (COMPUTERS)
Application of a parallel direct simulation Monte Carlo method to hypersonic rarefied flows p 1024 A92-54916
Modular techniques for dynamic fault-tree analysis p 1120 A92-56241
Real-time processing of radar return on a parallel computer [NASA-CR-4456] p 1043 N92-32606
Advanced techniques in reliability model representation and solution [NASA-TP-3242] p 1134 N92-33483
PARAMETER IDENTIFICATION
Parameter estimation of an augmented airplane with unsteady aerodynamics modelling p 1073 A92-53546
Parameter identification of unsteady aerodynamic forces for elastic vehicles [AIAA PAPER 92-4505] p 1027 A92-55372
Parameter identification of AV-8B wingborne aerodynamics for flight simulator model updates [AIAA PAPER 92-4506] p 1027 A92-55373
On-line identification and control of linearized aircraft dynamics p 1082 A92-55911
Application of restructurable flight control system using nonlinear control to an airliner p 1084 A92-56068
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test p 1093 A92-56114
The identification of coupled flapping/inflow models for hovering flight p 1058 A92-56335
The design and development of a portable, DSP micro-processor based, high-accuracy data acquisition system [NRC-32146] p 1134 N92-32851
Elementary flutter analysis p 1088 N92-34162
PARTIAL DIFFERENTIAL EQUATIONS
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program [AD-A247886] p 1108 N92-32629
PARTICLE MOTION
Vaporizing particle velocimeter [NASA-CASE-LAR-14685-1] p 1042 N92-34172
PARTICLE SIZE DISTRIBUTION
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
PASSENGER AIRCRAFT
777 - The airlines' higher-order technology airplane p 1052 A92-55104
A note on thrust control for jetliner during approach p 1053 A92-56061
Application of restructurable flight control system using nonlinear control to an airliner p 1084 A92-56068
Evaluation report of an experimental Satcom operation by a Japan Airline's B747 passenger plane p 1046 A92-56092
Development of aircraft bonded structure and the NDI method p 1016 A92-56100
PAVEMENTS
Performance of insulated pavements at Newton Fields, Jackman, Maine [CRREL-92-9] p 1101 N92-32903
Criteria for use of seal coats on airport pavements [DOT/FAA/RD-92/18] p 1102 N92-34247
PERFORMANCE PREDICTION
A testability-dependent maintainability-prediction technique p 1120 A92-56222
Tohoku University low-turbulence wind tunnel [AIAA PAPER 92-3913] p 1095 A92-56746
Performance evaluation of a transonic wind tunnel compressor [AIAA PAPER 92-3927] p 1096 A92-56758
Predicted aerodynamic characteristics for HL-20 lifting-body using the aerodynamic preliminary analysis system (APAS) [AIAA PAPER 92-3941] p 1033 A92-56771
Ski jump takeoff performance predictions for a mixed-flow, remote-lift STOVL aircraft [NASA-TM-103866] p 1060 N92-32887
Simulation model of a twin-tail, high performance airplane [NASA-TM-107601] p 1088 N92-33537
A nozzle internal performance prediction method [NASA-TP-3221] p 1040 N92-33625
An improved compressor performance prediction model [PNR-90873] p 1072 N92-33749
Finite difference time domain grid generation from AMC helicopter models [NASA-TM-107679] p 1128 N92-34017
PERFORMANCE TESTS
Pre-flight physical simulation test of HIMES reentry test vehicle p 1103 A92-53640
A comparison of the calculated and experimental off-design performance of a radial flow turbine [AIAA PAPER 92-3069] p 1020 A92-54004
Internal reversing flow in a tailpipe offtake configuration for SSTOVL aircraft [AIAA PAPER 92-3790] p 1069 A92-54169
Evaluation of electrolytic tilt sensors for wind tunnel model angle-of-attack (AOA) measurements p 1116 A92-54344
Effects of material choices on brush seal performance p 1116 A92-54650
Performance data of the new free-piston shock tunnel at GALCIT [AIAA PAPER 92-3943] p 1033 A92-56776
Description of a pressure measurement technique for obtaining surface static pressures of a radial turbine [AIAA PAPER 92-4006] p 1123 A92-56829
Effect of a simulated glaze ice shape on the aerodynamic performance of a rectangular wing [AIAA PAPER 92-4042] p 1035 A92-56861
Supportability evaluation of thermoplastic and thermoset composites p 1108 N92-32576
Residual strength of repaired graphite/epoxy laminates after 5 years of outdoor exposure p 1108 N92-32577
Simulation test and evaluation of TCAS 2 logic version 6.04 [DOT/FAA/RD-92/23] p 1048 N92-33098
Rapid development of the X-31 simulation to support flight-testing [NASA-TM-104256] p 1060 N92-33149
PERSONAL COMPUTERS
Implementation of a personal computer based parameter estimation program [AD-A252914] p 1061 N92-33502

PERTURBATION
Results of a perturbation analysis correlating flows entering and exiting an aircraft inlet system
[AIAA PAPER 92-3624] p 1021 A92-54091
PERTURBATION THEORY
Aeroelastic modal characteristics of mistuned blade assemblies - Mode localization and loss of eigenstructure p 1117 A92-54921
Selection of sampling rate for nonlinear flight trajectory controller of aircraft p 1084 A92-56070
PHASE DEVIATION
MIMO state-feedback control system considering phase stability by -90 deg phase-locus method p 1084 A92-56066
PHASE TRANSFORMATIONS
Experimental study of convection effects around the phase charge interface p 1111 A92-53755
PHOTOELECTRICITY
Fault diagnostics on jet engine starting p 1116 A92-54345
PHYSICAL PROPERTIES
Viscosity characteristics of synthetic aviation oils at low temperatures p 1105 A92-53875
PIEZOELECTRICITY
Active control of interior noise in a large scale cylinder *using piezoelectric actuators* p 1137 N92-32958
PILOT ERROR
A review and discussion of flight management system incidents reported to the aviation safety reporting system
[AD-A252438] p 1043 N92-32941
PILOT PERFORMANCE
An investigation of the automation of emergency landings for helicopters p 1083 A92-56026
Workshop on Aeronautical Decision Making (ADM). Volume 1: Executive summary
[DOT/FAA/RD-92/14-VOL-1] p 1142 N92-33305
Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081
PILOT TRAINING
The advantages of digital engine control as compared with traditional systems (hydraulic or pneumatic) p 1070 A92-56338
PILOTLESS AIRCRAFT
Aerodynamic analysis of the Pioneer unmanned air vehicle
[AIAA PAPER 92-4635] p 1027 A92-55382
PILOTS (PERSONNEL)
Pilots noise exposure during a Boeing 747-400 round trip: Ambient noise and acoustic-head recording and analysis of data p 1137 N92-32960
Pilot noise exposure during a Boeing 747-400 round trip: Judgement of noise and analysis in respect to hearing impairment of pilots p 1138 N92-32961
PISTON ENGINES
CIS engines - The range revealed. II p 1069 A92-54546
Proof of concept of a magnetically coupled Stirling engine-driven heat pump
[DE92-017129] p 1129 N92-33271
PITCH
Exposures from headset interference tones
[AD-A247175] p 1136 N92-32697
PITCH (INCLINATION)
Calibration of hemispherical-head flow angularity probes
[AIAA PAPER 92-4005] p 1122 A92-56828
Unsteady response of the leading-edge vortices on a *pitching delta wing* p 1041 N92-33851
PITCHING MOMENTS
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
Dynamics of helicopters with dissimilar blades in forward flight p 1056 A92-56288
On the estimation of jet-induced fountain lift and *additional suckdown in hover for two-jet configurations*
[NASA-TM-102268] p 1040 N92-33618
A nozzle internal performance prediction method
[NASA-TP-3221] p 1040 N92-33625
PITOT TUBES
Comparison between computational and experimental data for a hypersonic laser propelled vehicle
[AIAA PAPER 92-3808] p 1023 A92-54179
Test description and preliminary pitot-pressure surveys for Langley Test Technique Demonstrator at Mach 6
[AIAA PAPER 92-3940] p 1096 A92-56770
Millisecond aerodynamic force measurement with side-jet model in the ISL shock tunnel
[AIAA PAPER 92-3963] p 1097 A92-56790
Boundary layer study on nozzle wall at hypersonic velocities
[AIAA PAPER 92-4013] p 1034 A92-56836
Pilot-pressure probe for measuring pressure in a hypersonic wind tunnel
[NASA-CASE-LAR-14232-1] p 1102 N92-34213
PLANETARY BOUNDARY LAYER
Steady state risetimes of shock waves in the atmosphere p 1140 N92-33882
PLANT DESIGN
Small engine components test facility compressor testing cell at NASA Lewis Research Center
[AIAA PAPER 92-3980] p 1098 A92-56806
Transonic turbine blade cascade testing facility
[AIAA PAPER 92-4034] p 1101 A92-56856
PLASMA CONTROL
Formation and sustainment of a very low aspect ratio tokamak using coaxial helicity injection: Helicity Injected Torus (HIT) experiment
[DE92-014311] p 1136 N92-32595
PLASMA DIAGNOSTICS
Formation and sustainment of a very low aspect ratio tokamak using coaxial helicity injection: Helicity Injected Torus (HIT) experiment
[DE92-014311] p 1136 N92-32595
PLASMA EQUILIBRIUM
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
PLASMA JET WIND TUNNELS
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729
An overview of the planned aerospace test facilities at Capua, Italy
[AIAA PAPER 92-3944] p 1097 A92-56773
PLASMA JETS
High temperature aircraft research furnace facilities
[NASA-CR-184384] p 1101 N92-33826
PLASMA PRESSURE
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
PLASTIC AIRCRAFT STRUCTURES
Detailed analysis and test correlation of a stiffened composite wing panel p 1121 A92-56324
PLATE THEORY
Transverse shear effect on flutter of composite panels p 1122 A92-56607
PLATES (STRUCTURAL MEMBERS)
Investigation of a plate-ramp-configuration by means of laser Doppler anemometry at Mach 2.95
[AIAA PAPER 92-3956] p 1097 A92-56784
PNEUMATIC CONTROL
Effects of bleed air extraction of thrust levels on the F404-GE-400 turbofan engine
[AIAA PAPER 92-3092] p 1066 A92-54009
PNEUMATIC EQUIPMENT
Low energy ice protection for helicopters p 1059 A92-56348
POLLUTION CONTROL
Applied analytical combustion/emissions research at the NASA Lewis Research Center - A progress report
[AIAA PAPER 92-3338] p 1067 A92-54025
POLLUTION MONITORING
Time Resolved Lidar Fluorosensor operating from helicopter p 1121 A92-56296
A small light-weight rotor platform for ground observation and pollution control p 1057 A92-56329
POLYIMIDE RESINS
Fabrication test and evaluation of graphite/PMR-15 polyimide for HOPE primary structure p 1105 A92-53516
POLYMER MATRIX COMPOSITES
Advanced airframe structural materials: A primer and cost estimating methodology
[AD-A253371] p 1062 N92-34182
POLYSTYRENE
Performance of insulated pavements at Newton Fields, Jackman, Maine
[CRREL-92-9] p 1101 N92-32903
POROSITY
Effect of porosity in transpiration cooling system p 1112 A92-53786
Assessment of passive porosity with free and fixed separation on a tangent ogive forebody
[AIAA PAPER 92-4494] p 1081 A92-55363
POROUS BOUNDARY LAYER CONTROL
High subsonic wind tunnel test of a two-dimensional hybrid-laminar-flow-control airfoil with slotted surface p 1029 A92-56045
POSITION (LOCATION)
US Coast Guard GPS Information Center (GPSIC) and its function within the Civil GPS Service (CGS) p 1049 N92-33352
Evaluation of GPS/UTC steering performance p 1049 N92-33353
Precise GPS ephemerides from DMA and NGS tested *by time transfer* p 1049 N92-33355
POSITION ERRORS
A Kalman filter integrated navigation design for the IAR Twin Otter Atmospheric Research Aircraft
[NRC-32148] p 1048 N92-32849
POSITION INDICATORS
An investigation of switched reluctance rotor position estimation using neural networks
[AD-A252846] p 1061 N92-33414
Radar clutter classification
[ISBN-0-315-57981-1] p 1126 N92-33440
POSITION SENSING
Evaluation of electrolytic tilt sensors for wind tunnel model angle-of-attack (AOA) measurements p 1116 A92-54344
On improvements of three-dimensional position measuring system for dynamic wind tunnel testing p 1093 A92-56012
Measurement of position and attitude using laser and retro-reflectors p 1047 A92-56120
POTENTIAL FLOW
A potential flow theory of two-dimensional bifurcated *curtain jets. II* p 1118 A92-56039
Improved calculation of transonic potential flow past swept wings p 1031 A92-56179
Potential flow theory and operation guide for the panel *code PMARC*
[NASA-TM-102851] p 1036 N92-32422
POWER TRANSMISSION
Proof of concept of a magnetically coupled Stirling *engine-driven* heat pump
[DE92-017129] p 1129 N92-33271
POWERED LIFT AIRCRAFT
Comparison of turbulence models for powered-lift flow fields
[AIAA PAPER 92-3674] p 1022 A92-54117
Experimental performance of three design factors for ventral nozzles for SSTOVL aircraft
[AIAA PAPER 92-3789] p 1069 A92-54168
Internal reversing flow in a tailpipe offtake configuration for SSTOVL aircraft
[AIAA PAPER 92-3790] p 1069 A92-54169
Flight measurements of downwash on the Ball-Bartoe Jetwing powered lift aircraft p 1054 A92-56174
PRECIPITATION HARDENING
Joining a Ni-based creep-resistant (ODS) alloy by brazing p 1116 A92-54867
Diffusion bonding a creep-resistant Fe-ODS alloy p 1117 A92-54868
PREDICTION ANALYSIS TECHNIQUES
Three-dimensional Navier-Stokes heat transfer predictions for turbine blade rows
[AIAA PAPER 92-3068] p 1020 A92-54003
Understanding and development of a prediction method of transonic limit cycle oscillation characteristics of fighter aircraft
[AIAA PAPER 92-4501] p 1026 A92-55369
Leading-edge receptivity for blunt-nose bodies
[NASA-CR-190563] p 1036 N92-32648
Integration of wall interference assessment and wall adaptation
[NLR-TP-91119-U] p 1101 N92-32734
Life prediction and constitutive models for engine hot *section anisotropic materials program*
[NASA-CR-189223] p 1072 N92-33479
Dynamic response of induced pressures, suckdown, and temperatures for two tandem jet STOVL configurations
[NASA-TM-103934] p 1039 N92-33581
An improved compressor performance prediction model
[PNR-90873] p 1072 N92-33749
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations p 1127 N92-33968
PREDICTIONS
High speed transition prediction
[NASA-CR-190836] p 1039 N92-33424
PREFLIGHT ANALYSIS
Pre-flight physical simulation test of HIMES reentry test vehicle p 1103 A92-53640
PRESSURE DEPENDENCE
User's manual for AeroFcn: A FORTRAN program to compute aerodynamic parameters
[NASA-TM-104237] p 1133 N92-32507
PRESSURE DISTRIBUTION
Experimental performance of three design factors for ventral nozzles for SSTOVL aircraft
[AIAA PAPER 92-3789] p 1069 A92-54168
Use of an approximate similarity principle for the thermal scaling of a full-scale thrust augmenting ejector
[AIAA PAPER 92-3792] p 1069 A92-54171
Aerodynamic assessment of an optical pressure measurement system (OPMS) by comparison with conventional pressure measurements in a high speed wind tunnel p 1114 A92-54304
Preliminary airfoil testing experience in the NDA *cryogenic wind tunnel* p 1091 A92-54326

Evaluation of sidewall interference in the NAL two-dimensional transonic wind tunnel p 1092 A92-56011
Planning method of skirt systems for small ACVs p 1118 A92-56038
A potential flow theory of two-dimensional bifurcated curtain jets. II p 1118 A92-56039
Analysis of the main wing lift distribution of the STOL research aircraft Asuka p 1053 A92-56051
Analysis of helicopter rotor-fuselage interference with time averaged pressure distribution p 1032 A92-56331
An approach for increasing aeroelastic divergence dynamic pressure of wind-tunnel models [AIAA PAPER 92-4002] p 1099 A92-56825
Computations of unsteady multistage compressor flows in a workstation environment [NASA-TM-103839] p 1071 N92-32452
Unsteady wind tunnel tests p 1089 N92-34166

PRESSURE EFFECTS
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers [NASA-TM-104170] p 1138 N92-33160

PRESSURE GRADIENTS
Effect of streamwise pressure gradient on the supersonic mixing layer p 1025 A92-54936

PRESSURE MEASUREMENT
ICIASF '91 - International Congress on Instrumentation in Aerospace Simulation Facilities, 14th, Rockville, MD, Oct. 27-31, 1991, Record [ISBN 0-0783-0123-4] p 1114 A92-54301
Aerodynamic assessment of an optical pressure measurement system (OPMS) by comparison with conventional pressure measurements in a high speed wind tunnel p 1114 A92-54304
Application of a wall pressure method in a wind tunnel test section with adjustable longitudinal slots p 1091 A92-54336
The wind tunnel test 'system' of 1995 - Cost effective experimentation through a fusion of related technologies p 1091 A92-54342
Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance p 1029 A92-56009
An experimental study on variable pressure hydraulic flight control system p 1084 A92-56119
Test description and preliminary pitot-pressure surveys for Langley Test Technique Demonstrator at Mach 6 [AIAA PAPER 92-3940] p 1096 A92-56770
Application of electronically scanned pressure measurement system for engine simulation tests in the German-Dutch Wind Tunnel [AIAA PAPER 92-4003] p 1122 A92-56826
Description of a pressure measurement technique for obtaining surface static pressures of a radial turbine [AIAA PAPER 92-4006] p 1123 A92-56829
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter [NASA-TM-104211] p 1042 N92-34147
Unsteady wind tunnel tests p 1089 N92-34166
Pilot-pressure probe for measuring pressure in a hypersonic wind tunnel [NASA-CASE-LAR-14232-1] p 1102 N92-34213

PRESSURE PULSES
Pulsating spanwise blowing on a fighter aircraft [AIAA PAPER 92-4359] p 1025 A92-55345

PRESSURE RECOVERY
Results of a perturbation analysis correlating flows entering and exiting an aircraft inlet system [AIAA PAPER 92-3624] p 1021 A92-54091
Wind tunnel test of M = 2.5 mixed compression inlet p 1028 A92-56008
A model study on diffuser pressure recovery in NAL scramjet test facility with simulated hydrogen combustion [AIAA PAPER 92-3979] p 1071 A92-56805

PRESSURE REDUCTION
Effects of bleed air extraction of thrust levels on the F404-GE-400 turbofan engine [AIAA PAPER 92-3092] p 1066 A92-54009
Prediction of the pressure loss coefficient of wind tunnel turbulence reducing screens [AIAA PAPER 92-4043] p 1035 A92-56862

PRESSURE SENSORS
Aerodynamic assessment of an optical pressure measurement system (OPMS) by comparison with conventional pressure measurements in a high speed wind tunnel p 1114 A92-54304
Hypervelocity Wind Tunnel 9 control system p 1092 A92-54343
Skin friction measurements in 3-D boundary layers p 1092 A92-54351
Advanced nozzle and engine components test facility [AIAA PAPER 92-3993] p 1099 A92-56816
Calibration of hemispherical-head flow angularity probes [AIAA PAPER 92-4005] p 1122 A92-56828
Pilot-pressure probe for measuring pressure in a hypersonic wind tunnel [NASA-CASE-LAR-14232-1] p 1102 N92-34213

PROBABILITY DENSITY FUNCTIONS
An assumed joint-Beta PDF approach for supersonic turbulent combustion [AIAA PAPER 92-3844] p 1113 A92-54199

PROBABILITY THEORY
Development of an uncertainty methodology for multiple-channel instrumentation systems [AIAA PAPER 92-3953] p 1133 A92-56781

PROCESS CONTROL (INDUSTRY)
Improving reliability and maintainability through process management p 1141 A92-56212

PROCUREMENT
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301 [AD-A252912] p 1126 N92-33501

PRODUCT DEVELOPMENT
Improving designer productivity [AIAA PAPER 92-1187] p 1130 A92-54285
Turning up the heat on aircraft structures --- design and analysis for high-temperature conditions p 1052 A92-55131
Designing to cost effectiveness - Enhancing quality p 1119 A92-56209
Engineering reliability and maintainability review - A regimen for discovering production deficiencies p 1120 A92-56254
Design and development of test rigs for main rotor and main rotor transmission of a helicopter in the 6-ton-class p 1093 A92-56280
'A new proposal for an old problem' - The right engine for the right helicopter p 1070 A92-56281
AS 332 MKII - Development and certification p 1059 A92-56343
The 1991 Federal Aviation Administration plan for research, engineering and development p 1142 N92-32453
SATWG networked quality function deployment p 1134 N92-33339

PRODUCTION ENGINEERING
Development of an automatic drilling system. II p 1118 A92-56107

PRODUCTIVITY
Improving designer productivity [AIAA PAPER 92-1187] p 1130 A92-54285

PROGRAM VERIFICATION (COMPUTERS)
Simulation test and evaluation of TCAS 2 logic version 6.04 [DOT/FAA/RD-92/23] p 1048 N92-33098

PROJECT MANAGEMENT
United States Air Force summer research program 1991. Volume 1: Program management report [AD-A248763] p 1142 N92-32338
DoD key technologies plan [AD-A253692] p 1142 N92-33238

PROJECT PLANNING
The German Hypersonics Technology Programme - Status report 1992 [IAF PAPER 92-0867] p 1105 A92-57258

PROJECTILES
Analysis of the flight performance of the 155 mm M864 base burn projectile [BRL-TR-3083] p 1041 N92-33699

PROP-FAN TECHNOLOGY
Wind tunnel performance results of swirl recovery vanes as tested with an advanced high speed propeller [AIAA PAPER 92-3770] p 1068 A92-54159
Numerical calculations of propfan/swirl recovery vane flow field [AIAA PAPER 92-3771] p 1022 A92-54160
Unsteady blade pressures on a propfan - Predicted and measured compressibility effects [AIAA PAPER 92-3774] p 1023 A92-54161

PROPELLANT COMBUSTION
Experimental and computational investigation of scaling phenomena in a large caliber ram accelerator [AIAA PAPER 92-3245] p 1103 A92-54019

PROPELLER BLADES
An example of whirl flutter analysis p 1052 A92-56015
Whirl flutter analysis and application to aircraft design p 1053 A92-56017
Active synchrophasing of propeller unbalance p 1138 N92-32963

PROPELLER DRIVE
Low-speed wind tunnel testing for the high-speed propeller at high shaft angle of attack p 1030 A92-56054
Ideal efficiency of propellers based on Theodorsen's theory: A review and computer study, with extended plus simplified charts [UTIAS-TN-271] p 1071 N92-33102

PROPELLER EFFICIENCY
Propeller-nacelle whirl flutter analysis and wind tunnel test p 1052 A92-56016
Ideal efficiency of propellers based on Theodorsen's theory: A review and computer study, with extended plus simplified charts [UTIAS-TN-271] p 1071 N92-33102

PROPELLER NOISE
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055
Vibro-acoustic FE analyses of the Saab 2000 aircraft p 1137 N92-32952
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers [NASA-TM-104170] p 1138 N92-33160

PROPELLER SLIPSTREAMS
Further development of the CANAERO computer code to include propulsor modelling [DREA-CR-90-425] p 1038 N92-32811

PROPELLERS
Wind tunnel performance results of swirl recovery vanes as tested with an advanced high speed propeller [AIAA PAPER 92-3770] p 1068 A92-54159
Further development of the CANAERO computer code to include propulsor modelling [DREA-CR-90-425] p 1038 N92-32811
On the origin and acoustical behaviour of cloud cavitation [ISBN-90-9004317-9] p 1125 N92-33066

PROPULSION
DoD key technologies plan [AD-A253692] p 1142 N92-33238
Perspectives on hypersonic viscous and nonequilibrium flow research [NASA-CR-190817] p 1039 N92-33413

PROPULSION SYSTEM CONFIGURATIONS
The VRT gas turbine combustor - Phase II [AIAA PAPER 92-3471] p 1067 A92-54035
V-22 propulsion system design p 1070 A92-56300
Test data models to characterize turbine engine operation in altitude test facilities [AIAA PAPER 92-3917] p 1095 A92-56749
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance [NASA-CR-190638] p 1038 N92-33304
A graphical user-interface for propulsion system analysis [NASA-TM-105696] p 1134 N92-33894

PROPULSION SYSTEM PERFORMANCE
Some thermodynamical aspects in the optimization of supersonic combustors p 1065 A92-53486
Performance analysis of idealized scramjet p 1066 A92-53493
In-flight optimization of the total propulsion system [AIAA PAPER 92-3744] p 1068 A92-54146
Development of the full-envelope Performance Seeking Control algorithm [AIAA PAPER 92-3748] p 1068 A92-54148
Performance benefits of adaptive in-flight propulsion system optimization [AIAA PAPER 92-3749] p 1068 A92-54149
Further studies of kinetic energy methods in high speed ramjet cycle analysis [AIAA PAPER 92-3805] p 1069 A92-54177
Flowpath and sensitivity analyses of high speed propulsion systems [AIAA PAPER 92-3806] p 1069 A92-54178
Propulsion system performance resulting from an Integrated Flight/Propulsion Control design [AIAA PAPER 92-4602] p 1069 A92-55281
Analysis of airframe/engine interactions for a STOVL aircraft with integrated flight/propulsion control [AIAA PAPER 92-4623] p 1052 A92-55300
Thrust stand design principles [AIAA PAPER 92-3976] p 1098 A92-56802
Turbine engine performance test and evaluation techniques [AIAA PAPER 92-3977] p 1071 A92-56803
Tests results on Air Turbo Ramjet for a future space plane [IAF PAPER 92-0657] p 1071 A92-57098
Airbreathing engine selection criteria for SSTO propulsion system [IAF PAPER 92-0658] p 1071 A92-57099
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance [NASA-CR-190638] p 1038 N92-33304
A graphical user-interface for propulsion system analysis [NASA-TM-105696] p 1134 N92-33894

Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193
PROTECTION
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
PULSE DOPPLER RADAR
Real-time processing of radar return on a parallel computer
[NASA-CR-4456] p 1043 N92-32606
PYLON MOUNTING
Computations of the unsteady flow about a generic wing/pylon/finned-store configuration
[AIAA PAPER 92-4568] p 1027 A92-55377

Q

QUALITATIVE ANALYSIS
Advanced nozzle and engine components test facility
[AIAA PAPER 92-3993] p 1099 A92-56816
QUALITY CONTROL
Designing to cost effectiveness - Enhancing quality p 1119 A92-56209
Electronics/avionics integrity - Definition, measurement and improvement p 1120 A92-56252
Engineering reliability and maintainability review - A regimen for discovering production deficiencies p 1120 A92-56254
The 1991 Federal Aviation Administration plan for research, engineering and development p 1142 N92-32453
SATWG networked quality function deployment p 1134 N92-33339

R

RADAR EQUIPMENT
Airport Surveillance Radar (ASR-9) wind shear processor: 1991 test at Orlando, Florida
[AD-A252246] p 1124 N92-32686
RADAR IMAGERY
The application of imaging sensors to aircraft landings in adverse weather p 1045 A92-54902
Talons 95 GHz radar sensor for autonomous landing guidance p 1063 A92-55908
RADAR MEASUREMENT
Talons 95 GHz radar sensor for autonomous landing guidance p 1063 A92-55908
Time Resolved Lidar Fluorosensor operating from helicopter p 1121 A92-56296
RADAR TRACKING
A fuzzy logic based F/A-18 automatic carrier landing system
[AIAA PAPER 92-4392] p 1074 A92-55193
RADIAL FLOW
A comparison of the calculated and experimental off-design performance of a radial flow turbine
[AIAA PAPER 92-3069] p 1020 A92-54004
Radial inflow turbine study
[AD-A252783] p 1127 N92-33538
RADIANT HEATING
Effect of porosity in transpiration cooling system p 1112 A92-53786
RADIATIVE HEAT TRANSFER
Radiative heat transfer from nonequilibrium shock layer to a hypersonic reentry body p 1019 A92-53579
RADIATIVE TRANSFER
Three-dimensional calculation of radiative field in hypersonic air shock layers p 1023 A92-54498
RADIO ALTIMETERS
Integration of radar altimeter, precision navigation, and digital terrain data for low-altitude flight
[AIAA PAPER 92-4420] p 1063 A92-55212
RADIO COMMUNICATION
History of aeronautical satellite communications p 1046 A92-56088
RADIO FREQUENCIES
Integrated Russian VLF/Omega receiver design
[PB92-193390] p 1051 N92-33809
RADIO RECEIVERS
Integrated Russian VLF/Omega receiver design
[PB92-193390] p 1051 N92-33809
RADIOGRAPHY
Application of X-ray image radiography system for aircraft p 1118 A92-56084
Detection of honeycomb damage using hexagonal grid discontinuities
[DREP-89-9] p 1109 N92-32846
RAMJET ENGINES
Development study on air turbo-ramjet engine for space plane p 1065 A92-53487
A preliminary study of a supersonic wind tunnel for a ram jet test facility p 1089 A92-53564
Turbulent combustion modelling in a side dump ramjet combustor
[AIAA PAPER 92-3599] p 1112 A92-54075
RAMPS (STRUCTURES)
Investigation of a plate-ramp-configuration by means of laser Doppler anemometry at Mach 2.95
[AIAA PAPER 92-3956] p 1097 A92-56784
RANDOM ACCESS
Aircraft satellite communication systems p 1046 A92-56091
RANGEFINDING
Vision-based stereo ranging as an optimal control problem
[AIAA PAPER 92-4418] p 1045 A92-55211
Vision-based range estimation using helicopter flight data
[NASA-TM-103930] p 1047 N92-32424
RANKINE CYCLE
Study of potassium turbine electric generator system p 1129 N92-33794
RANKINE-HUGONIOT RELATION
Computation and stability analysis of laminar flow over a blunt cone in hypersonic flow p 1041 N92-33839
RAREFIED GAS DYNAMICS
Application of a parallel direct simulation Monte Carlo method to hypersonic rarefied flows p 1024 A92-54916
Test facilities and instrumentation for research in rarefied gas dynamics - An historical perspective
[AIAA PAPER 92-3969] p 1098 A92-56795
RAREFIED GASES
Rarefied gas numerical wind tunnel p 1017 A92-53552
Rarefied gas research at Berkeley - Current studies and future potentials
[AIAA PAPER 92-3971] p 1098 A92-56797
RASTER SCANNING
The C-17 Multifunction Display - A building block for avionic systems p 1063 A92-55907
RAYLEIGH SCATTERING
Rayleigh imaging and flow tagging in ground test facilities p 1115 A92-54330
RAYLEIGH-RITZ METHOD
Continuation of tailored composite structures of ordered staple thermoplastic material
[NASA-CR-189671] p 1110 N92-33613
REACTING FLOW
Detailed numerical analysis of standing oblique detonation p 1111 A92-53550
Efficient methods for inviscid non-equilibrium hypersonic flow fields p 1024 A92-54571
A code validation strategy and facility for nonequilibrium, reacting flows
[AIAA PAPER 92-3970] p 1098 A92-56796
An approximate viscous shock layer technique for calculating chemically reacting hypersonic flows about blunt-nosed bodies p 1041 N92-33837
REACTION CONTROL
A shock tunnel experiment on aerodynamic interference induced by RCS jet p 1029 A92-56042
REACTION KINETICS
Experimental and computational investigation of scaling phenomena in a large caliber ram accelerator
[AIAA PAPER 92-3245] p 1103 A92-54019
Flow contamination and flow quality in arc heaters used for hypersonic testing
[AIAA PAPER 92-4028] p 1100 A92-56850
Influence of the swirl producing construction in the flow and reaction field of turbulent diffusion flames
[ETN-92-92103] p 1127 N92-33916
READOUT
The utility of analog vertical velocity information during instrument flight with a Head-Up Display (HUD)
[AD-A252863] p 1065 N92-33277
REAL GASES
A fine-wire thermocouple probe for measurement of stagnation temperatures in real gas hypersonic flows of nitrogen p 1114 A92-54317
REAL TIME OPERATION
Recent developments in data acquisition and control systems at the Aircraft Research Association Limited p 1091 A92-54323
Signal processing schemes for Doppler global velocimetry p 1115 A92-54338
Fault diagnostics on jet engine starting p 1116 A92-54345
A general approach to optimal real-time guidance of dynamic systems based on nonlinear programming
[AIAA PAPER 92-4378] p 1131 A92-55182
Real-time helicopter simulation using the blade element method p 1132 A92-56278
A simulation study of tiltrotor vertical takeoff procedures using conventional and variable diameter rotor systems p 1056 A92-56301
HEPO mission simulator - Development and usage for NH90 helicopter p 1094 A92-56313
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
Real-time processing of radar return on a parallel computer
[NASA-CR-4456] p 1043 N92-32606
The development of an airborne information management system for flight test
[NASA-TM-104251] p 1065 N92-32866
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
Distributed systems: Interconnection and fault tolerance studies
[AD-A252869] p 1135 N92-33920
Piloted evaluation of an integrated propulsion and flight control simulator
[NASA-TM-105797] p 1088 N92-34107
RECTANGULAR PLATES
Initial postbuckling response of an unsymmetrically laminated rectangular plate p 1108 N92-32586
RECTANGULAR WINGS
Computation of vortex wake flows and control of their effects on trailing wings
[AIAA PAPER 92-4429] p 1025 A92-55353
Aeroelastic effects of spoiler surfaces on a low-aspect-ratio rectangular wing p 1030 A92-56154
Effect of a simulated glaze ice shape on the aerodynamic performance of a rectangular wing
[AIAA PAPER 92-4042] p 1035 A92-56861
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter
[NASA-TM-104211] p 1042 N92-34147
RECURSIVE FUNCTIONS
Application of recursive partially unknown system identification to aerodynamic coefficients estimation
[AIAA PAPER 92-4504] p 1081 A92-55371
REDUCED GRAVITY
Experimental study of convection effects around the phase charge interface p 1111 A92-53755
Fundamental studies on Marangoni convection related to Bridgman crystal growth p 1111 A92-53758
REDUNDANCY
Redundancy design philosophy for catastrophic loss protection p 1119 A92-56202
REENTRY TRAJECTORIES
Optimal launch trajectory of a hypersonic research vehicle
[AIAA PAPER 92-4302] p 1103 A92-55310
REENTRY VEHICLES
Hypersonic flows with air chemistry over a reentry vehicle at high altitudes p 1017 A92-53549
Radiative heat transfer from nonequilibrium shock layer to a hypersonic reentry body p 1019 A92-53579
Pre-flight physical simulation test of HIMES reentry test vehicle p 1103 A92-53640
HOPE re-entry experimental vehicle p 1103 A92-55098
A shock tunnel experiment on aerodynamic interference induced by RCS jet p 1029 A92-56042
REFRACTORY MATERIALS
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729
REGIONS
Issues in developing control zones for international space operations p 1141 A92-56602
REGULATIONS
Federal aviation regulations. Part 91: General operating and flight rules
[PB92-197334] p 1017 N92-33176
REINFORCED SHELLS
A dynamic stiffness technique for the vibration analysis of stiffened shell structures p 1123 A92-56866
RELIABILITY
Annual Reliability and Maintainability Symposium, Las Vegas, NV, Jan. 21-23, 1992, Proceedings
[ISBN 0-7803-0521-3] p 1119 A92-56201
Improving reliability and maintainability through process management p 1141 A92-56212
Field test of an advanced maintenance-system p 1016 A92-56221
RELIABILITY ANALYSIS
Change and reliability of the DC-9-81 digital flight guidance system p 1084 A92-56086
Electronics/avionics integrity - Definition, measurement and improvement p 1120 A92-56252
Smoothing CFM56 engine removal rate at USAir
[AIAA PAPER 92-3928] p 1070 A92-56759
Using the simulation modeling method to estimate the reliability of the crew-flight vehicle system p 1133 A92-57444
Damage tolerance certification methodology for composite structures p 1108 N92-32579
Analysis of data from a DO-178A software development process p 1134 N92-32880

Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483
RELIABILITY ENGINEERING
Redundancy design philosophy for catastrophic loss protection p 1119 A92-56202
Designing to cost effectiveness - Enhancing quality p 1119 A92-56209
Modular techniques for dynamic fault-tree analysis p 1120 A92-56241
Engineering reliability and maintainability review - A regimen for discovering production deficiencies p 1120 A92-56254
HiRel - Reliability/availability integrated workstation tool p 1120 A92-56257
Thrust stand design principles
[AIAA PAPER 92-3976] p 1098 A92-56802
REMOTE SENSING
Time Resolved Lidar Fluorosensor operating from helicopter p 1121 A92-56296
REMOTELY PILOTED VEHICLES
Aerodynamic analysis of the Pioneer unmanned air vehicle
[AIAA PAPER 92-4635] p 1027 A92-55382
REQUIREMENTS
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
RESEARCH
United States Air Force summer research program 1991. Volume 1: Program management report
[AD-A248763] p 1142 N92-32338
RESEARCH AIRCRAFT
Synthesis of a MLS automatic landing control law for the NAL experimental research aircraft Do-228 p 1084 A92-56062
Collaborative research on V/STOL control system/cockpit display tradeoffs under the NASA/MOD joint aeronautical program
[NASA-TM-103910] p 1087 N92-32788
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
RESEARCH AND DEVELOPMENT
Japan pushes high speed research p 1015 A92-53434
Organization and technical status of the NH90 European helicopter programme p 1016 A92-56306
The SR3 low density wind tunnel - Facility capabilities and research development
[AIAA PAPER 92-3972] p 1098 A92-56798
A conceptual study for future engine test facility
[AIAA PAPER 92-3992] p 1099 A92-56815
Departments of Veterans Affairs and Housing and Urban Development, and independent agencies appropriations for 1993, part 6
[GAO-55-636-PT-6] p 1141 N92-32505
Research and technology, 1990
[NASA-TM-107967] p 1143 N92-33948
RESEARCH FACILITIES
Future requirements for hypersonic aerodynamic and aerothermodynamic facilities
[AIAA PAPER 92-3903] p 1094 A92-56738
The ASU Transition Research Facility
[AIAA PAPER 92-3910] p 1094 A92-56744
Test facilities and instrumentation for research in rarefied gas dynamics - An historical perspective
[AIAA PAPER 92-3969] p 1098 A92-56795
High temperature aircraft research furnace facilities
[NASA-CR-184384] p 1101 N92-33826
Research and technology, 1990
[NASA-TM-107967] p 1143 N92-33948
RESEARCH MANAGEMENT
DoD key technologies plan
[AD-A253692] p 1142 N92-33238
RESEARCH VEHICLES
The F-18 high alpha research vehicle: A high-angle-of-attack testbed aircraft
[NASA-TM-104253] p 1060 N92-33404
Experience with Ada on the F-18 High Alpha Research Vehicle Flight Test Program
[NASA-TM-104259] p 1062 N92-34039
RESIDUAL STRENGTH
Residual strength of repaired graphite/epoxy laminates after 5 years of outdoor exposure p 1108 N92-32577
RESIN MATRIX COMPOSITES
Advanced airframe structural materials: A primer and cost estimating methodology
[AD-A253371] p 1062 N92-34182
RESISTANCE HEATING
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131
RESONANT FREQUENCIES
Aircraft ride quality controller design using new robust root clustering theory for linear uncertain systems
[AIAA PAPER 92-4399] p 1075 A92-55199
RETROREFLECTION
Measurement of position and attitude using laser and retro-reflectors p 1047 A92-56120
REVERSED FLOW
Internal reversing flow in a tailpipe offtake configuration for SSTOVL aircraft
[AIAA PAPER 92-3790] p 1069 A92-54169
A high speed edgewise rotor using circulation control only in the reversed flow area p 1059 A92-56347
REYNOLDS NUMBER
Increased heat transfer to elliptical leading edges due to spanwise variations in the freestream momentum - Numerical and experimental results
[AIAA PAPER 92-3070] p 1020 A92-54005
Computational and experimental studies of flow in multi-lobed forced mixers
[AIAA PAPER 92-3568] p 1112 A92-54057
REYNOLDS STRESS
Comparison of turbulence models for powered-lift flow fields
[AIAA PAPER 92-3674] p 1022 A92-54117
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
RIDING QUALITY
Aircraft ride quality controller design using new robust root clustering theory for linear uncertain systems
[AIAA PAPER 92-4399] p 1075 A92-55199
RIGID ROTORS
Design and testing of a composite hingeless hub for rotary-wing aircraft p 1053 A92-56075
RIGID WINGS
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter
[NASA-TM-104211] p 1042 N92-34147
RING WINGS
Aerodynamic calculation of an elliptic ring wing
[AIAA PAPER 91-0068] p 1035 A92-57035
ROBUSTNESS (MATHEMATICS)
Robust dynamic inversion control laws for aircraft control
[AIAA PAPER 92-4329] p 1073 A92-55173
Preliminary assessment of the robustness of dynamic inversion based flight control laws
[AIAA PAPER 92-4330] p 1074 A92-55174
Flight-determined stability analysis of multiple-input-multiple-output control systems
[AIAA PAPER 92-4396] p 1074 A92-55196
Aircraft ride quality controller design using new robust root clustering theory for linear uncertain systems
[AIAA PAPER 92-4399] p 1075 A92-55199
Robust sampled data eigenstructure assignment using the delta operator
[AIAA PAPER 92-4400] p 1075 A92-55200
Design of robust Quantitative Feedback Theory controllers for pitch attitude hold systems
[AIAA PAPER 92-4409] p 1075 A92-55203
Robustness of a helicopter flight control system designed using eigenstructure assignment
[AIAA PAPER 92-4469] p 1076 A92-55229
An algorithm for robust eigenstructure assignment using the Linear Quadratic Regulator
[AIAA PAPER 92-4478] p 1131 A92-55237
The application of direct transcription to commercial aircraft trajectory optimization
[AIAA PAPER 92-4528] p 1077 A92-55246
A robust gain scheduler interpolated into multiple models by membership functions
[AIAA PAPER 92-4553] p 1131 A92-55265
Applications of robust control theory - Educational implications
[AIAA PAPER 92-4559] p 1131 A92-55271
An framework for robust flight control design using constrained optimization
[AIAA PAPER 92-4603] p 1131 A92-55282
Robust control design of an automatic carrier landing system
[AIAA PAPER 92-4619] p 1077 A92-55296
Computer aided evaluation of aircraft handling qualities and flight control system robustness
[AIAA PAPER 92-4423] p 1080 A92-55347
Robust identification of nonlinear aerodynamic model structure
[AIAA PAPER 92-4503] p 1081 A92-55370
Robust control system design with multiple model approach p 1083 A92-56029
Flight control system design using H(infinity) optimal control p 1083 A92-56030
A learning enhanced flight control system for high performance aircraft
[AD-A252520] p 1086 N92-32435
ROCKET ENGINE DESIGN
Development study on air turbo-ramjet engine for space plane p 1065 A92-53487
Conceptual design of scramjet engine p 1065 A92-53490
Key design considerations for scramjet powered space plane p 1066 A92-53491
ROCKET FIRING
Scramjet engine and its flying test bed p 1066 A92-53492
ROCKET LAUNCHERS
Aerodynamic study of H-II Orbiting Plane, HOPE p 1103 A92-53639
ROCKET TEST FACILITIES
Scramjet engine and its flying test bed p 1066 A92-53492
Performance analysis of idealized scramjet p 1066 A92-53493
ROLL
Robust dynamic inversion control laws for aircraft control
[AIAA PAPER 92-4329] p 1073 A92-55173
A background to the handling qualities of aircraft
[ESDU-92006] p 1087 N92-32780
ROLLING MOMENTS
Effects of the roll angle on cruciform wing-body configurations at high incidences
[AIAA PAPER 92-4356] p 1079 A92-55342
Contribution of tailplane-mounted twin fins to sideforce, yawing moment, and rolling moment derivatives due to sideslip
[ESDU-92007] p 1086 N92-32487
Lift and rolling moment due to spoilers on wings with trailing-edge flaps deflected at subsonic speeds
[ESDU-92002-SUPPL] p 1037 N92-32782
A nozzle internal performance prediction method
[NASA-TP-3221] p 1040 N92-33625
ROTARY STABILITY
Experimental investigation of the stability of a clearance-excited rotor system with optimal parameters p 1114 A92-54223
ROTARY WING AIRCRAFT
Summary highlights of the Advanced Rotorcraft Transmission (ART) program
[AIAA PAPER 92-3362] p 1051 A92-54026
Rotary wing structural dynamics and aeroelasticity --- Book
[ISBN 1-56347-031-4] p 1052 A92-54550
Design and testing of a composite hingeless hub for rotary-wing aircraft p 1053 A92-56075
Finite-element analysis and multibody dynamics issues in rotorcraft dynamic analysis p 1055 A92-56286
A small light-weight rotor platform for ground observation and pollution control p 1057 A92-56329
Current European rotorcraft research activities on development of advanced CFD methods for the design of rotor blades (BRITE/EURAM 'DACRO' project) p 1032 A92-56332
Development of a conceptual design method for rotary-wing aircraft using digital computers p 1058 A92-56340
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers
[NASA-TM-104170] p 1138 N92-33160
The dynamics of flexible multibody systems: A finite segment approach p 1128 N92-34036
ROTARY WINGS
Rotary wing structural dynamics and aeroelasticity --- Book
[ISBN 1-56347-031-4] p 1052 A92-54550
Sensitivity analysis for structural optimization of helicopter rotor blades p 1053 A92-56073
A calculation method to predict helicopter noise and its verification p 1135 A92-56074
Helicopter rotor testing using scaled model p 1093 A92-56076
Flutter and stall response of a helicopter blade with structural nonlinearity p 1055 A92-56178
Design and development of test rigs for main rotor and main rotor transmission of a helicopter in the 6-ton-class p 1093 A92-56280
Response of helicopter blades to a sharp collective increase p 1084 A92-56282
Simulation of helicopter see-saw rotor motion p 1055 A92-56287
Dynamics of helicopters with dissimilar blades in forward flight p 1056 A92-56288
The application of math-dynamic models to characterise a range of helicopter rotor system faults p 1056 A92-56297
Modern helicopter technologies at MBB and the application in future programmes p 1016 A92-56304
Aeroelasticity of a coaxial helicopter rotor p 1057 A92-56309
Influence of cross section variations on the structural behaviour of composite rotor blades p 1121 A92-56320
A finite element method for shear stresses calculation in composite blade models p 1121 A92-56322
A generic harmonic rotor model for helicopter flight simulation p 1086 A92-56333

A study of helicopter rotor/fuselage response in low-speed manoeuvres - Comparison of theory with flight p 1086 A92-56334
Low energy ice protection for helicopters p 1059 A92-56348
Aerodynamic features of a coaxial rotor helicopter p 1032 A92-56349
Correlation of flight, tunnel and prediction data on a helicopter main rotor p 1059 A92-56350
Measurements of the dynamic stall vortex convection speed p 1032 A92-56351
Numerical investigation of the effects of icing on fixed and rotary wing aircraft [NASA-CR-190542] p 1044 N92-34105

ROTATING BODIES
The dynamics of flexible multibody systems: A finite segment approach p 1128 N92-34036

ROTATING FLUIDS
Flow induction by pressure forces [AIAA PAPER 92-3571] p 1067 A92-54060

ROTATING STALLS
Active control of compressor surge and stall [AD-A252771] p 1126 N92-33498

ROTATION
Effects of curvature and rotation on turbulence in the NASA low-speed centrifugal compressor impeller p 1124 N92-32292

ROTOR AERODYNAMICS
A finite-volume numerical method to calculate fluid forces and rotordynamic coefficients in seals [AIAA PAPER 92-3712] p 1113 A92-54132
Experimental investigation of the stability of a clearance-excited rotor system with optimal parameters p 1114 A92-54223
Comparison of frequency domain and time domain laser velocimeter signal processors p 1114 A92-54314
Particle image velocimetry measurements of the aerodynamics of a wind turbine p 1115 A92-54337
Helicopter rotor testing using scaled model p 1093 A92-56076
Dynamic analysis of rotor blades with root retention design variations p 1054 A92-56156
The computation and validation of hovering rotor performance p 1055 A92-56285
Finite-element analysis and multibody dynamics issues in rotorcraft dynamic analysis p 1055 A92-56286
The application of math-dynamic models to characterise a range of helicopter rotor system faults p 1056 A92-56297
Blade instability of horizontally stoppable rotors p 1085 A92-56308
A time-dependent tip loss formula for rotor blade dynamic analysis p 1057 A92-56310
Smart structures in the active control of blade vortex interaction p 1085 A92-56314
Current European research activities in helicopter interactional aerodynamics p 1058 A92-56330
A generic harmonic rotor model for helicopter flight simulation p 1086 A92-56333
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344
Aerodynamic features of a coaxial rotor helicopter p 1032 A92-56349
Correlation of flight, tunnel and prediction data on a helicopter main rotor p 1059 A92-56350
Measurements of the dynamic stall vortex convection speed p 1032 A92-56351
Radial inflow turbine study [AD-A252783] p 1127 N92-33538

ROTOR BLADES
The interaction between a high-frequency gust and a blade row p 1135 A92-54484
Measurements of blade flapping motion on a wind tunnel model p 1093 A92-56023
Structural optimization of a cantilevered beam subject to combined static loadings p 1118 A92-56024
Sensitivity analysis for structural optimization of helicopter rotor blades p 1053 A92-56073
Dynamic analysis of rotor blades with root retention design variations p 1054 A92-56156
Helicopter tail rotor stall flutter p 1056 A92-56290
Blade instability of horizontally stoppable rotors p 1085 A92-56308
A time-dependent tip loss formula for rotor blade dynamic analysis p 1057 A92-56310
Oscillations of an anisotropic rotor on an elastic anisotropic support p 1057 A92-56311
Coupled rotor-fuselage vibration reduction with multiple frequency blade pitch control p 1085 A92-56315
Current European rotorcraft research activities on development of advanced CFD methods for the design of rotor blades (BRITE/EURAM 'DACRO' project) p 1032 A92-56332
A study of helicopter rotor/fuselage response in low-speed manoeuvres - Comparison of theory with flight p 1086 A92-56334
Low energy ice protection for helicopters p 1059 A92-56348
Numerical simulation of unsteady rotor wakes p 1032 A92-56352
Experimental study of performance degradation of a rotating system in the NASA Lewis RC icing tunnel [NASA-CR-190684] p 1102 N92-34141

ROTOR BLADES (TURBOMACHINERY)
Real-time helicopter simulation using the blade element method p 1132 A92-56278
Trimming rotor blades with periodically deflecting trailing edge flaps p 1085 A92-56283
Research on measurement and control of helicopter rotor response using blade-mounted accelerometers 1990-91 p 1057 A92-56316
Composite blades for helicopter main and tail rotors developed by Mil Design Bureau p 1057 A92-56325
Statistics on aircraft gas turbine engine rotor failures that occurred in US commercial aviation during 1988 [DOT/FAA/CT-91/28] p 1071 N92-33105

ROTOR BODY INTERACTIONS
Response of helicopter blades to a sharp collective increase p 1084 A92-56282
Coupled rotor-fuselage vibration reduction with multiple frequency blade pitch control p 1085 A92-56315
Experimental investigation of helicopter coupled rotor/body control p 1086 A92-56318
Current European research activities in helicopter interactional aerodynamics p 1058 A92-56330
Analysis of helicopter rotor-fuselage interference with time averaged pressure distribution p 1032 A92-56331
A study of helicopter rotor/fuselage response in low-speed manoeuvres - Comparison of theory with flight p 1086 A92-56334
Approximations for inclusion of rotor lag dynamics in helicopter flight dynamics models p 1060 A92-56354

ROTOR DYNAMICS
Aeroelasticity of a coaxial helicopter rotor p 1057 A92-56309
Oscillations of an anisotropic rotor on an elastic anisotropic support p 1057 A92-56311
Research on measurement and control of helicopter rotor response using blade-mounted accelerometers 1990-91 p 1057 A92-56316
The identification of coupled flapping/inflow models for hovering flight p 1058 A92-56335
A high speed edgewise rotor using circulation control only in the reversed flow area p 1059 A92-56347
Approximations for inclusion of rotor lag dynamics in helicopter flight dynamics models p 1060 A92-56354
Joint study on the computerisation of in-field aero engines vibration diagnosis [PNR-90799] p 1072 N92-33815

ROTOR SPEED
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055
Turbulence-induced loads on a teetered rotor p 1042 N92-34029

ROTORCRAFT AIRCRAFT
Summary highlights of the Advanced Rotorcraft Transmission (ART) program [AIAA PAPER 92-3362] p 1051 A92-54026
Flight simulator fidelity assessment in a rotorcraft lateral translation maneuver [AIAA PAPER 92-4424] p 1092 A92-55348
Analysis of image-based navigation system for rotorcraft low-altitude flight p 1046 A92-55968
Technology exploitation for in-service support of future rotorcraft p 1016 A92-56327
Damage tolerance analysis for rotorcraft - What the issues are p 1058 A92-56336
First level release of 2GCHAS for comprehensive helicopter analysis p 1133 A92-56339
Approximations for inclusion of rotor lag dynamics in helicopter flight dynamics models p 1060 A92-56354

ROTORS
Description of a pressure measurement technique for obtaining surface static pressures of a radial turbine [AIAA PAPER 92-4006] p 1123 A92-56829
An investigation of switched reluctance rotor position estimation using neural networks [AD-A252846] p 1061 N92-33414
Cooled high-temperature radial turbine program 2 [NASA-CR-189122] p 1073 N92-34236

RUDDERS
E-6 flutter investigation and experience [AIAA PAPER 92-4601] p 1077 A92-55280

RUN TIME (COMPUTERS)
Computations of unsteady multistage compressor flows in a workstation environment [NASA-TM-103839] p 1071 N92-32452

RUNWAY CONDITIONS
Grooved runway surface texture before and after rubber removal p 1093 A92-56111
Criteria for use of seal coats on airport pavements [DOT/FAA/RD-92/18] p 1102 N92-34247

RUNWAYS
Performance of insulated pavements at Newton Fields, Jackman, Maine [CRREL-92-9] p 1101 N92-32903
ILS mathematical modeling study of an ILS localizer and glide slope proposed for runway 32R, Moffett Field Airport, California [DOT/FAA/CT-TN92/28] p 1048 N92-33308
Criteria for use of seal coats on airport pavements [DOT/FAA/RD-92/18] p 1102 N92-34247

S

SAAB AIRCRAFT
Vibro-acoustic FE analyses of the Saab 2000 aircraft p 1137 N92-32952

SAFETY FACTORS
Safety provision against 'ground resonance' free vibration of a coaxial helicopter p 1056 A92-56289
A module-level testing environment for safety-critical software systems p 1132 A92-56293
Safety study of TCAS 2 for logic version 6.04 [DOT/FAA/RD-92/22] p 1047 N92-32537

SAMPLED DATA SYSTEMS
A new system for recording unstable aerodynamic phenomena in NAVSWC Hypervelocity Wind Tunnel No. 9 p 1091 A92-54325

SANDWICH STRUCTURES
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
Stability failure of sandwich structures [MBB-UD-0613-92-PUB] p 1111 N92-33994

SATELLITE ANTENNAS
Calibration of GPS antennas [ETN-92-92034] p 1051 N92-33693

SATELLITE COMMUNICATION
History of aeronautical satellite communications p 1046 A92-56088
Aeronautical satellite communications system p 1046 A92-56089
Aircraft satellite communication systems p 1046 A92-56091
Evaluation report of an experimental Satcom operation by a Japan Airline's B747 passenger plane p 1046 A92-56092
An experimental program concerning a satellite data link for oceanic ATC p 1046 A92-56093

SCALE MODELS
Experimental investigation of an ejector-powered free-jet facility [AIAA PAPER 92-3569] p 1090 A92-54058
On the maneuvering tests of an ACV model p 1118 A92-56035
Helicopter rotor testing using scaled model p 1093 A92-56076
Experimental study of noise generation and propagation in a turbofan model p 1136 A92-56169
Demonstration of structural optimization applied to wind-tunnel model design p 1119 A92-56181
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344
Design of a variable contraction for a full-scale automotive wind tunnel [AIAA PAPER 92-3929] p 1096 A92-56760

SCALING
Experimental and computational investigation of scaling phenomena in a large caliber ram accelerator [AIAA PAPER 92-3245] p 1103 A92-54019

SCALING LAWS
Dynamical scaling of a model unsteady separating flow p 1117 A92-54932

SCARFING
Processing and environmental effects on mechanical properties of composite repairs [NRC-LTR-ST-1826] p 1109 N92-32791

SCATTERING
Development of 3D electromagnetic modeling tools for airborne vehicles [NASA-CR-190810] p 1126 N92-33307

SCHEDULING
Analysis of delay reducing and fuel saving sequencing and spacing algorithms for arrival traffic [NASA-TM-103880] p 1044 N92-33194

SCHLIEREN PHOTOGRAPHY
An experimental study of the flow over a sharp-edged delta wing at subsonic and transonic speeds [NLR-TP-91117-U] p 1037 N92-32732

SCREENS
Prediction of the pressure loss coefficient of wind tunnel turbulence reducing screens
[AIAA PAPER 92-4043] p 1035 A92-56862
SEALERS
Criteria for use of seal coats on airport pavements
[DOT/FAA/RD-92/18] p 1102 N92-34247
SEALS (STOPPERS)
A finite-volume numerical method to calculate fluid forces and rotordynamic coefficients in seals
[AIAA PAPER 92-3712] p 1113 A92-54132
SECONDARY FLOW
Numerical study on the secondary jet into a supersonic flow p 1018 A92-53556
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[AIAA PAPER 92-3177] p 1020 A92-54013
Flow induction by pressure forces
[AIAA PAPER 92-3571] p 1067 A92-54060
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[NASA-TM-105672] p 1128 N92-34112
SELECTION
Airbreathing engine selection criteria for SSTO propulsion system
[IAF PAPER 92-0658] p 1071 A92-57099
SELF CONSISTENT FIELDS
H-N2 interaction energies, transport cross sections, and collision integrals p 1135 A92-54660
SELF OSCILLATION
Stochastic self-induced roll oscillations of slender delta wing at high angles of attack
[AIAA PAPER 92-4498] p 1081 A92-55366
SEPARATED FLOW
Detecting 3-D, turbulent separation regions using unsteady computerized thermographic technique p 1023 A92-54308
Dynamical scaling of a model unsteady separating flow p 1117 A92-54932
Assessment of passive porosity with free and fixed separation on a tangent ogive forebody
[AIAA PAPER 92-4494] p 1081 A92-55363
State-space representation of aerodynamic characteristics of an aircraft at high angels of attack
[AIAA PAPER 92-4651] p 1028 A92-55395
A critical evaluation of a three-dimensional Navier-Stokes CFD as a tool to design supersonic turbine stages p 1124 N92-32268
Numerical investigation of the effects of icing on fixed and rotary wing aircraft
[NASA-CR-190542] p 1044 N92-34105
SERVICE LIFE
Effective maintenance practices to manage system aging p 1119 A92-56215
Supportability evaluation of thermoplastic and thermoset composites p 1108 N92-32576
Residual strength of repaired graphite/epoxy laminates after 5 years of outdoor exposure p 1108 N92-32577
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program
[AD-A247886] p 1108 N92-32629
Effects of the abrasiveness of test and training site soils on parachute life
[AD-A252389] p 1038 N92-32900
SHADOWGRAPH PHOTOGRAPHY
High-speed cinematography of supersonic mixing layers
[AIAA PAPER 92-3545] p 1112 A92-54044
SHAPE MEMORY ALLOYS
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131
SHAPES
Examples of advanced near-net shape manufacturing techniques for aerospace
[MBB-Z-0399-91-PUB] p 1125 N92-32742
Development of 3D electromagnetic modeling tools for airborne vehicles
[NASA-CR-190810] p 1126 N92-33307
SHARP LEADING EDGES
An experimental study of the flow over a sharp-edged delta wing at subsonic and transonic speeds
[NLR-TP-91117-U] p 1037 N92-32732
Strong coupling between inviscid fluid and boundary layer of sharp leading edges: Two-dimensional stationary and turbulent cases for isolated profiles and guard vanes
[ONERA-RT-44/1621-RY-016-R] p 1125 N92-32776
SHEAR FLOW
Assessment of compressibility corrections to the k-epsilon model in high-speed shear layers p 1024 A92-54905
SHEAR LAYERS
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
A laser fluorescence anemometer system for the Langley 16- by 24-inch water tunnel p 1092 A92-54347
High speed transition prediction
[NASA-CR-190836] p 1039 N92-33424
SHEAR STRAIN
Transverse shear effect on flutter of composite panels p 1122 A92-56607
SHEAR STRENGTH
Processing and environmental effects on mechanical properties of composite repairs
[NRC-LTR-ST-1826] p 1109 N92-32791
SHEAR STRESS
Shock detection on airfoils by means of piezo foil- and hot film arrays p 1115 A92-54334
A finite element method for shear stresses calculation in composite blade models p 1121 A92-56322
SHOCK LAYERS
Hypersonic flows with air chemistry over a reentry vehicle at high altitudes p 1017 A92-53549
Radiative heat transfer from nonequilibrium shock layer to a hypersonic reentry body p 1019 A92-53579
Three-dimensional calculation of radiative field in hypersonic air shock layers p 1023 A92-54498
An approximate viscous shock layer technique for calculating chemically reacting hypersonic flows about blunt-nosed bodies p 1041 N92-33837
SHOCK TUBES
Unsteady shock propagation in a steady flow nozzle expansion p 1023 A92-54489
Double piston shock-wave valve p 1117 A92-54938
A quiet-flow Ludwieg tube for experimental study of high speed boundary layer transition
[AIAA PAPER 92-3885] p 1094 A92-56727
The high enthalpy shock tunnel in Goettingen
[AIAA PAPER 92-3942] p 1104 A92-56772
TSNIIMASH capabilities for aerogasdynamical and thermal testing of hypersonic vehicles
[AIAA PAPER 92-3962] p 1097 A92-56789
Study on supersonic combustion in a hypersonic flight
[IAF PAPER 92-0661] p 1106 A92-57101
SHOCK TUNNELS
Three-dimensional Navier-Stokes heat transfer predictions for turbine blade rows
[AIAA PAPER 92-3068] p 1020 A92-54003
Comparison between computational and experimental data for a hypersonic laser propelled vehicle
[AIAA PAPER 92-3808] p 1023 A92-54179
Flow characterization in the NASA Ames 16-inch Shock Tunnel
[AIAA PAPER 92-3810] p 1090 A92-54180
Instrumentation key to NASP combustor tests p 1092 A92-55100
A shock tunnel experiment on aerodynamic interference induced by RCS jet p 1029 A92-56042
The high enthalpy shock tunnel in Goettingen
[AIAA PAPER 92-3942] p 1104 A92-56772
The G-range impulse facility - A high-performance free-piston shock tunnel
[AIAA PAPER 92-3946] p 1097 A92-56774
Performance data of the new free-piston shock tunnel at GALCIT
[AIAA PAPER 92-3943] p 1033 A92-56776
Millisecond aerodynamic force measurement with side-jet model in the ISL shock tunnel
[AIAA PAPER 92-3963] p 1097 A92-56790
Effects of oxygen dissociation on hypervelocity combustion experiments
[AIAA PAPER 92-3964] p 1098 A92-56791
Hypersonic shock tunnel testing for undergraduate laboratory instruction
[AIAA PAPER 92-4021] p 1100 A92-56843
Numerical simulation of unsteady flow in a hypersonic shock tunnel facility
[AIAA PAPER 92-4029] p 1034 A92-56851
SHOCK WAVE INTERACTION
The behaviour of the pressure temperature and density in an inviscid unsteady transonic axisymmetric flow with shock waves p 1018 A92-53553
Experimental investigation on turbulent phenomena in three-dimensional shock wave/turbulent boundary layer interaction induced by blunt fin p 1018 A92-53557
Numerical simulations of shock reflections by a TVD scheme p 1018 A92-53558
Interaction between a body flying at a supersonic velocity and a point explosion p 1019 A92-53867
Experimental study on three-dimensional shock wave-turbulent boundary layer interaction induced by protuberance p 1019 A92-53997
Thermal paints for shock/boundary layer interaction in inlet flows
[AIAA PAPER 92-3626] p 1113 A92-54093
Heat transfer measurements and CFD comparison of swept shock wave/boundary-layer interactions
[AIAA PAPER 92-3665] p 1021 A92-54110
An experimental examination of the effects of incoming boundary layer modifications on the dynamics of a turbulent compression corner interaction
[AIAA PAPER 92-3667] p 1022 A92-54111
Structure of crossing-shock wave/turbulent boundary-layer interactions
[AIAA PAPER 92-3670] p 1022 A92-54113
Experimental investigation of the reflection of a shock wave on a heated surface in presence of a turbulent boundary layer p 1023 A92-54569
Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance p 1029 A92-56009
On the structure of unsteady shock induced separation of the transonic airfoil in the NAL two-dimensional wind tunnel p 1029 A92-56010
Unsteady shock-vortex interaction on a flexible delta wing p 1030 A92-56157
SHOCK WAVE PROFILES
Analysis of sonic boom data to quantify distortions of shock profiles p 1139 N92-33879
The effect of turbulence on the loudness of minimized sonic boom signatures p 1139 N92-33880
Lateral spread of sonic boom measurements from US Air Force boomfile flight tests p 1140 N92-33883
Subjective loudness response to simulated sonic booms p 1140 N92-33885
SHOCK WAVE PROPAGATION
Unsteady shock propagation in a steady flow nozzle expansion p 1023 A92-54489
High-Speed Research: Sonic Boom, volume 1
[NASA-CP-3172] p 1061 N92-33874
A numerical model for sonic boom propagation through an inhomogeneous, windy atmosphere p 1138 N92-33876
Wave equations and computational models for sonic boom propagation through a turbulent atmosphere p 1139 N92-33877
Simulations of sonic boom ray tube area fluctuations for propagation through atmospheric turbulence including caustics via a Monte Carlo method p 1139 N92-33878
Analysis of sonic boom data to quantify distortions of shock profiles p 1139 N92-33879
Model experiment to study the effect of turbulence on risetime and waveform of N waves p 1139 N92-33881
Steady state risetimes of shock waves in the atmosphere p 1140 N92-33882
Lateral spread of sonic boom measurements from US Air Force boomfile flight tests p 1140 N92-33883
Preliminary results from the White Sands Missile Range sonic boom propagation experiment p 1140 N92-33884
Subjective loudness response to simulated sonic booms p 1140 N92-33885
SHOCK WAVES
A double chaotic attractor in transonic flow p 1019 A92-53561
Shock detection on airfoils by means of piezo foil- and hot film arrays p 1115 A92-54334
Experimental investigation of the reflection of a shock wave on a heated surface in presence of a turbulent boundary layer p 1023 A92-54569
Double piston shock-wave valve p 1117 A92-54938
A hypersonic wind tunnel test of a mixed-compression air inlet model p 1028 A92-56007
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043
The research of reducing 3-D low supersonic shock wave reflection in a 2-D transonic flexible walls adaptive wind tunnel
[AIAA PAPER 92-3924] p 1095 A92-56755
Swept shock/boundary layer interaction experiments in support of CFD code validation
[NASA-CR-190583] p 1036 N92-32494
An examination of several high resolution schemes applied to complex problems in high speed flows
[AD-A250814] p 1124 N92-32632
SHORT CRACKS
Inspection of fabricated fuselage panels using electronic shearography
[DOT/FAA/CT-TN92/26] p 1127 N92-33627
SHORT TAKEOFF AIRCRAFT
Experimental performance of three design factors for ventral nozzles for SSTOVL aircraft
[AIAA PAPER 92-3789] p 1069 A92-54168
Internal reversing flow in a tailpipe offtake configuration for SSTOVL aircraft
[AIAA PAPER 92-3790] p 1069 A92-54169
Analysis of airframe/engine interactions for a STOVL aircraft with integrated flight/propulsion control
[AIAA PAPER 92-4623] p 1052 A92-55300

Analysis of the main wing lift distribution of the STOL research aircraft Asuka p 1053 A92-56051
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
Flight simulator test of cockpit advisory system p 1054 A92-56115
Short takeoff optimization for the XV-15 tiltrotor aircraft p 1056 A92-56302

SHROUDED TURBINES
Experimental modeling of film-cooled axial turbine tip seals
[AIAA PAPER 92-4058] p 1119 A92-56141

SHROUDS
Effects of curvature and rotation on turbulence in the NASA low-speed centrifugal compressor impeller p 1124 N92-32292

SIDESLIP
Contribution of tailplane-mounted twin fins to sideforce, yawing moment, and rolling moment derivatives due to sideslip
[ESDU-92007] p 1086 N92-32487

SIGNAL PROCESSING
Comparison of frequency domain and time domain laser velocimeter signal processors p 1114 A92-54314
Signal processing schemes for Doppler global velocimetry p 1115 A92-54338
The use of silicon microsensors in smart skins for aerodynamic research p 1116 A92-54348
Real-time processing of radar return on a parallel computer
[NASA-CR-4456] p 1043 N92-32606
Airport Surveillance Radar (ASR-9) wind shear processor: 1991 test at Orlando, Florida
[AD-A252246] p 1124 N92-32686
The design and development of a portable, DSP micro-processor based, high-accuracy data acquisition system
[NRC-32146] p 1134 N92-32851
Distributed systems: Interconnection and fault tolerance studies
[AD-A252869] p 1135 N92-33920

SIGNATURE ANALYSIS
Blockage correction in three-dimensional wind tunnel testing based on the wall signature method
[AIAA PAPER 92-3925] p 1095 A92-56756

SIGNATURES
The effect of turbulence on the loudness of minimized sonic boom signatures p 1139 N92-33880
Lateral spread of sonic boom measurements from US Air Force boomfile flight tests p 1140 N92-33883
Subjective loudness response to simulated sonic booms p 1140 N92-33885

SIKORSKY AIRCRAFT
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575

SIMILARITY THEOREM
Use of an approximate similarity principle for the thermal scaling of a full-scale thrust augmenting ejector
[AIAA PAPER 92-3792] p 1069 A92-54171

SIMULATION
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
Ski jump takeoff performance predictions for a mixed-flow, remote-lift STOVL aircraft
[NASA-TM-103866] p 1060 N92-32887

SIMULATORS
Conception of a UHB engine simulator for the essential characteristics of a true-scale engine --- ultrahigh bypass p 1090 A92-54322

SINGLE CRYSTALS
Life prediction and constitutive models for engine hot section anisotropic materials program
[NASA-CR-189223] p 1072 N92-33479

SINGLE STAGE TO ORBIT VEHICLES
Key design considerations for scramjet powered space plane p 1066 A92-53491
Aerodynamic studies on space plane configuration at hypersonic speed p 1019 A92-53641
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
Airbreathing engine selection criteria for SSTO propulsion system
[IAF PAPER 92-0658] p 1071 A92-57099

SINGLE-PHASE FLOW
Pulsation characteristics of one-phase and two-phase steam flows in Laval nozzles under off-design conditions p 1019 A92-53882

SINGULARITY (MATHEMATICS)
A Lie Bracket solution of the optimal thrust magnitude on a singular arc in atmospheric flight
[AIAA PAPER 92-4345] p 1079 A92-55334

SIZING (SHAPING)
PAYCOS, a multidisciplinary sizing code for hypersonic vehicles
[AIAA PAPER 92-4564] p 1132 A92-55376

SKIN (STRUCTURAL MEMBER)
The use of silicon microsensors in smart skins for aerodynamic research p 1116 A92-54348
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043

SKIN FRICTION
Skin friction measurements in 3-D boundary layers p 1092 A92-54351
Physics of vortical flows p 1031 A92-56166

SKIRTS
Configuration of flexible-skirts for an ACV and its CAD p 1118 A92-56036
Planning method of skirt systems for small ACVs p 1118 A92-56038

SLENDER BODIES
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations p 1127 N92-33968

SLENDER CONES
Approximate Riemann solver for hypervelocity flows p 1117 A92-54934

SLENDER WINGS
A discrete vortex model for predicting wing rock of slender wings
[AIAA PAPER 92-4497] p 1026 A92-55365
Stochastic self-induced roll oscillations of slender delta wing at high angles of attack
[AIAA PAPER 92-4498] p 1081 A92-55366
Wind tunnel blockage effects on slender wings undergoing large amplitude motions
[AIAA PAPER 92-3926] p 1096 A92-56757

SLOTS
Numerical simulation of slot injection into a turbulent supersonic stream p 1024 A92-54914

SMALL PERTURBATION FLOW
Efficient iterative methods for the transonic small disturbance equation p 1025 A92-54933

SMART STRUCTURES
The use of silicon microsensors in smart skins for aerodynamic research p 1116 A92-54348
Smart structures in the active control of blade vortex interaction p 1085 A92-56314
Active vibrations and noise control for turboprop application research program activities p 1138 N92-32962

SMOKE
Degenerate four-wave mixing for measurement of NO2 and smoke concentration in jet engine exhaust
[AIAA PAPER 92-3658] p 1113 A92-54108

SOFTWARE ENGINEERING
Analysis of data from a DO-178A software development process p 1134 N92-32880

SOFTWARE TOOLS
FREPS - A forced response prediction system for turbomachinery blade rows
[AIAA PAPER 92-3072] p 1130 A92-54006
Multidisciplinary optimization of aeroservoelastic systems using reduced-size models p 1054 A92-56176
HiRel - Reliability/availability integrated workstation tool p 1120 A92-56257
Test and integration concept for complex helicopter avionic systems p 1064 A92-56292
First level release of 2GCHAS for comprehensive helicopter analysis p 1133 A92-56339
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483

SOILS
Effects of the abrasiveness of test and training site soils on parachute life
[AD-A252389] p 1038 N92-32900

SOLAR GENERATORS
Study of potassium turbine electric generator system p 1129 N92-33794

SOLID PROPELLANT ROCKET ENGINES
Optimal launch trajectory of a hypersonic research vehicle
[AIAA PAPER 92-4302] p 1103 A92-55310

SOLID SURFACES
Experimental and numerical investigation of a supersonic free jet impinging on a perpendicular surface p 1018 A92-53555

SONIC BOOMS
Application of computational fluid dynamics to sonic boom near- and mid-field prediction p 1031 A92-56173
Application of magnitude estimation scaling to the assessment of subjective loudness response to simulated sonic booms
[NASA-TM-107657] p 1138 N92-33719
High-Speed Research: Sonic Boom, volume 1
[NASA-CP-3172] p 1061 N92-33874
A numerical model for sonic boom propagation through an inhomogeneous, windy atmosphere p 1138 N92-33876
Wave equations and computational models for sonic boom propagation through a turbulent atmosphere p 1139 N92-33877
Simulations of sonic boom ray tube area fluctuations for propagation through atmospheric turbulence including caustics via a Monte Carlo method p 1139 N92-33878
Analysis of sonic boom data to quantify distortions of shock profiles p 1139 N92-33879
The effect of turbulence on the loudness of minimized sonic boom signatures p 1139 N92-33880
Model experiment to study the effect of turbulence on risetime and waveform of N waves p 1139 N92-33881
Steady state risetimes of shock waves in the atmosphere p 1140 N92-33882
Lateral spread of sonic boom measurements from US Air Force boomfile flight tests p 1140 N92-33883
Preliminary results from the White Sands Missile Range sonic boom propagation experiment p 1140 N92-33884
Subjective loudness response to simulated sonic booms p 1140 N92-33885

SOUND FIELDS
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964

SOUND GENERATORS
Sound produced by vortex-airfoil interaction p 1136 A92-56345

SOUND PRESSURE
Exposures from headset interference tones
[AD-A247175] p 1136 N92-32697
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers
[NASA-TM-104170] p 1138 N92-33160

SOUND TRANSMISSION
Active control of sound transmission through stiff lightweight composite fuselage constructions p 1137 N92-32957
Pilot noise exposure during a Boeing 747-400 round trip: Judgement of noise and analysis in respect to hearing impairment of pilots p 1138 N92-32961

SOUND WAVES
Exposures from headset interference tones
[AD-A247175] p 1136 N92-32697

SPACE EXPLORATION
Analysis of spacecraft entry into Mars atmosphere p 1105 N92-33763

SPACE FLIGHT
Improvement of atmospheric flight performance of a space vehicle through H infinity-control theory p 1130 A92-53785

SPACE MISSIONS
Issues in developing control zones for international space operations p 1141 A92-56602

SPACE STATION FREEDOM
Issues in developing control zones for international space operations p 1141 A92-56602

SPACE STATIONS
Issues in developing control zones for international space operations p 1141 A92-56602

SPACE TRANSPORTATION SYSTEM
Optimization of two stage reusable space transportation systems with rocket and airbreathing propulsion concepts
[IAF PAPER 92-0863] p 1104 A92-57254

SPACECRAFT CONTROL
Dynamics and control of hypersonic aeropropulsive/aeroelastic vehicles
[AIAA PAPER 92-4326] p 1073 A92-55170

SPACECRAFT DESIGN
Spaceplane aerodynamic heating and thermal protection design method p 1102 A92-53578
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
Optimization of a 2D scramjet-vehicle using CFD and simplified approximate flow analysis techniques
[AIAA PAPER 92-3673] p 1022 A92-54116

SPACECRAFT GUIDANCE
A guidance law for hypersonic descent to a point
[AIAA PAPER 92-4303] p 1104 A92-55311

SPACECRAFT PERFORMANCE
Laboratory simulation of aerothermodynamic phenomena - A review
[AIAA PAPER 92-4025] p 1104 A92-56847

SPACECRAFT REENTRY
Thermally and chemically nonequilibrium hypersonic flow in three-dimensional geometry p 1019 A92-53580
Analysis of spacecraft entry into Mars atmosphere p 1105 N92-33763

SPECIFIC IMPULSE
Conceptual design of scramjet engine p 1065 A92-53490

SPECTRAL METHODS
Effects of spectrum variations on fatigue crack growth p 1123 A92-57399

SPEED CONTROL
Multiaxis control in longitudinal mode of aircraft p 1083 A92-56027
A note on thrust control for jetliner during approach p 1053 A92-56061

SPILLING
Criteria for use of seal coats on airport pavements [DOT/FAA/RD-92/18] p 1102 N92-34247

SPIN STABILIZATION
Model flight tests of a spin-resistant trainer configuration p 1054 A92-56158

SPIN TESTS
Analysis of the flight performance of the 155 mm M864 base burn projectile
[BRL-TR-3083] p 1041 N92-33699

SPOILERS
Aeroelastic effects of spoiler surfaces on a low-aspect-ratio rectangular wing p 1030 A92-56154
Lift and rolling moment due to spoilers on wings with trailing-edge flaps deflected at subsonic speeds
[ESDU-92002-SUPPL] p 1037 N92-32782

SPRAY CHARACTERISTICS
Spray nozzle for fire control
[CA-PATENT-APPL-SN-2-011-94] p 1125 N92-32856

SPRAY NOZZLES
Spray nozzle for fire control
[CA-PATENT-APPL-SN-2-011-94] p 1125 N92-32856

SPRAYING
Current repair technologies for jet engine components p 1016 A92-56085

STABILITY AUGMENTATION
C-17 flight control system overview p 1082 A92-55906

STABILITY DERIVATIVES
Dynamic derivative data for high angle of attack simulation
[AIAA PAPER 92-4355] p 1079 A92-55341
Simulation model of a twin-tail, high performance airplane
[NASA-TM-107601] p 1088 N92-33537

STABILITY TESTS
Computation and stability analysis of laminar flow over a blunt cone in hypersonic flow p 1041 N92-33839

STABILIZATION
Active control of compressor surge and stall
[AD-A252771] p 1126 N92-33498

STAGNATION POINT
The high enthalpy shock tunnel in Goettingen
[AIAA PAPER 92-3942] p 1104 A92-56772

STAGNATION PRESSURE
Structure of crossing-shock wave/turbulent boundary-layer interactions
[AIAA PAPER 92-3670] p 1022 A92-54113
The G-range impulse facility - A high-performance free-piston shock tunnel
[AIAA PAPER 92-3946] p 1097 A92-56774

STAGNATION TEMPERATURE
A fine-wire thermocouple probe for measurement of stagnation temperatures in real gas hypersonic flows of nitrogen p 1114 A92-54317
Turbine disk cavity aerodynamics and heat transfer p 1124 N92-32265

STAINLESS STEELS
Stainless steel welding shines through on wind tunnel project p 1123 A92-57039

STALLING
The F-18 high alpha research vehicle: A high-angle-of-attack testbed aircraft
[NASA-TM-104253] p 1060 N92-33404

STANDARDIZATION
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program
[AD-A247886] p 1108 N92-32629
The need for GPS standardization p 1049 N92-33351

STARTING
Fault diagnostics on jet engine starting p 1116 A92-54345

STATE ESTIMATION
Estimation of aircraft inertial characteristics using maximum likelihood estimation p 1084 A92-56057
A physical approach to the estimation of aerodynamic characteristics from flight data p 1030 A92-56058

STATIC AERODYNAMIC CHARACTERISTICS
Measurements of longitudinal static aerodynamic coefficients with cable mount system p 1093 A92-56013

STATIC LOADS
Structural optimization of a cantilevered beam subject to combined static loadings p 1118 A92-56024

STATIC PRESSURE
Description of a pressure measurement technique for obtaining surface static pressures of a radial turbine
[AIAA PAPER 92-4006] p 1123 A92-56829

STATISTICAL ANALYSIS
Development of an uncertainty methodology for multiple-channel instrumentation systems
[AIAA PAPER 92-3953] p 1133 A92-56781
Use of SEA to predict structure-borne noise in aircraft p 1137 N92-32955
Experimental study of performance degradation of a rotating system in the NASA Lewis RC icing tunnel
[NASA-CR-190684] p 1102 N92-34141
Engine bird ingestion experience of the Boeing 737 aircraft: Expanded data base
[DOT/FAA/CT-91/32] p 1045 N92-34151

STATORS
Investigation of the flight control requirements of a half-scale ducted fan unmanned aerial vehicle
[AD-A252730] p 1087 N92-32988
An investigation of switched reluctance rotor position estimation using neural networks
[AD-A252846] p 1061 N92-33414

STEADY FLOW
Unsteady shock propagation in a steady flow nozzle expansion p 1023 A92-54489
Efficient iterative methods for the transonic small disturbance equation p 1025 A92-54933
Increasing the accuracy of the Godunov scheme for calculating steady-state supersonic gas flows by solving the generalized Riemann problem p 1035 A92-57499

STEADY STATE
Steady state risetimes of shock waves in the atmosphere p 1140 N92-33882

STEAM FLOW
Pulsation characteristics of one-phase and two-phase steam flows in Laval nozzles under off-design conditions p 1019 A92-53882

STEERING
Evaluation of GPS/UTC steering performance p 1049 N92-33353

STEREOSCOPIC VISION
Vision-based stereo ranging as an optimal control problem
[AIAA PAPER 92-4418] p 1045 A92-55211

STEREOSCOPY
Computational algorithms for increased control of depth-viewing volume for stereo three-dimensional graphic displays
[NASA-TM-4379] p 1065 N92-34109

STIFFNESS MATRIX
A dynamic stiffness technique for the vibration analysis of stiffened shell structures p 1123 A92-56866

STIRLING ENGINES
Proof of concept of a magnetically coupled Stirling engine-driven heat pump
[DE92-017129] p 1129 N92-33271

STOKES FLOW
Stokes flows in superposed immiscible liquids with horizontal heating
[IAF PAPER 92-0909] p 1123 A92-57288

STOVL AIRCRAFT
Preliminary dynamic tests of a flight-type ejector
[AIAA PAPER 92-3261] p 1066 A92-54020
Propulsion system performance resulting from an Integrated Flight/Propulsion Control design
[AIAA PAPER 92-4602] p 1069 A92-55281
Ski jump takeoff performance predictions for a mixed-flow, remote-lift STOVL aircraft
[NASA-TM-103866] p 1060 N92-32887
Dynamic response of induced pressures, suckdown, and temperatures for two tandem jet STOVL configurations
[NASA-TM-103934] p 1039 N92-33581

STRAIN GAGE BALANCES
The cryogenic balance design and balance calibration methods
[AIAA PAPER 92-4001] p 1122 A92-56824

STRAIN MEASUREMENT
Electro optical system to measure strains at high temperature
[NASA-CR-190450] p 1127 N92-33696

STRANGE ATTRACTORS
A double chaotic attractor in transonic flow p 1019 A92-53561

STREAM FUNCTIONS (FLUIDS)
Effect of streamwise pressure gradient on the supersonic mixing layer p 1025 A92-54936

STRESS ANALYSIS
Global/local methods research using the CSM testbed p 1107 N92-32528
Computational methods for global/local analysis
[NASA-TM-107591] p 1125 N92-33104
Global/local interlaminar stress analysis of a grid-stiffened composite panel
[NASA-CR-190822] p 1125 N92-33139
Effects of constraint on crack growth under aircraft spectrum loading
[NASA-TM-107677] p 1128 N92-34178

STRESS INTENSITY FACTORS
Effects of constraint on crack growth under aircraft spectrum loading
[NASA-TM-107677] p 1128 N92-34178

STRETCH FORMING
Continuation of tailored composite structures of ordered staple thermoplastic material
[NASA-CR-189671] p 1110 N92-33613

STRUCTURAL ANALYSIS
Sensitivity analysis for structural optimization of helicopter rotor blades p 1053 A92-56073
Fatigue cracking threshold prediction of transport airplanes p 1118 A92-56094
Detailed analysis and test correlation of a stiffened composite wing panel p 1121 A92-56324
Structural assessment of ultralightweight composites p 1107 N92-32525
Global/local methods research using the CSM testbed p 1107 N92-32528
Initial postbuckling response of an unsymmetrically laminated rectangular plate p 1108 N92-32586
Computational methods for global/local analysis
[NASA-TM-107591] p 1125 N92-33104

STRUCTURAL DESIGN
Turning up the heat on aircraft structures --- design and analysis for high-temperature conditions p 1052 A92-55131
Wing mass formula for twin fuselage aircraft p 1054 A92-56171
Multidisciplinary optimization of aeroservoelastic systems using reduced-size models p 1054 A92-56176
Demonstration of structural optimization applied to wind-tunnel model design p 1119 A92-56181
Structural design and testing results of composite landing gear components p 1057 A92-56328
The cryogenic balance design and balance calibration methods
[AIAA PAPER 92-4001] p 1122 A92-56824
Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, part 1
[NASA-CP-3087-PT-1] p 1106 N92-32513
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575

STRUCTURAL DESIGN CRITERIA
Global/local interlaminar stress analysis of a grid-stiffened composite panel
[NASA-CR-190822] p 1125 N92-33139
The Rolls-Royce Trent
[PNR-90875] p 1061 N92-33750

STRUCTURAL ENGINEERING
Repair procedures for advanced composites for helicopters p 1016 A92-56277
Aeroelasticity of bluff bodies p 1089 N92-34165

STRUCTURAL FAILURE
Design, evaluation and experimental effort toward development of a high strain composite wing for Navy aircraft p 1107 N92-32514

STRUCTURAL STABILITY
Stability failure of sandwich structures
[MBB-UD-0613-92-PUB] p 1111 N92-33994

STRUCTURAL VIBRATION
Monitoring fatigue cracks in gears p 1116 A92-54496
DAMVIBS looks at rotorcraft vibration p 1052 A92-55128
Safety provision against 'ground resonance' free vibration of a coaxial helicopter p 1056 A92-56289
The application of math-dynamic models to characterise a range of helicopter rotor system faults p 1056 A92-56297
Coupled rotor-fuselage vibration reduction with multiple frequency blade pitch control p 1085 A92-56315
Path identification in structural acoustics p 1059 A92-56346
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers
[NASA-TM-104170] p 1138 N92-33160

STUDENTS
United States Air Force summer research program 1991. Volume 1: Program management report
[AD-A248763] p 1142 N92-32338

SUBSONIC AIRCRAFT
High angle-of-attack flush airdata sensing system p 1064 A92-56172

High Reynolds number testing in support of transport airplane development
[AIAA PAPER 92-3982] p 1099 A92-56807
SUBSONIC FLOW
Navier-Stokes simulation for the winged space vehicle 'HOPE' at subsonic, transonic, and supersonic regimes p 1018 A92-53559
Calculations for aerodynamic characteristics of HOPE type vehicle in subsonic and hypersonic flow p 1018 A92-53560
An experimental investigation of the flow in a diffusing S-duct
[AIAA PAPER 92-3622] p 1021 A92-54090
The SR3 low density wind tunnel - Facility capabilities and research development
[AIAA PAPER 92-3972] p 1098 A92-56798
Effects of external influences in subsonic delta wing vortices
[AIAA PAPER 92-4033] p 1034 A92-56855
An experimental study of the flow over a sharp-edged delta wing at subsonic and transonic speeds
[NLR-TP-91117-U] p 1037 N92-32732
High speed transition prediction
[NASA-CR-190836] p 1039 N92-33424
SUBSONIC FLUTTER
E-6 flutter investigation and experience
[AIAA PAPER 92-4601] p 1077 A92-55280
SUBSONIC SPEED
Advanced subsonic transport approach noise: The relative contribution of airframe noise
[NASA-TM-104112] p 1140 N92-34148
SUBSONIC WIND TUNNELS
Assessment of passive porosity with free and fixed separation on a tangent ogive forebody
[AIAA PAPER 92-4494] p 1081 A92-55363
High subsonic wind tunnel test of a two-dimensional hybrid-laminar-flow-control airfoil with slotted surface p 1029 A92-56045
The design of a subsonic low-noise, low-turbulence wind tunnel for acoustic measurements
[AIAA PAPER 92-3883] p 1094 A92-56726
SUCTION
Experimental evaluation of a 50-percent thick airfoil with blowing and suction boundary layer control
[AIAA PAPER 92-4500] p 1026 A92-55368
SUPERCHARGERS
Radial inflow turbine study
[AD-A252783] p 1127 N92-33538
SUPERCRITICAL PRESSURES
Structure and penetration of a transverse fluid jet injected at supercritical pressure in supersonic flow
[AIAA PAPER 92-3652] p 1113 A92-54105
SUPERSONIC AIRCRAFT
Study on international cooperative test facilities for future SST/HST
[AIAA PAPER 92-3945] p 1097 A92-56775
A method for designing blended wing-body configurations for low wave drag
[NASA-TP-3261] p 1036 N92-32480
Supportability evaluation of thermoplastic and thermoset composites p 1108 N92-32576
Survey and analysis of research on supersonic drag-due-to-lift minimization with recommendations for wing design
[NASA-TP-3202] p 1040 N92-33656
Lateral spread of sonic boom measurements from US Air Force boomfile flight tests p 1140 N92-33883
SUPERSONIC BOUNDARY LAYERS
Linear stability of supersonic cone boundary layers p 1024 A92-54910
SUPERSONIC COMBUSTION
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
An assumed joint-Beta PDF approach for supersonic turbulent combustion
[AIAA PAPER 92-3844] p 1113 A92-54199
Interaction between chemical reaction and turbulence in supersonic nonpremixed H2-air combustion p 1117 A92-54931
Free-radicals aided combustion with scramjet applications
[IAF PAPER 92-0659] p 1106 A92-57100
Study on supersonic combustion in a hypersonic flight
[IAF PAPER 92-0661] p 1106 A92-57101
Theories of turbulent combustion in high speed flows
[AD-A253032] p 1111 N92-33624
SUPERSONIC COMBUSTION RAMJET ENGINES
Some thermodynamical aspects in the optimization of supersonic combustors p 1065 A92-53486
Conceptual design of scramjet engine p 1065 A92-53490
Key design considerations for scramjet powered space plane p 1066 A92-53491
Scramjet engine and its flying test bed p 1066 A92-53492
Performance analysis of idealized scramjet p 1066 A92-53493
Detailed numerical analysis of standing oblique detonation p 1111 A92-53550
Flow measurements in scramjet inlets p 1102 A92-53565
The enhancement of the mixing and combustion processes in supersonic flow applied to scramjet engine
[AIAA PAPER 92-3428] p 1112 A92-54029
Optimization of a 2D scramjet-vehicle using CFD and simplified approximate flow analysis techniques
[AIAA PAPER 92-3673] p 1022 A92-54116
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
Further studies of kinetic energy methods in high speed ramjet cycle analysis
[AIAA PAPER 92-3805] p 1069 A92-54177
Dynamics and control of hypersonic aeropropulsive/aeroelastic vehicles
[AIAA PAPER 92-4326] p 1073 A92-55170
A clean air continuous flow propulsion facility
[AIAA PAPER 92-3912] p 1094 A92-56745
Test description and preliminary pitot-pressure surveys for Langley Test Technique Demonstrator at Mach 6
[AIAA PAPER 92-3940] p 1096 A92-56770
A model study on diffuser pressure recovery in NAL scramjet test facility with simulated hydrogen combustion
[AIAA PAPER 92-3979] p 1071 A92-56805
Free-radicals aided combustion with scramjet applications
[IAF PAPER 92-0659] p 1106 A92-57100
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
Perspectives on hypersonic viscous and nonequilibrium flow research
[NASA-CR-190817] p 1039 N92-33413
SUPERSONIC DIFFUSERS
A model study on diffuser pressure recovery in NAL scramjet test facility with simulated hydrogen combustion
[AIAA PAPER 92-3979] p 1071 A92-56805
SUPERSONIC DRAG
Survey and analysis of research on supersonic drag-due-to-lift minimization with recommendations for wing design
[NASA-TP-3202] p 1040 N92-33656
SUPERSONIC FLIGHT
The trisonic wind tunnel Muenchen and its involvement in the German SAeNGER-programme
[AIAA PAPER 92-4019] p 1100 A92-56841
SUPERSONIC FLOW
Numerical study on the secondary jet into a supersonic flow p 1018 A92-53556
Navier-Stokes simulation for the winged space vehicle 'HOPE' at subsonic, transonic, and supersonic regimes p 1018 A92-53559
The enhancement of the mixing and combustion processes in supersonic flow applied to scramjet engine
[AIAA PAPER 92-3428] p 1112 A92-54029
High-speed cinematography of supersonic mixing layers
[AIAA PAPER 92-3545] p 1112 A92-54044
Structure and penetration of a transverse fluid jet injected at supercritical pressure in supersonic flow
[AIAA PAPER 92-3652] p 1113 A92-54105
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
A new look at surface flow visualization to provide insight into complex fluid dynamic behavior p 1090 A92-54307
Nonintrusive measurements in fluid dynamic flows from Mach .0005 to 14 p 1090 A92-54311
Numerical simulation of slot injection into a turbulent supersonic stream p 1024 A92-54914
Effect of streamwise pressure gradient on the supersonic mixing layer p 1025 A92-54936
Numerical simulation of supersonic unsteady flow using a panel method p 1030 A92-56048
Euler/experiment correlation of a generic fighter p 1031 A92-56164
The research of reducing 3-D low supersonic shock wave reflection in a 2-D transonic flexible walls adaptive wind tunnel
[AIAA PAPER 92-3924] p 1095 A92-56755
Investigation of a plate-ramp-configuration by means of laser Doppler anemometry at Mach 2.95
[AIAA PAPER 92-3956] p 1097 A92-56784
The SR3 low density wind tunnel - Facility capabilities and research development
[AIAA PAPER 92-3972] p 1098 A92-56798
Experimental unsteady pressures on an oscillating cascade with supersonic leading edge locus
[AIAA PAPER 92-4035] p 1035 A92-56857
Increasing the accuracy of the Godunov scheme for calculating steady-state supersonic gas flows by solving the generalized Riemann problem p 1035 A92-57499
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations p 1127 N92-33968
SUPERSONIC FLUTTER
Transverse shear effect on flutter of composite panels p 1122 A92-56607
SUPERSONIC JET FLOW
Experimental and numerical investigation of a supersonic free jet impinging on a perpendicular surface p 1018 A92-53555
Numerical study of the 3-D flowfield for a supersonic jet exiting into a hypersonic stream from a conical surface
[AIAA PAPER 92-3675] p 1022 A92-54118
Broadband shock associated noise from supersonic jets measured by a ground observer p 1135 A92-54909
SUPERSONIC NOZZLES
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
SUPERSONIC SPEED
Interaction between a body flying at a supersonic velocity and a point explosion p 1019 A92-53867
Application of computational fluid dynamics to sonic boom near- and mid-field prediction p 1031 A92-56173
SUPERSONIC TRANSPORTS
Experimental investigation of an ejector-powered free-jet facility
[AIAA PAPER 92-3569] p 1090 A92-54058
Full Navier-Stokes analysis of a two-dimensional mixer/ejector nozzle for noise suppression
[AIAA PAPER 92-3570] p 1067 A92-54059
Roles of wind tunnel tests and CFD analyses in the design of energy-efficient SST
[AIAA PAPER 92-3923] p 1133 A92-56754
Isothermal aging of IM7/8320 and IM7/5260
[NASA-TM-107666] p 1110 N92-33423
Experimental study of a generic high-speed civil transport
[NASA-TM-4382] p 1040 N92-33631
SUPERSONIC TURBINES
A critical evaluation of a three-dimensional Navier-Stokes CFD as a tool to design supersonic turbine stages p 1124 N92-32268
SUPERSONIC WIND TUNNELS
A preliminary study of a supersonic wind tunnel for a ram jet test facility p 1089 A92-53564
High-speed cinematography of supersonic mixing layers
[AIAA PAPER 92-3545] p 1112 A92-54044
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
Structure of crossing-shock wave/turbulent boundary-layer interactions
[AIAA PAPER 92-3670] p 1022 A92-54113
A new look at surface flow visualization to provide insight into complex fluid dynamic behavior p 1090 A92-54307
Rayleigh imaging and flow tagging in ground test facilities p 1115 A92-54330
Double piston shock-wave valve p 1117 A92-54938
Supersonic wind tunnel test of airintake/airframe integrated models p 1028 A92-56006
Supersonic and hypersonic quiet tunnel technology at NASA Langley
[AIAA PAPER 92-3908] p 1094 A92-56743
Roles of wind tunnel tests and CFD analyses in the design of energy-efficient SST
[AIAA PAPER 92-3923] p 1133 A92-56754
CAN-DO, CFD-based Aerodynamic Nozzle Design and Optimization program for supersonic/hypersonic wind tunnels
[AIAA PAPER 92-4009] p 1033 A92-56832
Experimental unsteady pressures on an oscillating cascade with supersonic leading edge locus
[AIAA PAPER 92-4035] p 1035 A92-56857
SUPPORT SYSTEMS
Developing robust support structures for high-technology subsystems: The AH-64 Apache helicopter
[AD-A252773] p 1017 N92-33499
SURFACE ROUGHNESS
Grooved runway surface texture before and after rubber removal p 1093 A92-56111

Numerical investigation of the effects of icing on fixed and rotary wing aircraft
[NASA-CR-190542] p 1044 N92-34105
SURFACE TEMPERATURE
Swept shock/boundary layer interaction experiments in support of CFD code validation
[NASA-CR-190583] p 1036 N92-32494
SURVEILLANCE
DoD key technologies plan
[AD-A253692] p 1142 N92-33238
SURVEILLANCE RADAR
Airport Surveillance Radar (ASR-9) wind shear processor: 1991 test at Orlando, Florida
[AD-A252246] p 1124 N92-32686
SURVEYS
Survey and analysis of research on supersonic drag-due-to-lift minimization with recommendations for wing design
[NASA-TP-3202] p 1040 N92-33656
SWEAT COOLING
Effect of porosity in transpiration cooling system
p 1112 A92-53786
SWEPT FORWARD WINGS
Research on aeroelastic tailoring at NAL
p 1053 A92-56019
SWEPT WINGS
High angle-of-attack control enhancement on a forward swept wing aircraft
[AIAA PAPER 92-4427] p 1080 A92-55351
Improved calculation of transonic potential flow past swept wings p 1031 A92-56179
Analysis of iced wings
[NASA-TM-105773] p 1042 N92-34144
SWEPTBACK WINGS
Research on aeroelastic tailoring at NAL
p 1053 A92-56019
SWIRLING
Wind tunnel performance results of swirl recovery vanes as tested with an advanced high speed propeller
[AIAA PAPER 92-3770] p 1068 A92-54159
Numerical calculations of propfan/swirl recovery vane flow field
[AIAA PAPER 92-3771] p 1022 A92-54160
Computational and experimental investigation of annulus heat transfer with swirl
[AIAA PAPER 92-4060] p 1119 A92-56143
Influence of the swirl producing construction in the flow and reaction field of turbulent diffusion flames
[ETN-92-92103] p 1127 N92-33916
SYNCHROPHASING
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951
Active synchrophasing of propeller unbalance
p 1138 N92-32963
SYSTEM IDENTIFICATION
Robust identification of nonlinear aerodynamic model structure
[AIAA PAPER 92-4503] p 1081 A92-55370
Application of recursive partially unknown system identification to aerodynamic coefficients estimation
[AIAA PAPER 92-4504] p 1081 A92-55371
An identification procedure for a system with a choice of feedback structures p 1132 A92-55426
SYSTEMS ANALYSIS
A graphical user-interface for propulsion system analysis
[NASA-TM-105696] p 1134 N92-33894
SYSTEMS ENGINEERING
Improving designer productivity
[AIAA PAPER 92-1187] p 1130 A92-54285
Enlisting industry support for a flight controls design lab
[AIAA PAPER 92-4560] p 1141 A92-55272
Designing to cost effectiveness - Enhancing quality
p 1119 A92-56209
Helicopter nonlinear flight control system development
p 1085 A92-56317
The 1991 Federal Aviation Administration plan for research, engineering and development
p 1142 N92-32453
SYSTEMS INTEGRATION
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
Test and integration concept for complex helicopter avionic systems p 1064 A92-56292
Integrated test and evaluation for hypervelocity systems
[AIAA PAPER 92-3901] p 1017 A92-56736
Design and evaluation of an advanced air-ground data-link system for air traffic control
[NASA-TM-103899] p 1050 N92-33407

T

T-37 AIRCRAFT
Implementation of a personal computer based parameter estimation program
[AD-A252914] p 1061 N92-33502
TAIL ROTORS
Composite blades for helicopter main and tail rotors developed by Mil Design Bureau p 1057 A92-56325
TAKEOFF
Optimal control of tiltrotor aircraft following power failure p 1085 A92-56303
Ski jump takeoff performance predictions for a mixed-flow, remote-lift STOVL aircraft
[NASA-TM-103866] p 1060 N92-32887
TANKS (CONTAINERS)
Fire bombing and fire bombers
[CA-PATENT-1-268-164] p 1061 N92-33582
TARGETS
Development of 3D electromagnetic modeling tools for airborne vehicles
[NASA-CR-190810] p 1126 N92-33307
TARS
Criteria for use of seal coats on airport pavements
[DOT/FAA/RD-92/18] p 1102 N92-34247
TECHNOLOGICAL FORECASTING
Air transports in the 21st century
p 1015 A92-55103
TECHNOLOGIES
DoD key technologies plan
[AD-A253692] p 1142 N92-33238
TECHNOLOGY ASSESSMENT
Getting up to speed in hypersonic structures
p 1117 A92-55127
New materials drive high-performance aircraft
p 1105 A92-55134
State-of-the-art materials for future gas turbine engines p 1070 A92-56122
New aircraft technologies - Challenges for dependability p 1120 A92-56225
Modern helicopter technologies at MBB and the application in future programmes p 1016 A92-56304
The 1991 Federal Aviation Administration plan for research, engineering and development
p 1142 N92-32453
Examples of advanced near-net shape manufacturing techniques for aerospace
[MBB-Z-0399-91-PUB] p 1125 N92-32742
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
Study objectives: Will commercial avionics do the job? Improvements needed? p 1065 N92-33340
TECHNOLOGY TRANSFER
An international aerospace information system: A cooperative opportunity
[NASA-TM-108171] p 1142 N92-33237
TEMPERATURE CONTROL
A clean air continuous flow propulsion facility
[AIAA PAPER 92-3912] p 1094 A92-56745
TEMPERATURE DEPENDENCE
Use of an approximate similarity principle for the thermal scaling of a full-scale thrust augmenting ejector
[AIAA PAPER 92-3792] p 1069 A92-54171
TEMPERATURE DISTRIBUTION
New 1.27-m leg of the National Aerospace Laboratory hypersonic wind tunnel p 1092 A92-56003
TEMPERATURE EFFECTS
The cryogenic balance design and balance calibration methods
[AIAA PAPER 92-4001] p 1122 A92-56824
Performance of insulated pavements at Newton Fields, Jackman, Maine
[CRREL-92-9] p 1101 N92-32903
Isothermal aging of IM7/8320 and IM7/5260
[NASA-TM-107666] p 1110 N92-33423
Electro optical system to measure strains at high temperature
[NASA-CR-190450] p 1127 N92-33696
TEMPERATURE MEASUREMENT
Acoustic control of combustor primary zone air-jet mixing
[AIAA PAPER 92-3651] p 1067 A92-54104
A fine-wire thermocouple probe for measurement of stagnation temperatures in real gas hypersonic flows of nitrogen p 1114 A92-54317
Turbine engine hot-part temperature measurement techniques
[AIAA PAPER 92-3960] p 1122 A92-56788
Boundary layer study on nozzle wall at hypersonic velocities
[AIAA PAPER 92-4013] p 1034 A92-56836
Feasibility of measuring transverse electric noise at VLF and LF on an ice cap
[AD-A252280] p 1129 N92-33220
TEMPERATURE MEASURING INSTRUMENTS
Notes on the use of fusible temperature indicators to bound the temperature of hot graphite in the NAVSWC hypervelocity wind tunnel facility p 1090 A92-54315
TENSILE STRENGTH
Processing and environmental effects on mechanical properties of composite repairs
[NRC-LTR-ST-1826] p 1109 N92-32791
TERMINAL FACILITIES
Accomplishments under the Airport Improvement Program, FY 1991
[AD-A253046] p 1101 N92-33434
TERMINAL GUIDANCE
CTAS: Computer intelligence for air traffic control in the terminal area
[NASA-TM-103959] p 1044 N92-33080
TERMINOLOGY
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program
[AD-A247886] p 1108 N92-32629
TERRAIN
Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081
TERRAIN FOLLOWING AIRCRAFT
Integration of radar altimeter, precision navigation, and digital terrain data for low-altitude flight
[AIAA PAPER 92-4420] p 1063 A92-55212
Laser-radar based obstacle avoidance system for helicopters p 1064 A92-56295
TEST FACILITIES
A preliminary study of a supersonic wind tunnel for a ram jet test facility p 1089 A92-53564
V-22 propulsion system design p 1070 A92-56300
Supersonic and hypersonic quiet tunnel technology at NASA Langley
[AIAA PAPER 92-3908] p 1094 A92-56743
A clean air continuous flow propulsion facility
[AIAA PAPER 92-3912] p 1094 A92-56745
An overview of the planned aerospace test facilities at Capua, Italy
[AIAA PAPER 92-3944] p 1097 A92-56773
Study on international cooperative test facilities for future SST/HST
[AIAA PAPER 92-3945] p 1097 A92-56775
TSNIIMASH capabilities for aerogasdynamical and thermal testing of hypersonic vehicles
[AIAA PAPER 92-3962] p 1097 A92-56789
Test facilities and instrumentation for research in rarefied gas dynamics - An historical perspective
[AIAA PAPER 92-3969] p 1098 A92-56795
A code validation strategy and facility for nonequilibrium, reacting flows
[AIAA PAPER 92-3970] p 1098 A92-56796
Thrust stand design principles
[AIAA PAPER 92-3976] p 1098 A92-56802
Turbine engine performance test and evaluation techniques
[AIAA PAPER 92-3977] p 1071 A92-56803
Small engine components test facility compressor testing cell at NASA Lewis Research Center
[AIAA PAPER 92-3980] p 1098 A92-56806
Comparison of recent results from different wind tunnel facilities along with comparisons of measured flight results and wind tunnel based predictions
[AIAA PAPER 92-3985] p 1060 A92-56809
Advanced nozzle and engine components test facility
[AIAA PAPER 92-3993] p 1099 A92-56816
Engine component instrumentation development facility at NASA Lewis Research Center
[AIAA PAPER 92-3995] p 1099 A92-56818
Calibration of hemispherical-head flow angularity probes
[AIAA PAPER 92-4005] p 1122 A92-56828
Aerodynamics laboratory education at Purdue University - Ground testing facilities
[AIAA PAPER 92-4018] p 1100 A92-56840
The trisonic wind tunnel Muenchen and its involvement in the German SAeNGER-programme
[AIAA PAPER 92-4019] p 1100 A92-56841
Laboratory simulation of aerothermodynamic phenomena - A review
[AIAA PAPER 92-4025] p 1104 A92-56847
Transonic turbine blade cascade testing facility
[AIAA PAPER 92-4034] p 1101 A92-56856
Thermal-structural test facilities at NASA Dryden
[NASA-TM-104249] p 1062 N92-34202
TEST FIRING
Scramjet engine and its flying test bed
p 1066 A92-53492
TEST STANDS
Scramjet engine and its flying test bed
p 1066 A92-53492

Design and development of test rigs for main rotor and main rotor transmission of a helicopter in the 6-ton-class p 1093 A92-56280
Development of an uncertainty methodology for multiple-channel instrumentation systems [AIAA PAPER 92-3953] p 1133 A92-56781
TEST VEHICLES
The German Hypersonics Technology Programme - Status report 1992 [IAF PAPER 92-0867] p 1105 A92-57258
THEODORSEN TRANSFORMATION
Ideal efficiency of propellers based on Theodorsen's theory: A review and computer study, with extended plus simplified charts [UTIAS-TN-271] p 1071 N92-33102
THERMAL ANALYSIS
Thermal mechanical analysis of sprag clutches [NASA-CR-190686] p 1128 N92-34207
THERMAL CYCLING TESTS
Criteria for use of seal coats on airport pavements [DOT/FAA/RD-92/18] p 1102 N92-34247
THERMAL ENVIRONMENTS
Thermal-structural test facilities at NASA Dryden [NASA-TM-104249] p 1062 N92-34202
THERMAL FATIGUE
Life prediction and constitutive models for engine hot section anisotropic materials program [NASA-CR-189223] p 1072 N92-33479
THERMAL INSULATION
Performance of insulated pavements at Newton Fields, Jackman, Maine [CRREL-92-9] p 1101 N92-32903
THERMAL PROTECTION
Spaceplane aerodynamic heating and thermal protection design method p 1102 A92-53578
Effect of porosity in transpiration cooling system p 1112 A92-53786
THERMAL SIMULATION
Thermal-structural test facilities at NASA Dryden [NASA-TM-104249] p 1062 N92-34202
THERMAL STABILITY
High-temperature metal matrix composite p 1105 A92-53878
Liquid lubricants for advanced aircraft engines [NASA-TM-104531] p 1109 N92-32863
THERMAL STRESSES
Turning up the heat on aircraft structures --- design and analysis for high-temperature conditions p 1052 A92-55131
THERMOCOUPLES
A fine-wire thermocouple probe for measurement of stagnation temperatures in real gas hypersonic flows of nitrogen p 1114 A92-54317
THERMODYNAMIC CYCLES
Some thermodynamical aspects in the optimization of supersonic combustors p 1065 A92-53486
THERMOGRAPHY
Detecting 3-D, turbulent separation regions using unsteady computerized thermographic technique p 1023 A92-54308
Quantitative heat transfer measurements in hypersonic wind tunnels by means of infrared thermography p 1115 A92-54321
THERMOPLASTIC RESINS
Supportability evaluation of thermoplastic and thermoset composites p 1108 N92-32576
Fluid effects: Thermoset and thermoplastic matrix composites p 1110 N92-33049
Jet fuel absorption and dynamic mechanical analysis of carbon fibre composites p 1110 N92-33050
Isothermal aging of IM7/8320 and IM7/5260 [NASA-TM-107666] p 1110 N92-33423
THERMOPLASTICITY
Development of thermoplastic components for structural validation p 1107 N92-32522
Continuation of tailored composite structures of ordered staple thermoplastic material [NASA-CR-189671] p 1110 N92-33613
THERMOSETTING RESINS
Supportability evaluation of thermoplastic and thermoset composites p 1108 N92-32576
CFRP stiffened panels under compression p 1109 N92-33044
Isothermal aging of IM7/8320 and IM7/5260 [NASA-TM-107666] p 1110 N92-33423
THIN AIRFOILS
Flutter and stall response of a helicopter blade with structural nonlinearity p 1055 A92-56178
THREE DIMENSIONAL BODIES
Rarefied gas numerical wind tunnel p 1017 A92-53552
Three-dimensional calculation of radiative field in hypersonic air shock layers p 1023 A92-54498
THREE DIMENSIONAL BOUNDARY LAYER
Experimental investigation on turbulent phenomena in three-dimensional shock wave/turbulent boundary layer interaction induced by blunt fin p 1018 A92-53557
Experimental study on three-dimensional shock wave-turbulent boundary layer interaction induced by protuberance p 1019 A92-53997
Skin friction measurements in 3-D boundary layers p 1092 A92-54351
THREE DIMENSIONAL FLOW
Navier-Stokes analysis of three-dimensional unsteady flows inside turbine stages [AIAA PAPER 92-3211] p 1021 A92-54016
High-speed cinematography of supersonic mixing layers [AIAA PAPER 92-3545] p 1112 A92-54044
Numerical calculations of propfan/swirl recovery vane flow field [AIAA PAPER 92-3771] p 1022 A92-54160
Detecting 3-D, turbulent separation regions using unsteady computerized thermographic technique p 1023 A92-54308
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance p 1029 A92-56009
Physics of vortical flows p 1031 A92-56166
Improved calculation of transonic potential flow past swept wings p 1031 A92-56179
A time-dependent tip loss formula for rotor blade dynamic analysis p 1057 A92-56310
The research of reducing 3-D low supersonic shock wave reflection in a 2-D transonic flexible walls adaptive wind tunnel [AIAA PAPER 92-3924] p 1095 A92-56755
Blockage correction in three-dimensional wind tunnel testing based on the wall signature method [AIAA PAPER 92-3925] p 1095 A92-56756
A critical evaluation of a three-dimensional Navier-Stokes CFD as a tool to design supersonic turbine stages p 1124 N92-32268
Numerical simulation of turbulence at the back of the airplane [ETN-92-91664] p 1037 N92-32769
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS [NIFS-110] p 1138 N92-33743
THREE DIMENSIONAL MODELS
Three-dimensional Navier-Stokes heat transfer predictions for turbine blade rows [AIAA PAPER 92-3068] p 1020 A92-54003
Modal simulation of gearbox vibration with experimental correlation [AIAA PAPER 92-3494] p 1112 A92-54036
Numerical study of the 3-D flowfield for a supersonic jet exiting into a hypersonic stream from a conical surface [AIAA PAPER 92-3675] p 1022 A92-54118
Potential flow theory and operation guide for the panel code PMARC [NASA-TM-102851] p 1036 N92-32422
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS [NIFS-110] p 1138 N92-33743
Numerical investigation of the effects of icing on fixed and rotary wing aircraft [NASA-CR-190542] p 1044 N92-34105
THROTTLING
Flight testing and simulation of an F-15 airplane using throttles for flight control [NASA-TM-104255] p 1087 N92-32864
THRUST
Effects of bleed air extraction of thrust levels on the F404-GE-400 turbofan engine [AIAA PAPER 92-3092] p 1066 A92-54009
Preliminary dynamic tests of a flight-type ejector [AIAA PAPER 92-3261] p 1066 A92-54020
Investigation of the flight control requirements of a half-scale ducted fan unmanned aerial vehicle [AD-A252730] p 1087 N92-32988
Ideal efficiency of propellers based on Theodorsen's theory: A review and computer study, with extended plus simplified charts [UTIAS-TN-271] p 1071 N92-33102
THRUST AUGMENTATION
Use of an approximate similarity principle for the thermal scaling of a full-scale thrust augmenting ejector [AIAA PAPER 92-3792] p 1069 A92-54171
The compound helicopter - A concept revisited p 1058 A92-56341
THRUST CONTROL
Performance benefits of adaptive in-flight propulsion system optimization [AIAA PAPER 92-3749] p 1068 A92-54149
A note on thrust control for jetliner during approach p 1053 A92-56061
THRUST MEASUREMENT
Thrust stand design principles [AIAA PAPER 92-3976] p 1098 A92-56802
THRUST VECTOR CONTROL
Optimal launch trajectory of a hypersonic research vehicle [AIAA PAPER 92-4302] p 1103 A92-55310
Ski jump takeoff performance predictions for a mixed-flow, remote-lift STOVL aircraft [NASA-TM-103866] p 1060 N92-32887
The F-18 high alpha research vehicle: A high-angle-of-attack testbed aircraft [NASA-TM-104253] p 1060 N92-33404
Nonlinear dynamic-inversion flight control of supermaneuverable aircraft p 1062 N92-33953
THUNDERSTORMS
Airport Surveillance Radar (ASR-9) wind shear processor: 1991 test at Orlando, Florida [AD-A252246] p 1124 N92-32686
TILT ROTOR AIRCRAFT
Summary highlights of the Advanced Rotorcraft Transmission (ART) program [AIAA PAPER 92-3362] p 1051 A92-54026
Research needs for a commercial passenger tiltrotor p 1056 A92-56298
The Eurofar program - An European overview on advanced VTOL civil transportation system p 1016 A92-56299
V-22 propulsion system design p 1070 A92-56300
A simulation study of tiltrotor vertical takeoff procedures using conventional and variable diameter rotor systems p 1056 A92-56301
Short takeoff optimization for the XV-15 tiltrotor aircraft p 1056 A92-56302
Optimal control of tiltrotor aircraft following power failure p 1085 A92-56303
Development of a conceptual design method for rotary-wing aircraft using digital computers p 1058 A92-56340
Impacts of technology on the capacity needs of the US national airspace system [NASA-CR-4470] p 1045 N92-34192
TIME
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
TIME DEPENDENCE
Dynamic response of induced pressures, suckdown, and temperatures for two tandem jet STOVL configurations [NASA-TM-103934] p 1039 N92-33581
Investigation of advancing front method for generating unstructured grid [NASA-CR-190902] p 1128 N92-34043
TIME LAG
Approximations for inclusion of rotor lag dynamics in helicopter flight dynamics models p 1060 A92-56354
TIME MARCHING
Evaluation of a multigrid-based Navier-Stokes solver for aerothermodynamic computations [AIAA PAPER 92-4563] p 1027 A92-55375
TIME MEASUREMENT
The need for GPS standardization p 1049 N92-33351
Evaluation of GPS/UTC steering performance p 1049 N92-33353
Precise GPS ephemerides from DMA and NGS tested by time transfer p 1049 N92-33355
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG p 1050 N92-33356
LORAN-C data reduction at the US Naval Observatory p 1050 N92-33358
TIME RESPONSE
Flight test results using a low order equivalent systems technique to estimate flying qualities [AIAA PAPER 92-4425] p 1080 A92-55349
TIME SIGNALS
Evaluation of GPS/UTC steering performance p 1049 N92-33353
Precise GPS ephemerides from DMA and NGS tested by time transfer p 1049 N92-33355
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG p 1050 N92-33356
TITANIUM ALLOYS
Titanium alloy casting for aerospace p 1106 A92-56103
TOKAMAK DEVICES
Formation and sustainment of a very low aspect ratio tokamak using coaxial helicity injection: Helicity Injected Torus (HIT) experiment [DE92-014311] p 1136 N92-32595

TOLERANCES (MECHANICS)
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
Damage tolerance certification methodology for composite structures p 1108 N92-32579
TOROIDAL PLASMAS
Formation and sustainment of a very low aspect ratio tokamak using coaxial helicity injection: Helicity Injected Torus (HIT) experiment
[DE92-014311] p 1136 N92-32595
TOROIDS
Spray nozzle for fire control
[CA-PATENT-APPL-SN-2-011-94] p 1125 N92-32856
TORQUE
Dynamics of helicopters with dissimilar blades in forward flight p 1056 A92-56288
Thermal mechanical analysis of sprag clutches
[NASA-CR-190686] p 1128 N92-34207
TORSION
Elementary flutter analysis p 1088 N92-34162
Thermal mechanical analysis of sprag clutches
[NASA-CR-190686] p 1128 N92-34207
TORSIONAL VIBRATION
Helicopter tail rotor stall flutter p 1056 A92-56290
TORUSES
Formation and sustainment of a very low aspect ratio tokamak using coaxial helicity injection: Helicity Injected Torus (HIT) experiment
[DE92-014311] p 1136 N92-32595
TOTAL QUALITY MANAGEMENT
Improving reliability and maintainability through process management p 1141 A92-56212
TOXICITY
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301
[AD-A252912] p 1126 N92-33501
TRACKING (POSITION)
Development of new flight procedures for the Microwave Landing System (MLS)
[NLR-TP-91156-U] p 1047 N92-32830
TRAILING EDGE FLAPS
Trimming rotor blades with periodically deflecting trailing edge flaps p 1085 A92-56283
Lift and rolling moment due to spoilers on wings with trailing-edge flaps deflected at subsonic speeds
[ESDU-92002-SUPPL] p 1037 N92-32782
TRAILING EDGES
Computation of vortex wake flows and control of their effects on trailing wings
[AIAA PAPER 92-4429] p 1025 A92-55353
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131
TRAINING AIRCRAFT
Model flight tests of a spin-resistant trainer configuration p 1054 A92-56158
TRAJECTORIES
Analysis of the flight performance of the 155 mm M864 base burn projectile
[BRL-TR-3083] p 1041 N92-33699
TRAJECTORY CONTROL
Invertibility and trajectory control for nonlinear maneuvers of aircraft
[AIAA PAPER 92-4410] p 1075 A92-55204
Selection of sampling rate for nonlinear flight trajectory controller of aircraft p 1084 A92-56070
A workstation-based evaluation of a far-field route planner for helicopters
[NASA-TM-102882] p 1051 N92-33609
TRAJECTORY OPTIMIZATION
An efficient algorithm for optimal aircraft trajectories
[AIAA PAPER 92-4412] p 1076 A92-55206
The application of direct transcription to commercial aircraft trajectory optimization
[AIAA PAPER 92-4528] p 1077 A92-55246
Optimal launch trajectory of a hypersonic research vehicle
[AIAA PAPER 92-4302] p 1103 A92-55310
Optimal recovery from microburst wind shear
[AIAA PAPER 92-4338] p 1078 A92-55327
Optimal trajectories for an unmanned air-vehicle in the horizontal plane
[AIAA PAPER 92-4344] p 1079 A92-55333
TRAJECTORY PLANNING
A workstation-based evaluation of a far-field route planner for helicopters
[NASA-TM-102882] p 1051 N92-33609
TRANSFER FUNCTIONS
Transfer function between airborne VLF transmit and receive loop antenna p 1045 A92-54754
MIMO state-feedback control system considering phase stability by -90 deg phase-locus method p 1084 A92-56066
TRANSFER OF TRAINING
Development and integration of modern laboratories in aerospace education
[AIAA PAPER 92-4022] p 1141 A92-56844
TRANSIENT RESPONSE
Preliminary dynamic tests of a flight-type ejector
[AIAA PAPER 92-3261] p 1066 A92-54020
TRANSMISSIONS (MACHINE ELEMENTS)
Summary highlights of the Advanced Rotorcraft Transmission (ART) program
[AIAA PAPER 92-3362] p 1051 A92-54026
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
Design and development of test rigs for main rotor and main rotor transmission of a helicopter in the 6-ton-class p 1093 A92-56280
TRANSONIC COMPRESSORS
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
TRANSONIC FLIGHT
An experimental study of the flow over a sharp-edged delta wing at subsonic and transonic speeds
[NLR-TP-91117-U] p 1037 N92-32732
Flutter in the transonic flight regime p 1089 N92-34167
TRANSONIC FLOW
The behaviour of the pressure temperature and density in an inviscid unsteady transonic axisymmetric flow with shock waves p 1018 A92-53553
Navier-Stokes simulation for the winged space vehicle 'HOPE' at subsonic, transonic, and supersonic regimes p 1018 A92-53559
A double chaotic attractor in transonic flow p 1019 A92-53561
Nonintrusive measurements in fluid dynamic flows from Mach .0005 to 14 p 1090 A92-54311
Efficient iterative methods for the transonic small disturbance equation p 1025 A92-54933
Navier-Stokes computations for oscillating control surfaces
[AIAA PAPER 92-4431] p 1026 A92-55355
Understanding and development of a prediction method of transonic limit cycle oscillation characteristics of fighter aircraft
[AIAA PAPER 92-4501] p 1026 A92-55369
Unsteady shock-vortex interaction on a flexible delta wing p 1030 A92-56157
Navier-Stokes simulation of a close-coupled canard-wing-body configuration p 1031 A92-56163
Euler/experiment correlation of a generic fighter p 1031 A92-56164
Improved calculation of transonic potential flow past swept wings p 1031 A92-56179
Numerical modeling of transonic juncture flow
[AIAA PAPER 92-4036] p 1035 A92-56858
An examination of several high resolution schemes applied to complex problems in high speed flows
[AD-A250814] p 1124 N92-32632
Research on some centered implicit methods for calculating transonic flows by solving Navier-Stokes equations
[ONERA-RSF-24/1408-AY-150A] p 1037 N92-32773
Flutter in the transonic flight regime p 1089 N92-34167
TRANSONIC FLUTTER
Aeroelastic effects of spoiler surfaces on a low-aspect-ratio rectangular wing p 1030 A92-56154
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter
[NASA-TM-104211] p 1042 N92-34147
TRANSONIC WIND TUNNELS
Aerodynamic assessment of an optical pressure measurement system (OPMS) by comparison with conventional pressure measurements in a high speed wind tunnel p 1114 A92-54304
Recent developments in data acquisition and control systems at the Aircraft Research Association Limited p 1091 A92-54323
Shock detection on airfoils by means of piezo foil- and hot film arrays p 1115 A92-54334
Application of a wall pressure method in a wind tunnel test section with adjustable longitudinal slots p 1091 A92-54336
On the structure of unsteady shock induced separation of the transonic airfoil in the NAL two-dimensional wind tunnel p 1029 A92-56010
Evaluation of sidewall interference in the NAL two-dimensional transonic wind tunnel p 1092 A92-56011
The research of reducing 3-D low supersonic shock wave reflection in a 2-D transonic flexible walls adaptive wind tunnel
[AIAA PAPER 92-3924] p 1095 A92-56755
Performance evaluation of a transonic wind tunnel compressor
[AIAA PAPER 92-3927] p 1096 A92-56758
An overview of the planned aerospace test facilities at Capua, Italy
[AIAA PAPER 92-3944] p 1097 A92-56773
The cryogenic balance design and balance calibration methods
[AIAA PAPER 92-4001] p 1122 A92-56824
Transonic turbine blade cascade testing facility
[AIAA PAPER 92-4034] p 1101 A92-56856
Stainless steel welding shines through on wind tunnel project p 1123 A92-57039
TRANSPORT AIRCRAFT
Applied analytical combustion/emissions research at the NASA Lewis Research Center - A progress report
[AIAA PAPER 92-3338] p 1067 A92-54025
Continuous flying quality improvement - The measure and the payoff
[AIAA PAPER 92-4327] p 1073 A92-55171
A simulator evaluation of various manual control concepts for fly-by-wire transport aircraft
[AIAA PAPER 92-4328] p 1073 A92-55172
Optimal recovery from microburst wind shear
[AIAA PAPER 92-4338] p 1078 A92-55327
Fatigue cracking threshold prediction of transport airplanes p 1118 A92-56094
The Eurofar program - An European overview on advanced VTOL civil transportation system p 1016 A92-56299
Study on international cooperative test facilities for future SST/HST
[AIAA PAPER 92-3945] p 1097 A92-56775
High Reynolds number testing in support of transport airplane development
[AIAA PAPER 92-3982] p 1099 A92-56807
Combined exo/endoatmospheric transport alternatives
[IAF PAPER 92-0663] p 1104 A92-57102
An experimental study of organismic principles of the functioning of the crew-transport aircraft system p 1133 A92-57446
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480
Applications of a direct/iterative design method to complex transonic configurations
[NASA-TP-3234] p 1039 N92-33484
Advanced subsonic transport approach noise: The relative contribution of airframe noise
[NASA-TM-104112] p 1140 N92-34148
Flutter analyses using high speed computers. Part 1: Flutter analyses for large aircraft p 1089 N92-34168
TRANSPORTATION
Air traffic control: FAA's advanced automation system contract
[GAO/IMTEC-91-25] p 1048 N92-32861
TRANSPUTERS
Real-time processing of radar return on a parallel computer
[NASA-CR-4456] p 1043 N92-32606
TRANSVERSE WAVES
Detonation duct gas generator demonstration program
[AIAA PAPER 92-3174] p 1066 A92-54011
TRAPPED VORTICES
Two-fence concept for efficient trapping of vortices on airfoils p 1031 A92-56165
TREND ANALYSIS
Regional airline and equipment review - Evolution, trends, and future prospects p 1015 A92-55102
TROPOSPHERE
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
TUNGSTEN ALLOYS
High-temperature metal matrix composite p 1105 A92-53878
TUNING
Intelligent control law tuning for AIAA Controls Design Challenge
[AIAA PAPER 92-4631] p 1132 A92-55306
TURBINE BLADES
Three-dimensional Navier-Stokes heat transfer predictions for turbine blade rows
[AIAA PAPER 92-3068] p 1020 A92-54003
FREPS - A forced response prediction system for turbomachinery blade rows
[AIAA PAPER 92-3072] p 1130 A92-54006
Unsteady blade pressures on a propfan - Predicted and measured compressibility effects
[AIAA PAPER 92-3774] p 1023 A92-54161
State-of-the-art materials for future gas turbine engines p 1070 A92-56122
Transonic turbine blade cascade testing facility
[AIAA PAPER 92-4034] p 1101 A92-56856
A critical evaluation of a three-dimensional Navier-Stokes CFD as a tool to design supersonic turbine stages p 1124 N92-32268

The dynamics of flexible multibody systems: A finite segment approach p 1128 N92-34036

TURBINE ENGINES

Development study on air turbo-ramjet engine for space plane p 1065 A92-53487

Turbine engine hot-part temperature measurement techniques
[AIAA PAPER 92-3960] p 1122 A92-56788

Turbine engine performance test and evaluation techniques
[AIAA PAPER 92-3977] p 1071 A92-56803

Engine component instrumentation development facility at NASA Lewis Research Center
[AIAA PAPER 92-3995] p 1099 A92-56818

Study of potassium turbine electric generator system p 1129 N92-33794

TURBINE PUMPS

Turbine disk cavity aerodynamics and heat transfer p 1124 N92-32265

TURBINE WHEELS

Aeroelastic modal characteristics of mistuned blade assemblies - Mode localization and loss of eigenstructure p 1117 A92-54921

Turbine disk cavity aerodynamics and heat transfer p 1124 N92-32265

Cooled high-temperature radial turbine program 2
[NASA-CR-189122] p 1073 N92-34236

TURBINES

A comparison of the calculated and experimental off-design performance of a radial flow turbine
[AIAA PAPER 92-3069] p 1020 A92-54004

Description of a pressure measurement technique for obtaining surface static pressures of a radial turbine
[AIAA PAPER 92-4006] p 1123 A92-56829

Method of reducing drag in aerodynamic systems
[NASA-CASE-LEW-14791-1] p 1043 N92-34243

TURBOCOMPRESSORS

Mixed flow compressor surge margin gain using a manifolded diffuser system
[AIAA PAPER 92-3753] p 1068 A92-54151

Computations of unsteady multistage compressor flows in a workstation environment
[NASA-TM-103839] p 1071 N92-32452

Active control of compressor surge and stall
[AD-A252771] p 1126 N92-33498

Radial inflow turbine study
[AD-A252783] p 1127 N92-33538

TURBOFAN ENGINES

Effects of bleed air extraction of thrust levels on the F404-GE-400 turbofan engine
[AIAA PAPER 92-3092] p 1066 A92-54009

Performance benefits of adaptive in-flight propulsion system optimization
[AIAA PAPER 92-3749] p 1068 A92-54149

CIS engines - The range revealed. II p 1069 A92-54546

Experimental study of noise generation and propagation in a turbofan model p 1136 A92-56169

Test data models to characterize turbine engine operation in altitude test facilities
[AIAA PAPER 92-3917] p 1095 A92-56749

Application of electronically scanned pressure measurement system for engine simulation tests in the German-Dutch Wind Tunnel
[AIAA PAPER 92-4003] p 1122 A92-56826

Bird ingestion into large turbofan engines
[DOT/FAA/CT-91/17] p 1043 N92-33005

Engine bird ingestion experience of the Boeing 737 aircraft: Expanded data base
[DOT/FAA/CT-91/32] p 1045 N92-34151

TURBOJET ENGINE CONTROL

A multivariable control concept for a gas turbine engine
[ETN-92-92104] p 1072 N92-33645

TURBOJET ENGINES

Liquid lubricants for advanced aircraft engines
[NASA-TM-104531] p 1109 N92-32863

TURBOMACHINE BLADES

Navier-Stokes analysis of three-dimensional unsteady flows inside turbine stages
[AIAA PAPER 92-3211] p 1021 A92-54016

Numerical calculations of propfan/swirl recovery vane flow field
[AIAA PAPER 92-3771] p 1022 A92-54160

TURBOPROP AIRCRAFT

Escape strategies for turboprop aircraft in microburst windshear p 1084 A92-56151

Active vibrations and noise control for turboprop application research program activities p 1138 N92-32962

TURBORAMJET ENGINES

The study of experimental turboramjets
[AIAA PAPER 92-3720] p 1067 A92-54135

Tests results on Air Turbo Ramjet for a future space plane
[IAF PAPER 92-0657] p 1071 A92-57098

TURBULENCE

Effects of curvature and rotation on turbulence in the NASA low-speed centrifugal compressor impeller p 1124 N92-32292

Swept shock/boundary layer interaction experiments in support of CFD code validation
[NASA-CR-190583] p 1036 N92-32494

Perspectives on hypersonic viscous and nonequilibrium flow research
[NASA-CR-190817] p 1039 N92-33413

High speed transition prediction
[NASA-CR-190836] p 1039 N92-33424

Influence of the swirl producing construction in the flow and reaction field of turbulent diffusion flames
[ETN-92-92103] p 1127 N92-33916

TURBULENCE EFFECTS

Some important factors in turbulence in flight measurement p 1063 A92-54324

High-Speed Research: Sonic Boom, volume 1
[NASA-CP-3172] p 1061 N92-33874

Wave equations and computational models for sonic boom propagation through a turbulent atmosphere p 1139 N92-33877

The effect of turbulence on the loudness of minimized sonic boom signatures p 1139 N92-33880

Model experiment to study the effect of turbulence on risetime and waveform of N waves p 1139 N92-33881

Turbulence-induced loads on a teetered rotor p 1042 N92-34029

TURBULENCE METERS

The ASU Transition Research Facility
[AIAA PAPER 92-3910] p 1094 A92-56744

TURBULENCE MODELS

The enhancement of the mixing and combustion processes in supersonic flow applied to scramjet engine
[AIAA PAPER 92-3428] p 1112 A92-54029

Comparison of turbulence models for powered-lift flow fields
[AIAA PAPER 92-3674] p 1022 A92-54117

Comparative numerical study of two turbulence models for airfoil static and dynamic stall
[AIAA PAPER 92-4649] p 1028 A92-55394

Turbulence-induced loads on a teetered rotor p 1042 N92-34029

TURBULENT BOUNDARY LAYER

Experimental investigation on turbulent phenomena in three-dimensional shock wave/turbulent boundary layer interaction induced by blunt fin p 1018 A92-53557

Experimental study on three-dimensional shock wave-turbulent boundary layer interaction induced by protuberance p 1019 A92-53997

Thermal paints for shock/boundary layer interaction in inlet flows
[AIAA PAPER 92-3626] p 1113 A92-54093

Heat transfer measurements and CFD comparison of swept shock wave/boundary-layer interactions
[AIAA PAPER 92-3665] p 1021 A92-54110

An experimental examination of the effects of incoming boundary layer modifications on the dynamics of a turbulent compression corner interaction
[AIAA PAPER 92-3667] p 1022 A92-54111

Structure of crossing-shock wave/turbulent boundary-layer interactions
[AIAA PAPER 92-3670] p 1022 A92-54113

Experimental investigation of the reflection of a shock wave on a heated surface in presence of a turbulent boundary layer p 1023 A92-54569

Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance p 1029 A92-56009

Surface heat transfer and flow properties of vortex arrays induced artificially and from centrifugal instabilities p 1121 A92-56371

A quiet-flow Ludwieg tube for experimental study of high speed boundary layer transition
[AIAA PAPER 92-3885] p 1094 A92-56727

Acoustic loads prediction on jet aircraft p 1136 N92-32949

Simulations of sonic boom ray tube area fluctuations for propagation through atmospheric turbulence including caustics via a Monte Carlo method p 1139 N92-33878

Analysis of sonic boom data to quantify distortions of shock profiles p 1139 N92-33879

TURBULENT COMBUSTION

Turbulent combustion modelling in a side dump ramjet combustor
[AIAA PAPER 92-3599] p 1112 A92-54075

An assumed joint-Beta PDF approach for supersonic turbulent combustion
[AIAA PAPER 92-3844] p 1113 A92-54199

TURBULENT DIFFUSION

An experimental investigation of the flow in a diffusing S-duct
[AIAA PAPER 92-3622] p 1021 A92-54090

Numerical simulation of unsteady rotor wakes p 1032 A92-56352

Theories of turbulent combustion in high speed flows
[AD-A253032] p 1111 N92-33624

TURBULENT FLOW

Turbulent combustion modelling in a side dump ramjet combustor
[AIAA PAPER 92-3599] p 1112 A92-54075

Detecting 3-D, turbulent separation regions using unsteady computerized thermographic technique p 1023 A92-54308

Numerical simulation of slot injection into a turbulent supersonic stream p 1024 A92-54914

Measurements of turbulence in hypersonic flow p 1092 A92-56005

Tohoku University low-turbulence wind tunnel
[AIAA PAPER 92-3913] p 1095 A92-56746

Prediction of the pressure loss coefficient of wind tunnel turbulence reducing screens
[AIAA PAPER 92-4043] p 1035 A92-56862

Numerical simulation of turbulence at the back of the airplane
[ETN-92-91664] p 1037 N92-32769

Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063

Theories of turbulent combustion in high speed flows
[AD-A253032] p 1111 N92-33624

TURBULENT JETS

Interaction between chemical reaction and turbulence in supersonic nonpremixed H2-air combustion p 1117 A92-54931

TURBULENT MIXING

The enhancement of the mixing and combustion processes in supersonic flow applied to scramjet engine
[AIAA PAPER 92-3428] p 1112 A92-54029

Computational and experimental studies of flow in multi-lobed forced mixers
[AIAA PAPER 92-3568] p 1112 A92-54057

TURBULENT WAKES

Blockage correction in three-dimensional wind tunnel testing based on the wall signature method
[AIAA PAPER 92-3925] p 1095 A92-56756

TVD SCHEMES

Numerical simulations of shock reflections by a TVD scheme p 1018 A92-53558

TWISTED WINGS

Survey and analysis of research on supersonic drag-due-to-lift minimization with recommendations for wing design
[NASA-TP-3202] p 1040 N92-33656

TWO DIMENSIONAL BODIES

Tow-tank study of nonlinear aerodynamics of a 2-D airfoil
[AIAA PAPER 92-4499] p 1026 A92-55367

TWO DIMENSIONAL FLOW

Methodology for calculating aerodynamic sensitivity derivatives p 1024 A92-54911

Evaluation of sidewall interference in the NAL two-dimensional transonic wind tunnel p 1092 A92-56011

BGK1 airfoil oilflow tests in the NAL two-dimensional wind tunnel. II p 1029 A92-56044

Small two-dimensional surface excrescences on aircraft wings approaching separation p 1031 A92-56170

TWO DIMENSIONAL JETS

Numerical study on the secondary jet into a supersonic flow p 1018 A92-53556

Numerical simulation of turbulence at the back of the airplane
[ETN-92-91664] p 1037 N92-32769

TWO DIMENSIONAL MODELS

Optimization of a 2D scramjet-vehicle using CFD and simplified approximate flow analysis techniques
[AIAA PAPER 92-3673] p 1022 A92-54116

Drag computation by vortex methods p 1031 A92-56161

Predicting droplet impingement on yawed wings p 1043 A92-56180

Research on some centered implicit methods for calculating transonic flows by solving Navier-Stokes equations
[ONERA-RSF-24/1408-AY-150A] p 1037 N92-32773

Numerical investigation of the effects of icing on fixed and rotary wing aircraft
[NASA-CR-190542] p 1044 N92-34105

TWO PHASE FLOW

Pulsation characteristics of one-phase and two-phase steam flows in Laval nozzles under off-design conditions p 1019 A92-53882

U

ULTRALIGHT AIRCRAFT
Stability, control and gust response characteristics of an ultralight freewing airplane
[AIAA PAPER 92-4342] p 1079 A92-55331
UNDERWATER ACOUSTICS
On the origin and acoustical behaviour of cloud cavitation
[ISBN-90-9004317-9] p 1125 N92-33066
UNIVERSAL TIME
Evaluation of GPS/UTC steering performance p 1049 N92-33353
UNIVERSITIES
Enlisting industry support for a flight controls design lab
[AIAA PAPER 92-4560] p 1141 A92-55272
Development and integration of modern laboratories in aerospace education
[AIAA PAPER 92-4022] p 1141 A92-56844
United States Air Force summer research program 1991. Volume 1: Program management report
[AD-A248763] p 1142 N92-32338
UNSTEADY AERODYNAMICS
Stability and dynamic coupling of elastic vehicles with unsteady aerodynamic forces considered p 1102 A92-53545
Parameter estimation of an augmented airplane with unsteady aerodynamics modelling p 1073 A92-53546
Numerical simulations of shock reflections by a TVD scheme p 1018 A92-53558
Pulsation characteristics of one-phase and two-phase steam flows in Laval nozzles under off-design conditions p 1019 A92-53882
Navier-Stokes analysis of three-dimensional unsteady flows inside turbine stages
[AIAA PAPER 92-3211] p 1021 A92-54016
Unsteady blade pressures on a propfan - Predicted and measured compressibility effects
[AIAA PAPER 92-3774] p 1023 A92-54161
Unsteady shock propagation in a steady flow nozzle expansion p 1023 A92-54489
Vortical flow computations on a flexible blended wing-body configuration p 1024 A92-54922
Pulsating spanwise blowing on a fighter aircraft
[AIAA PAPER 92-4359] p 1025 A92-55345
Active control of asymmetric vortical flows around cones using injection and heating
[AIAA PAPER 92-4426] p 1025 A92-55350
Navier-Stokes computations for oscillating control surfaces
[AIAA PAPER 92-4431] p 1026 A92-55355
A discrete vortex model for predicting wing rock of slender wings
[AIAA PAPER 92-4497] p 1026 A92-55365
Stochastic self-induced roll oscillations of slender delta wing at high angles of attack
[AIAA PAPER 92-4498] p 1081 A92-55366
Understanding and development of a prediction method of transonic limit cycle oscillation characteristics of fighter aircraft
[AIAA PAPER 92-4501] p 1026 A92-55369
Parameter identification of unsteady aerodynamic forces for elastic vehicles
[AIAA PAPER 92-4505] p 1027 A92-55372
State-space representation of aerodynamic characteristics of an aircraft at high angels of attack
[AIAA PAPER 92-4651] p 1028 A92-55395
Numerical simulations of flutter and its suppression by active control
[AIAA PAPER 92-4652] p 1082 A92-55396
Computing high-speed flows past an oscillating cylinder near a vertical wall
[AIAA PAPER 92-4653] p 1028 A92-55397
Current European rotorcraft research activities on development of advanced CFD methods for the design of rotor blades (BRITE/EURAM 'DACRO' project) p 1032 A92-56332
Numerical simulation of unsteady rotor wakes p 1032 A92-56352
The ASU Transition Research Facility
[AIAA PAPER 92-3910] p 1094 A92-56744
Experimental unsteady pressures on an oscillating cascade with supersonic leading edge locus
[AIAA PAPER 92-4035] p 1035 A92-56857
Potential flow theory and operation guide for the panel code PMARC
[NASA-TM-102851] p 1036 N92-32422
Strong coupling between inviscid fluid and boundary layer of sharp leading edges: Two-dimensional stationary and turbulent cases for isolated profiles and guard vanes
[ONERA-RT-44/1621-RY-016-R] p 1125 N92-32776
Introduction to Flutter of Winged Aircraft, volume 2
[VKI-LS-1992-01-VOL-2] p 1088 N92-34161
Elementary flutter analysis p 1088 N92-34162
Unsteady wind tunnel tests p 1089 N92-34166
Flutter in the transonic flight regime p 1089 N92-34167
Flutter analyses using high speed computers. Part 2: Aerodynamic procedures p 1089 N92-34169
UNSTEADY FLOW
The behaviour of the pressure temperature and density in an inviscid unsteady transonic axisymmetric flow with shock waves p 1018 A92-53553
Navier-Stokes analysis of three-dimensional unsteady flows inside turbine stages
[AIAA PAPER 92-3211] p 1021 A92-54016
Analysis of the onset of dynamic stall p 1024 A92-54919
Dynamical scaling of a model unsteady separating flow p 1117 A92-54932
Computations of the unsteady flow about a generic wing/pylon/finned-store configuration
[AIAA PAPER 92-4568] p 1027 A92-55377
Computing high-speed flows past an oscillating cylinder near a vertical wall
[AIAA PAPER 92-4653] p 1028 A92-55397
Numerical simulation of supersonic unsteady flow using a panel method p 1030 A92-56048
Generalized aerodynamics analysis by the boundary element method p 1030 A92-56050
Simulation of helicopter see-saw rotor motion p 1055 A92-56287
Image processing in the undergraduate fluid dynamics laboratory
[AIAA PAPER 92-4020] p 1141 A92-56842
Numerical simulation of unsteady flow in a hypersonic shock tunnel facility
[AIAA PAPER 92-4029] p 1034 A92-56851
Experimental unsteady pressures on an oscillating cascade with supersonic leading edge locus
[AIAA PAPER 92-4035] p 1035 A92-56857
Computations of unsteady multistage compressor flows in a workstation environment
[NASA-TM-103839] p 1071 N92-32452
Unsteady response of the leading-edge vortices on a pitching delta wing p 1041 N92-33851
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations p 1127 N92-33968
UPPER SURFACE BLOWING
Analysis of the main wing lift distribution of the STOL research aircraft Asuka p 1053 A92-56051
USER MANUALS (COMPUTER PROGRAMS)
User's manual for AeroFcn: A FORTRAN program to compute aerodynamic parameters
[NASA-TM-104237] p 1133 N92-32507
USER REQUIREMENTS
First level release of 2GCHAS for comprehensive helicopter analysis p 1133 A92-56339

V

V-22 AIRCRAFT
V-22 propulsion system design p 1070 A92-56300
Development of thermoplastic components for structural validation p 1107 N92-32522
V/STOL AIRCRAFT
Reduction of the side force on pointed forebodies through add-on tip devices p 1024 A92-54918
A multi-diagnostic approach to testing V/STOL craft
[AIAA PAPER 92-4008] p 1099 A92-56831
Collaborative research on V/STOL control system/cockpit display tradeoffs under the NASA/MOD joint aeronautical program
[NASA-TM-103910] p 1087 N92-32788
On the anomalies in single-jet hover suckdown data
[NASA-TM-102261] p 1038 N92-33306
Dynamic response of induced pressures, suckdown, and temperatures for two tandem jet STOVL configurations
[NASA-TM-103934] p 1039 N92-33581
On the estimation of jet-induced fountain lift and additional suckdown in hover for two-jet configurations
[NASA-TM-102268] p 1040 N92-33618
VALVES
Double piston shock-wave valve p 1117 A92-54938
VANES
Wind tunnel performance results of swirl recovery vanes as tested with an advanced high speed propeller
[AIAA PAPER 92-3770] p 1068 A92-54159
Numerical calculations of propfan/swirl recovery vane flow field
[AIAA PAPER 92-3771] p 1022 A92-54160
Strong coupling between inviscid fluid and boundary layer of sharp leading edges: Two-dimensional stationary and turbulent cases for isolated profiles and guard vanes
[ONERA-RT-44/1621-RY-016-R] p 1125 N92-32776
Investigation of the flight control requirements of a half-scale ducted fan unmanned aerial vehicle
[AD-A252730] p 1087 N92-32988
Cooled high-temperature radial turbine program 2
[NASA-CR-189122] p 1073 N92-34236
VAPORIZING
Vaporizing particle velocimeter
[NASA-CASE-LAR-14685-1] p 1042 N92-34172
VARIABLE GEOMETRY STRUCTURES
Methodology for calculating aerodynamic sensitivity derivatives p 1024 A92-54911
VARIABLE STREAM CONTROL ENGINES
A multivariable control concept for a gas turbine engine
[ETN-92-92104] p 1072 N92-33645
VELOCITY
The utility of analog vertical velocity information during instrument flight with a Head-Up Display (HUD)
[AD-A252863] p 1065 N92-33277
VELOCITY ERRORS
A Kalman filter integrated navigation design for the IAR Twin Otter Atmospheric Research Aircraft
[NRC-32148] p 1048 N92-32849
VELOCITY MEASUREMENT
Comparison of frequency domain and time domain laser velocimeter signal processors p 1114 A92-54314
Rayleigh imaging and flow tagging in ground test facilities p 1115 A92-54330
A simple three component velocity measurement method using a rotated split-film sensor p 1115 A92-54333
Vaporizing particle velocimeter
[NASA-CASE-LAR-14685-1] p 1042 N92-34172
VENTING
Lift and rolling moment due to spoilers on wings with trailing-edge flaps deflected at subsonic speeds
[ESDU-92002-SUPPL] p 1037 N92-32782
VERTICAL DISTRIBUTION
The vortical structure in the wake during dynamic stall
[AIAA PAPER 92-4496] p 1026 A92-55364
VERTICAL FLIGHT
A Lie Bracket solution of the optimal thrust magnitude on a singular arc in atmospheric flight
[AIAA PAPER 92-4345] p 1079 A92-55334
Investigation of the flight control requirements of a half-scale ducted fan unmanned aerial vehicle
[AD-A252730] p 1087 N92-32988
VERTICAL LANDING
Experimental performance of three design factors for ventral nozzles for SSTOVL aircraft
[AIAA PAPER 92-3789] p 1069 A92-54168
Internal reversing flow in a tailpipe offtake configuration for SSTOVL aircraft
[AIAA PAPER 92-3790] p 1069 A92-54169
Analysis of airframe/engine interactions for a STOVL aircraft with integrated flight/propulsion control
[AIAA PAPER 92-4623] p 1052 A92-55300
VERTICAL MOTION
The utility of analog vertical velocity information during instrument flight with a Head-Up Display (HUD)
[AD-A252863] p 1065 N92-33277
VERTICAL TAKEOFF AIRCRAFT
Calculations of aerodynamic forces on a wing with thrust using B.E.M p 1030 A92-56049
The Eurofar program - An European overview on advanced VTOL civil transportation system p 1016 A92-56299
A simulation study of tiltrotor vertical takeoff procedures using conventional and variable diameter rotor systems p 1056 A92-56301
Blade instability of horizontally stoppable rotors p 1085 A92-56308
On the estimation of jet-induced fountain lift and additional suckdown in hover for two-jet configurations
[NASA-TM-102268] p 1040 N92-33618
VERY LOW FREQUENCIES
Transfer function between airborne VLF transmit and receive loop antenna p 1045 A92-54754
Feasibility of measuring transverse electric noise at VLF and LF on an ice cap
[AD-A252280] p 1129 N92-33220
Integrated Russian VLF/Omega receiver design
[PB92-193390] p 1051 N92-33809
VIBRATION
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
Joint study on the computerisation of in-field aero engines vibration diagnosis
[PNR-90799] p 1072 N92-33815
VIBRATION DAMPING
New literal approximations for the longitudinal dynamic characteristics of flexible flight vehicles
[AIAA PAPER 92-4411] p 1075 A92-55205

Numerical simulations of flutter and its suppression by active control
[AIAA PAPER 92-4652] p 1082 A92-55396
Aeroelastic effects of spoiler surfaces on a low-aspect-ratio rectangular wing p 1030 A92-56154
Dynamic analysis of rotor blades with root retention design variations p 1054 A92-56156
Helicopter tail rotor stall flutter p 1056 A92-56290
Modern helicopter technologies at MBB and the application in future programmes p 1016 A92-56304
Coupled rotor-fuselage vibration reduction with multiple frequency blade pitch control p 1085 A92-56315
The compound helicopter - A concept revisited p 1058 A92-56341
A dynamic stiffness technique for the vibration analysis of stiffened shell structures p 1123 A92-56866
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
Computational aspects of helicopter trim analysis and damping levels from Floquet theory
[NASA-CR-190736] p 1087 N92-33107

VIBRATION ISOLATORS
MD-80 aft cabin noise control: A case history p 1137 N92-32950
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951
Active control of interior noise in a large scale cylinder using piezoelectric actuators p 1137 N92-32958
Active vibrations and noise control for turboprop application research program activities p 1138 N92-32962

VIBRATION MEASUREMENT
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951
Vibro-acoustic FE analyses of the Saab 2000 aircraft p 1137 N92-32952
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
Active control of sound transmission through stiff lightweight composite fuselage constructions p 1137 N92-32957

VIBRATION MODE
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
Automated procedures for aircraft aeroservoelastic compensation
[AIAA PAPER 92-4606] p 1077 A92-55284
Flutter analysis and wind tunnel test with respect to a low-aspect-ratio wing with free-rotational control surface p 1052 A92-56014
An example of whirl flutter analysis p 1052 A92-56015
Simulation of helicopter see-saw rotor motion p 1055 A92-56287

VIBRATION TESTS
Monitoring fatigue cracks in gears p 1116 A92-54496
Flight flutter testing p 1089 N92-34163

VIDEO EQUIPMENT
On improvements of three-dimensional position measuring system for dynamic wind tunnel testing p 1093 A92-56012

VIEWING
Computational algorithms for increased control of depth-viewing volume for stereo three-dimensional graphic displays
[NASA-TM-4379] p 1065 N92-34109

VISCOUS FLOW
Hypersonic flows with air chemistry over a reentry vehicle at high altitudes p 1017 A92-53549
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
Perspectives on hypersonic viscous and nonequilibrium flow research
[NASA-CR-190817] p 1039 N92-33413
An approximate viscous shock layer technique for calculating chemically reacting hypersonic flows about blunt-nosed bodies p 1041 N92-33837
Analysis of iced wings
[NASA-TM-105773] p 1042 N92-34144

VISCOUS FLUIDS
Viscosity characteristics of synthetic aviation oils at low temperatures p 1105 A92-53875
Continuation of tailored composite structures of ordered staple thermoplastic material
[NASA-CR-189671] p 1110 N92-33613

VISUAL FLIGHT RULES
Federal aviation regulations. Part 91: General operating and flight rules
[PB92-197334] p 1017 N92-33176
Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081

VISUAL OBSERVATION
Vision-based range estimation using helicopter flight data
[NASA-TM-103930] p 1047 N92-32424

VOIDS
On the origin and acoustical behaviour of cloud cavitation
[ISBN-90-9004317-9] p 1125 N92-33066

VORTEX BREAKDOWN
State-space representation of aerodynamic characteristics of an aircraft at high angels of attack
[AIAA PAPER 92-4651] p 1028 A92-55395
Modeling and numerical simulation of vortex flow in aerodynamics
[NLR-TP-91154-U] p 1037 N92-32673
Static and dynamic flow visualization studies of two double-delta wing models at high angles of attack
[AD-A252878] p 1040 N92-33678
Unsteady response of the leading-edge vortices on a pitching delta wing p 1041 N92-33851

VORTEX GENERATORS
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[AIAA PAPER 92-3177] p 1020 A92-54013
Enhancement of laminar boundary layer heat transfer by a vortex generator p 1118 A92-55453
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[NASA-TM-105672] p 1128 N92-34112

VORTEX LATTICE METHOD
Development of a high-angle-of-attack stability and control prediction code
[AIAA PAPER 92-4354] p 1079 A92-55340
Optimal design of wing shape by use of neural-network p 1054 A92-56112
Drag computation by vortex methods p 1031 A92-56161

VORTEX SHEDDING
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations p 1127 N92-33968
Aeroelasticity of bluff bodies p 1089 N92-34165

VORTEX SHEETS
Physics of vortical flows p 1031 A92-56166
Vortex flow visualization using colored and fluorescent dyes on flat plate delta wing with leading edge extension
[AD-A251139] p 1036 N92-32651
Further development of the CANAERO computer code to include propulsor modelling
[DREA-CR-90-425] p 1038 N92-32811

VORTICES
Active control of asymmetric vortical flows around cones using injection and heating
[AIAA PAPER 92-4426] p 1025 A92-55350
Navier-Stokes prediction of large-amplitude delta-wing roll oscillations characterizing wing rock
[AIAA PAPER 92-4428] p 1080 A92-55352
Computation of vortex wake flows and control of their effects on trailing wings
[AIAA PAPER 92-4429] p 1025 A92-55353
Vortical flow control on a wing-body combination using tangential blowing
[AIAA PAPER 92-4430] p 1081 A92-55354
A discrete vortex model for predicting wing rock of slender wings
[AIAA PAPER 92-4497] p 1026 A92-55365
Unsteady shock-vortex interaction on a flexible delta wing p 1030 A92-56157
Measurements of the dynamic stall vortex convection speed p 1032 A92-56351
Surface heat transfer and flow properties of vortex arrays induced artificially and from centrifugal instabilities p 1121 A92-56371
Effects of external influences in subsonic delta wing vortices
[AIAA PAPER 92-4033] p 1034 A92-56855
Vortex flow visualization using colored and fluorescent dyes on flat plate delta wing with leading edge extension
[AD-A251139] p 1036 N92-32651
Modeling and numerical simulation of vortex flow in aerodynamics
[NLR-TP-91154-U] p 1037 N92-32673
Unsteady response of the leading-edge vortices on a pitching delta wing p 1041 N92-33851
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations p 1127 N92-33968
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[NASA-TM-105672] p 1128 N92-34112

VORTICITY
Vortical flow computations on a flexible blended wing-body configuration p 1024 A92-54922
Numerical simulation of unsteady rotor wakes p 1032 A92-56352

VORTICITY EQUATIONS
The interaction between a high-frequency gust and a blade row p 1135 A92-54484

W

WAKES
Numerical simulation of unsteady rotor wakes p 1032 A92-56352

WALL FLOW
Computing high-speed flows past an oscillating cylinder near a vertical wall
[AIAA PAPER 92-4653] p 1028 A92-55397
Integration of wall interference assessment and wall adaptation
[NLR-TP-91119-U] p 1101 N92-32734

WALL PRESSURE
Blockage correction in three-dimensional wind tunnel testing based on the wall signature method
[AIAA PAPER 92-3925] p 1095 A92-56756

WALL TEMPERATURE
Experimental investigation of the reflection of a shock wave on a heated surface in presence of a turbulent boundary layer p 1023 A92-54569

WARNING SYSTEMS
Laser-radar based obstacle avoidance system for helicopters p 1064 A92-56295
Safety study of TCAS 2 for logic version 6.04
[DOT/FAA/RD-92/22] p 1047 N92-32537
Simulation test and evaluation of TCAS 2 logic version 6.04
[DOT/FAA/RD-92/23] p 1048 N92-33098
Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081

WASHERS (CLEANERS)
The operational status of automated aircraft washing system p 1016 A92-56087

WASPALOY
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-34019

WATER
Fire bombing and fire bombers
[CA-PATENT-1-268-164] p 1061 N92-33582

WATER TUNNEL TESTS
Vortex flow visualization using colored and fluorescent dyes on flat plate delta wing with leading edge extension
[AD-A251139] p 1036 N92-32651
Static and dynamic flow visualization studies of two double-delta wing models at high angles of attack
[AD-A252878] p 1040 N92-33678

WAVE DRAG
A method for designing blended wing-body configurations for low wave drag
[NASA-TP-3261] p 1036 N92-32480

WAVE EQUATIONS
Wave equations and computational models for sonic boom propagation through a turbulent atmosphere p 1139 N92-33877

WAVE REFLECTION
Experimental investigation of the reflection of a shock wave on a heated surface in presence of a turbulent boundary layer p 1023 A92-54569
The research of reducing 3-D low supersonic shock wave reflection in a 2-D transonic flexible walls adaptive wind tunnel
[AIAA PAPER 92-3924] p 1095 A92-56755

WAVEFORMS
Analysis of sonic boom data to quantify distortions of shock profiles p 1139 N92-33879
Model experiment to study the effect of turbulence on risetime and waveform of N waves p 1139 N92-33881

WEAPON SYSTEMS
Developing robust support structures for high-technology subsystems: The AH-64 Apache helicopter
[AD-A252773] p 1017 N92-33499

WEAR TESTS
Effects of material choices on brush seal performance p 1116 A92-54650

WEATHER
Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081
WEIGHT REDUCTION
Aluminium-lithium alloys - Application on helicopters
p 1106 A92-56326
Structural assessment of ultralightweight composites
p 1107 N92-32525
Aspects of compression in aerospace composites: Future requirements p 1109 N92-33036
WELDING
Current repair technologies for jet engine components
p 1016 A92-56085
WIND EFFECTS
Severe turbulence and maneuvering from airline flight records
[AIAA PAPER 92-4341] p 1078 A92-55330
WIND PROFILES
Effect of a simulated glaze ice shape on the aerodynamic performance of a rectangular wing
[AIAA PAPER 92-4042] p 1035 A92-56861
WIND SHEAR
Modified Doppler detects wind shear more reliably
p 1015 A92-55099
Optimal recovery from microburst wind shear
[AIAA PAPER 92-4338] p 1078 A92-55327
Escape strategies for turboprop aircraft in microburst windshear p 1084 A92-56151
Airport Surveillance Radar (ASR-9) wind shear processor: 1991 test at Orlando, Florida
[AD-A252246] p 1124 N92-32686
WIND TUNNEL APPARATUS
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729
Tohoku University low-turbulence wind tunnel
[AIAA PAPER 92-3913] p 1095 A92-56746
Flow quality studies of the NASA Lewis Research Center 8- by 6-foot supersonic/9- by 15-foot Low Speed Wind Tunnel
[AIAA PAPER 92-3916] p 1095 A92-56748
Performance evaluation of a transonic wind tunnel compressor
[AIAA PAPER 92-3927] p 1096 A92-56758
Pilot-pressure probe for measuring pressure in a hypersonic wind tunnel
[NASA-CASE-LAR-14232-1] p 1102 N92-34213
WIND TUNNEL CALIBRATION
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729
WIND TUNNEL DRIVES
An overview of the planned aerospace test facilities at Capua, Italy
[AIAA PAPER 92-3944] p 1097 A92-56773
WIND TUNNEL MODELS
Conception of a UHB engine simulator for the essential characteristics of a true-scale engine --- ultrahigh bypass
p 1090 A92-54322
Evaluation of electrolytic tilt sensors for wind tunnel model angle-of-attack (AOA) measurements
p 1116 A92-54344
Research on aeroelastic tailoring at NAL
p 1053 A92-56019
Measurements of blade flapping motion on a wind tunnel model p 1093 A92-56023
Demonstration of structural optimization applied to wind-tunnel model design p 1119 A92-56181
Laser-driven hypersonic air-breathing propulsion simulator
[AIAA PAPER 92-3922] p 1095 A92-56753
An approach for increasing aeroelastic divergence dynamic pressure of wind-tunnel models
[AIAA PAPER 92-4002] p 1099 A92-56825
Buffet test in the National Transonic Facility
[AIAA PAPER 92-4032] p 1100 A92-56854
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
Experimental study of a generic high-speed civil transport
[NASA-TM-4382] p 1040 N92-33631
Effect of afterbody geometry on aerodynamic characteristics of isolated nonaxisymmetric afterbodies at transonic Mach numbers
[NASA-TP-3236] p 1041 N92-33706
WIND TUNNEL NOZZLES
Hypersonic aerodynamic/aerothermodynamic testing capabilities at Langley Research Center
[AIAA PAPER 92-3937] p 1096 A92-56767
CAN-DO, CFD-based Aerodynamic Nozzle Design and Optimization program for supersonic/hypersonic wind tunnels
[AIAA PAPER 92-4009] p 1033 A92-56832
WIND TUNNEL TESTS
Rarefied gas numerical wind tunnel
p 1017 A92-53552
A preliminary study of a supersonic wind tunnel for a ram jet test facility p 1089 A92-53564
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
Structure of crossing-shock wave/turbulent boundary-layer interactions
[AIAA PAPER 92-3670] p 1022 A92-54113
Wind tunnel performance results of swirl recovery vanes as tested with an advanced high speed propeller
[AIAA PAPER 92-3770] p 1068 A92-54159
Aerodynamic assessment of an optical pressure measurement system (OPMS) by comparison with conventional pressure measurements in a high speed wind tunnel p 1114 A92-54304
Notes on the use of fusible temperature indicators to bound the temperature of hot graphite in the NAVSWC hypervelocity wind tunnel facility p 1090 A92-54315
Application of a wall pressure method in a wind tunnel test section with adjustable longitudinal slots
p 1091 A92-54336
The wind tunnel test 'system' of 1995 - Cost effective experimentation through a fusion of related technologies
p 1091 A92-54342
Evaluation of electrolytic tilt sensors for wind tunnel model angle-of-attack (AOA) measurements
p 1116 A92-54344
Instrumentation key to NASP combustor tests
p 1092 A92-55100
Aerodynamic parameters of the X-31 drop model estimated from flight-data at high angles of attack
[AIAA PAPER 92-4357] p 1080 A92-55343
Aerodynamic analysis of the Pioneer unmanned air vehicle
[AIAA PAPER 92-4635] p 1027 A92-55382
Supersonic wind tunnel test of airintake/airframe integrated models p 1028 A92-56006
A hypersonic wind tunnel test of a mixed-compression air inlet model p 1028 A92-56007
Wind tunnel test of M = 2.5 mixed compression inlet
p 1028 A92-56008
On the structure of unsteady shock induced separation of the transonic airfoil in the NAL two-dimensional wind tunnel p 1029 A92-56010
On improvements of three-dimensional position measuring system for dynamic wind tunnel testing
p 1093 A92-56012
Flutter analysis and wind tunnel test with respect to a low-aspect-ratio wing with free-rotational control surface
p 1052 A92-56014
Propeller-nacelle whirl flutter analysis and wind tunnel test p 1052 A92-56016
Whirl flutter analysis and application to aircraft design
p 1053 A92-56017
Analysis and wind tunnel test of low aspect wing gust load alleviation p 1053 A92-56020
High subsonic wind tunnel test of a two-dimensional hybrid-laminar-flow-control airfoil with slotted surface
p 1029 A92-56045
Design and wind tunnel test of low-Reynolds-number airfoil p 1029 A92-56047
On the effect of canards on NAL spaceplane model (0 order) in low speed area p 1030 A92-56052
Low-speed wind tunnel testing for the high-speed propeller at high shaft angle of attack
p 1030 A92-56054
Helicopter rotor testing using scaled model
p 1093 A92-56076
A low speed wind tunnel investigation of a joined-wing aircraft with an overhanging fin p 1030 A92-56078
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test
p 1093 A92-56114
Evaluation of a IMU with optical fiber gyros in dynamic windtunnel tests p 1104 A92-56121
Small two-dimensional surface excrescences on aircraft wings approaching separation p 1031 A92-56170
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344
Correlation of flight, tunnel and prediction data on a helicopter main rotor p 1059 A92-56350
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729
Supersonic and hypersonic quiet tunnel technology at NASA Langley
[AIAA PAPER 92-3908] p 1094 A92-56743
The ASU Transition Research Facility
[AIAA PAPER 92-3910] p 1094 A92-56744
Development and validation of a freejet technique for inlet-engine compatibility testing
[AIAA PAPER 92-3921] p 1033 A92-56752
Laser-driven hypersonic air-breathing propulsion simulator
[AIAA PAPER 92-3922] p 1095 A92-56753
Roles of wind tunnel tests and CFD analyses in the design of energy-efficient SST
[AIAA PAPER 92-3923] p 1133 A92-56754
Blockage correction in three-dimensional wind tunnel testing based on the wall signature method
[AIAA PAPER 92-3925] p 1095 A92-56756
Wind tunnel blockage effects on slender wings undergoing large amplitude motions
[AIAA PAPER 92-3926] p 1096 A92-56757
Control of large cryogenic tunnels
[AIAA PAPER 92-3930] p 1096 A92-56761
Hypersonic aerodynamic/aerothermodynamic testing capabilities at Langley Research Center
[AIAA PAPER 92-3937] p 1096 A92-56767
Performance data of the new free-piston shock tunnel at GALCIT
[AIAA PAPER 92-3943] p 1033 A92-56776
TSNIIMASH capabilities for aerogasdynamical and thermal testing of hypersonic vehicles
[AIAA PAPER 92-3962] p 1097 A92-56789
The SR3 low density wind tunnel - Facility capabilities and research development
[AIAA PAPER 92-3972] p 1098 A92-56798
Comparison of recent results from different wind tunnel facilities along with comparisons of measured flight results and wind tunnel based predictions
[AIAA PAPER 92-3985] p 1060 A92-56809
High-lift testing at high Reynolds numbers
[AIAA PAPER 92-3986] p 1033 A92-56810
Application of electronically scanned pressure measurement system for engine simulation tests in the German-Dutch Wind Tunnel
[AIAA PAPER 92-4003] p 1122 A92-56826
Computational and numerical analysis of hypersonic nozzle flows with comparisons to wind tunnel calibration data
[AIAA PAPER 92-4011] p 1033 A92-56834
Hypersonic wind tunnel nozzle study
[AIAA PAPER 92-4012] p 1033 A92-56835
Numerical prediction of the flow characteristics in an arc wind tunnel
[AIAA PAPER 92-4016] p 1100 A92-56838
Hypersonic shock tunnel testing for undergraduate laboratory instruction
[AIAA PAPER 92-4021] p 1100 A92-56843
Laboratory simulation of aerothermodynamic phenomena - A review
[AIAA PAPER 92-4025] p 1104 A92-56847
Buffet test in the National Transonic Facility
[AIAA PAPER 92-4032] p 1100 A92-56854
Effects of external influences in subsonic delta wing vortices
[AIAA PAPER 92-4033] p 1034 A92-56855
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
Integration of wall interference assessment and wall adaptation
[NLR-TP-91119-U] p 1101 N92-32734
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063
Implementation of a personal computer based parameter estimation program
[AD-A252914] p 1061 N92-33502
Experimental study of a generic high-speed civil transport
[NASA-TM-4382] p 1040 N92-33631
Effect of afterbody geometry on aerodynamic characteristics of isolated nonaxisymmetric afterbodies at transonic Mach numbers
[NASA-TP-3236] p 1041 N92-33706
Flutter models: Their design, manufacture, and ground testing p 1089 N92-34164
Unsteady wind tunnel tests p 1089 N92-34166
Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193
WIND TUNNEL WALLS
Evaluation of sidewall interference in the NAL two-dimensional transonic wind tunnel
p 1092 A92-56011
Tohoku University low-turbulence wind tunnel
[AIAA PAPER 92-3913] p 1095 A92-56746
The research of reducing 3-D low supersonic shock wave reflection in a 2-D transonic flexible walls adaptive wind tunnel
[AIAA PAPER 92-3924] p 1095 A92-56755
Numerical modeling of transonic juncture flow
[AIAA PAPER 92-4036] p 1035 A92-56858

WIND TUNNELS
A quiet-flow Ludwieg tube for experimental study of high speed boundary layer transition
[AIAA PAPER 92-3885] p 1094 A92-56727
Tohoku University low-turbulence wind tunnel
[AIAA PAPER 92-3913] p 1095 A92-56746
Design of a variable contraction for a full-scale automotive wind tunnel
[AIAA PAPER 92-3929] p 1096 A92-56760
Calibration of hemispherical-head flow angularity probes
[AIAA PAPER 92-4005] p 1122 A92-56828
The wind tunnel, its evolution for aerospace test purposes, perspective for curriculum development
[AIAA PAPER 92-4017] p 1100 A92-56839
Aerodynamics laboratory education at Purdue University - Ground testing facilities
[AIAA PAPER 92-4018] p 1100 A92-56840
The trisonic wind tunnel Muenchen and its involvement in the German SAeNGER-programme
[AIAA PAPER 92-4019] p 1100 A92-56841
Prediction of the pressure loss coefficient of wind tunnel turbulence reducing screens
[AIAA PAPER 92-4043] p 1035 A92-56862
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063
WIND TURBINES
Particle image velocimetry measurements of the aerodynamics of a wind turbine p 1115 A92-54337
Turbulence-induced loads on a teetered rotor p 1042 N92-34029
WIND VELOCITY
On the effect of canards on NAL spaceplane model (0 order) in low speed area p 1030 A92-56052
WING LOADING
Effects of the roll angle on cruciform wing-body configurations at high incidences
[AIAA PAPER 92-4356] p 1079 A92-55342
WING OSCILLATIONS
Navier-Stokes prediction of large-amplitude delta-wing roll oscillations characterizing wing rock
[AIAA PAPER 92-4428] p 1080 A92-55352
Navier-Stokes computations for oscillating control surfaces
[AIAA PAPER 92-4431] p 1026 A92-55355
Stochastic self-induced roll oscillations of slender delta wing at high angles of attack
[AIAA PAPER 92-4498] p 1081 A92-55366
Multidisciplinary optimization of aeroservoelastic systems using reduced-size models p 1054 A92-56176
Elementary flutter analysis p 1088 N92-34162
WING PANELS
Detailed analysis and test correlation of a stiffened composite wing panel p 1121 A92-56324
Global/local interlaminar stress analysis of a grid-stiffened composite panel
[NASA-CR-190822] p 1125 N92-33139
WING PLANFORMS
Lift and rolling moment due to spoilers on wings with trailing-edge flaps deflected at subsonic speeds
[ESDU-92002-SUPPL] p 1037 N92-32782
WING PROFILES
Optimal design of wing shape by use of neural-network p 1054 A92-56112
Small two-dimensional surface excrescences on aircraft wings approaching separation p 1031 A92-56170
Wing mass formula for twin fuselage aircraft p 1054 A92-56171
WING ROOTS
Dynamic analysis of rotor blades with root retention design variations p 1054 A92-56156
WING TIP VORTICES
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
Two-fence concept for efficient trapping of vortices on airfoils p 1031 A92-56165
WING TIPS
Experimental study of a generic high-speed civil transport
[NASA-TM-4382] p 1040 N92-33631
WINGED VEHICLES
Navier-Stokes simulation for the winged space vehicle 'HOPE' at subsonic, transonic, and supersonic regimes p 1018 A92-53559
Improvement of atmospheric flight performance of a space vehicle through H infinity-control theory p 1130 A92-53785
WINGS
Computations of the unsteady flow about a generic wing/pylon/finned-store configuration
[AIAA PAPER 92-4568] p 1027 A92-55377
Aerodynamic centre of wing-body combinations
[ESDU-92024] p 1036 N92-32479
Design, evaluation and experimental effort toward development of a high strain composite wing for Navy aircraft p 1107 N92-32514
Out of plane analysis for composite structures p 1107 N92-32527
Damage tolerance certification methodology for composite structures p 1108 N92-32579
Lift and rolling moment due to spoilers on wings with trailing-edge flaps deflected at subsonic speeds
[ESDU-92002-SUPPL] p 1037 N92-32782
Survey and analysis of research on supersonic drag-due-to-lift minimization with recommendations for wing design
[NASA-TP-3202] p 1040 N92-33656
Investigation of advancing front method for generating unstructured grid
[NASA-CR-190902] p 1128 N92-34043
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131
WORKLOADS (PSYCHOPHYSIOLOGY)
A consideration on air traffic control processing capability in terminal area p 1047 A92-56110
The advantages of digital engine control as compared with traditional systems (hydraulic or pneumatic) p 1070 A92-56338
WORKSTATIONS
Computations of unsteady multistage compressor flows in a workstation environment
[NASA-TM-103839] p 1071 N92-32452

X

X RAY IMAGERY
Application of X-ray image radiography system for aircraft p 1118 A92-56084
X RAY INSPECTION
Detection of honeycomb damage using hexagonal grid discontinuities
[DREP-89-9] p 1109 N92-32846
X-29 AIRCRAFT
High angle-of-attack control enhancement on a forward swept wing aircraft
[AIAA PAPER 92-4427] p 1080 A92-55351
X-30 VEHICLE
Supersonic and hypersonic quiet tunnel technology at NASA Langley
[AIAA PAPER 92-3908] p 1094 A92-56743
Technologies for the National Aero-Space Plane
[IAF PAPER 92-0868] p 1105 A92-57259
XV-15 AIRCRAFT
Short takeoff optimization for the XV-15 tiltrotor aircraft p 1056 A92-56302

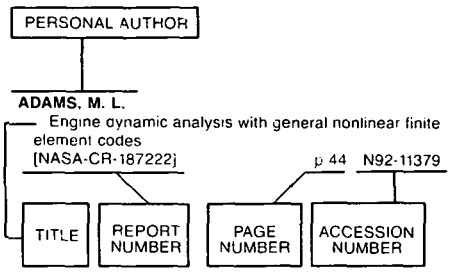
Y

YAW
Full Navier-Stokes calculations on the installed F/A-18 inlet at a high angle of attack
[AIAA PAPER 92-3175] p 1020 A92-54012
A simple three component velocity measurement method using a rotated split-film sensor p 1115 A92-54333
On the maneuvering tests of an ACV model p 1118 A92-56035
Predicting droplet impingement on yawed wings p 1043 A92-56180
Calibration of hemispherical-head flow angularity probes
[AIAA PAPER 92-4005] p 1122 A92-56828
Contribution of tailplane-mounted twin fins to sideforce, yawing moment, and rolling moment derivatives due to sideslip
[ESDU-92007] p 1086 N92-32487
YAWING MOMENTS
Contribution of tailplane-mounted twin fins to sideforce, yawing moment, and rolling moment derivatives due to sideslip
[ESDU-92007] p 1086 N92-32487
A nozzle internal performance prediction method
[NASA-TP-3221] p 1040 N92-33625

Z

ZERO LIFT
A Lie Bracket solution of the optimal thrust magnitude on a singular arc in atmospheric flight
[AIAA PAPER 92-4345] p 1079 A92-55334

Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence.

A

AALFS, DAVID D.
Real-time processing of radar return on a parallel computer
[NASA-CR-4456] p 1043 N92-32606

ABE, TAKASHI
Effect of streamwise pressure gradient on the supersonic mixing layer p 1025 A92-54936

ACHAR, N. S.
Computational aspects of helicopter trim analysis and damping levels from Floquet theory
[NASA-CR-190736] p 1087 N92-33107

ACHARYA, MUKUND
Dynamical scaling of a model unsteady separating flow p 1117 A92-54932

ADAM, P.
Hypersonic shock tunnel testing for undergraduate laboratory instruction
[AIAA PAPER 92-4021] p 1100 A92-56843

ADAMS, CATHERINE A.
Workshop on Aeronautical Decision Making (ADM). Volume 1: Executive summary
[DOT/FAA/RD-92/14-VOL-1] p 1142 N92-33305

ADAMS, RICHARD J.
Gain scheduled linear PID autopilot for the AIAA Controls Design Challenge aircraft
[AIAA PAPER 92-4629] p 1078 A92-55304
Workshop on Aeronautical Decision Making (ADM). *Volume 1: Executive summary*
[DOT/FAA/RD-92/14-VOL-1] p 1142 N92-33305

ADLER, CHARLES O.
Development of a high-angle-of-attack stability and control prediction code
[AIAA PAPER 92-4354] p 1079 A92-55340

ADVANI, S.
An evaluation of decelerating IFR approaches utilizing a helicopter flight simulator
[CTN-92-60348] p 1048 N92-32845

AESCHLIMAN, DANIEL P.
Calibration of *hemispherical-head flow angularity* probes
[AIAA PAPER 92-4005] p 1122 A92-56828

AFTOSMIS, MICHAEL
An examination of several high resolution schemes applied to complex problems in high speed flows
[AD-A250814] p 1124 N92-32632

AGARWALA, AJAY S.
Redundancy design philosophy for catastrophic loss protection p 1119 A92-56202

AGAWALA, ASHOK
Distributed systems: Interconnection and fault tolerance studies
[AD-A252869] p 1135 N92-33920

AHMED-ZAID, F.
Identification and control of aircraft dynamics using radial basis function neural networks
[AIAA PAPER 92-4393] p 1074 A92-55194

AHMED, S. R.
Analysis of helicopter rotor-fuselage interference with time averaged pressure distribution p 1032 A92-56331

AIHARA, Y.
Measurements of turbulence in hypersonic flow p 1092 A92-56005

AIZAWA, YASUTAKA
A robust gain scheduler interpolated into multiple models by membership functions
[AIAA PAPER 92-4553] p 1131 A92-55265

AKIMOTO, TOSHIO
Navier-Stokes simulation for the winged space vehicle 'HOPE' at subsonic, transonic, and supersonic regimes p 1018 A92-53559
Calculations for aerodynamic characteristics of HOPE type vehicle in subsonic and hypersonic flow p 1018 A92-53560
Concepts of flight experiments for HOPE development p 1103 A92-53635
Aerodynamic study of H-II Orbiting Plane, HOPE p 1103 A92-53639
HOPE re-entry experimental vehicle p 1103 A92-55098

AKIYOSHI, RYO
Fundamental studies on Marangoni convection related to Bridgman crystal growth p 1111 A92-53758

AL-BAHI, ALI M.
Effect of atmospheric disturbances on airplane response
[AIAA PAPER 92-4340] p 1078 A92-55329

AL'-DZHANABI, SH. KH.
Pulsation characteristics of one-phase and two-phase steam flows in Laval nozzles under off-design conditions p 1019 A92-53882

ALEXANDER, HAROLD
Research needs for a commercial passenger tiltrotor p 1056 A92-56298

ALEXOPOULOS, G. A.
An assumed joint-Beta PDF approach for supersonic *turbulent combustion*
[AIAA PAPER 92-3844] p 1113 A92-54199

ALHUSEIN, MAHMOUD A.
Small two-dimensional surface excrescences on aircraft wings approaching separation p 1031 A92-56170

ALJABARI, SAMER
Prediction of the pressure loss coefficient of wind tunnel turbulence reducing screens
[AIAA PAPER 92-4043] p 1035 A92-56862

ALLEGRE, J.
The SR3 low density wind tunnel - Facility capabilities and research development
[AIAA PAPER 92-3972] p 1098 A92-56798

AMANO, K.
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055

AMIN, S.
Flow induction by pressure forces
[AIAA PAPER 92-3571] p 1067 A92-54060

AMINPOUR, MOHAMMAD A.
Computational methods for global/local analysis
[NASA-TM-107591] p 1125 N92-33104

ANDERS, S. G.
Supersonic and hypersonic quiet tunnel technology at NASA Langley
[AIAA PAPER 92-3908] p 1094 A92-56743

ANDERSON, BERNHARD H.
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[AIAA PAPER 92-3177] p 1020 A92-54013
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[NASA-TM-105672] p 1128 N92-34112

ANDERSON, KARL F.
Thermal-structural test facilities at NASA Dryden
[NASA-TM-104249] p 1062 N92-34202

ANDERSON, MARK R.
Analytical development of an equivalent system mismatch function
[AIAA PAPER 92-4422] p 1080 A92-55346

ANDERSON, WILLIAM J.
Wing mass formula for twin fuselage aircraft p 1054 A92-56171

ANDO, HIROYUKI
Application of automation for structural-composites *production* p 1119 A92-56109

ANDRADE, LUIZ
Design of the Boeing 777 electric system p 1070 A92-55902

ANDREW, MIKE
The application of math-dynamic models to characterise a range of helicopter rotor system faults p 1056 A92-56297

ANFIMOV, N. A.
TSNIIMASH capabilities for aerogasdynamical and thermal testing of hypersonic vehicles
[AIAA PAPER 92-3962] p 1097 A92-56789

ANIKIN, V. A.
Aerodynamic features of a coaxial rotor helicopter p 1032 A92-56349

ANSLEY, GEORGE
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480

AOKI, TOSHIYUKI
Mechanical properties of laminate aluminum matrix composites p 1106 A92-56102

ARAI, T.
Numerical prediction of the flow characteristics in an arc wind tunnel
[AIAA PAPER 92-4016] p 1100 A92-56838

ARASHI, KAZUO
Experimental study on three-dimensional shock wave-turbulent boundary layer interaction induced by protuberance p 1019 A92-53997
Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance p 1029 A92-56009

ARBUCKLE, P. DOUGLAS
Simulation model of a twin-tail, high performance *airplane*
[NASA-TM-107601] p 1088 N92-33537

ARENA, ANDREW S., JR.
A discrete vortex model for predicting wing rock of slender wings
[AIAA PAPER 92-4497] p 1026 A92-55365

ARIGA, HIRONOBU
Effect of streamwise pressure gradient on the supersonic mixing layer p 1025 A92-54936

ARIMOTO, H.
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743

ARNOLD, U.
Blade instability of horizontally stoppable rotors p 1085 A92-56308

ARRINGTON, E. A.
Flow quality studies of the NASA Lewis Research Center 8- by 6-foot supersonic/9- by 15-foot Low Speed Wind Tunnel
[AIAA PAPER 92-3916] p 1095 A92-56748

ASADA, SHOICHIRO
HOPE re-entry experimental vehicle p 1103 A92-55098

ASHBY, DALE L.
Potential flow theory and operation guide for the panel code PMARC
[NASA-TM-102851] p 1036 N92-32422
ASHBY, GEORGE C., JR.
Test description and preliminary pitot-pressure surveys for Langley Test Technique Demonstrator at Mach 6
[AIAA PAPER 92-3940] p 1096 A92-56770
Pilot-pressure probe for measuring pressure in a hypersonic wind tunnel
[NASA-CASE-LAR-14232-1] p 1102 N92-34213
ASO, SHIGERU
Experimental investigation on turbulent phenomena in three-dimensional shock wave/turbulent boundary layer interaction induced by blunt fin p 1018 A92-53557
Numerical simulations of shock reflections by a TVD scheme p 1018 A92-53558
Experimental study on three-dimensional shock wave-turbulent boundary layer interaction induced by protuberance p 1019 A92-53997
Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance p 1029 A92-56009
ATENCIO, A., JR.
Flight simulator fidelity assessment in a rotorcraft lateral translation maneuver
[AIAA PAPER 92-4424] p 1092 A92-55348
ATHAVALE, M. M.
A finite-volume numerical method to calculate fluid forces and rotordynamic coefficients in seals
[AIAA PAPER 92-3712] p 1113 A92-54132
ATKINSON, EDWARD
Effects of material choices on brush seal performance p 1116 A92-54650
ATSUMI, MOTOHIRO
Fabrication test and evaluation of graphite/PMR-15 polyimide for HOPE primary structure p 1105 A92-53516
AUSROTAS, RAYMOND A.
Impacts of technology on the capacity needs of the US national airspace system
[NASA-CR-4470] p 1045 N92-34192
AVERY, JOHN G.
Development of thermoplastic components for structural validation p 1107 N92-32522
AZAM, MISBAHUL
Neural networks for feedback linearization in aircraft control
[AIAA PAPER 92-4391] p 1074 A92-55192
Invertibility and trajectory control for nonlinear maneuvers of aircraft
[AIAA PAPER 92-4410] p 1075 A92-55204
AZZAM, HESHAM
The application of math-dynamic models to characterise a range of helicopter rotor system faults p 1056 A92-56297

B

BABA, S.
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055
BABA, SHIGEO
On the structure of unsteady shock induced separation of the transonic airfoil in the NAL two-dimensional wind tunnel p 1029 A92-56010
BGK1 airfoil oilflow tests in the NAL two-dimensional wind tunnel. II p 1029 A92-56044
BABA, Y.
Selection of sampling rate for nonlinear flight trajectory controller of aircraft p 1084 A92-56070
BABIN, ROBERT S.
Engineering reliability and maintainability review - A regimen for discovering production deficiencies p 1120 A92-56254
BAEDER, J. D.
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
BAKANAS, STEPHEN
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480
BAKER, DONALD J.
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575
Flight service environmental effects on composite materials and structures p 1110 N92-33054
BAKOS, R. J.
Effects of oxygen dissociation on hypervelocity combustion experiments
[AIAA PAPER 92-3964] p 1098 A92-56791
BAKUNIN, V. N.
Viscosity characteristics of synthetic aviation oils at low temperatures p 1105 A92-53875
BALAKRISHNA, S.
Control of large cryogenic tunnels
[AIAA PAPER 92-3930] p 1096 A92-56761
BALAS, GARY J.
Robust dynamic inversion control laws for aircraft control
[AIAA PAPER 92-4329] p 1073 A92-55173
BALMFORD, D. E. H.
The compound helicopter - A concept revisited p 1058 A92-56341
BANDA, SIVA S.
Gain scheduled linear PID autopilot for the AIAA Controls Design Challenge aircraft
[AIAA PAPER 92-4629] p 1078 A92-55304
BANDOU, SHUNICHI
Design and testing of a composite hingeless hub for rotary-wing aircraft p 1053 A92-56075
BANGERT, LINDA S.
Effect of afterbody geometry on aerodynamic characteristics of isolated nonaxisymmetric afterbodies at transonic Mach numbers
[NASA-TP-3236] p 1041 N92-33706
BANILOWER, HOWARD
Bird ingestion into large turbofan engines
[DOT/FAA/CT-91/17] p 1043 N92-33005
BANKS, DANIEL W.
Assessment of passive porosity with free and fixed separation on a tangent ogive forebody
[AIAA PAPER 92-4494] p 1081 A92-55363
BANNYKH, O. A.
High-temperature metal matrix composite p 1105 A92-53878
BAR-KANA, IZHAK
On-line identification and control of linearized aircraft dynamics p 1082 A92-55911
BARANKIEWICZ, WENDY
Use of an approximate similarity principle for the thermal scaling of a full-scale thrust augmenting ejector
[AIAA PAPER 92-3792] p 1069 A92-54171
BARE, E. ANN
Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193
BARGER, RAYMOND L.
A method for designing blended wing-body configurations for low wave drag
[NASA-TP-3261] p 1036 N92-32480
BARKER, J. C.
Lynx - A 50 year product? p 1056 A92-56307
BARLAS, M. R.
Nonlinear model-following control application to airplane control (1992 AIAA Controls Design Challenge)
[AIAA PAPER 92-4625] p 1077 A92-55302
BARLOW, JEWEL B.
Stability, control and gust response characteristics of an ultralight freewing airplane
[AIAA PAPER 92-4342] p 1079 A92-55331
The wind tunnel, its evolution for aerospace test purposes, perspective for curriculum development
[AIAA PAPER 92-4017] p 1100 A92-56839
BARNDT, LUANN
US Coast Guard GPS Information Center (GPSIC) and its function within the Civil GPS Service (CGS) p 1049 N92-33352
BARNES, J. D.
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301
[AD-A252912] p 1126 N92-33501
BARON, A.
Numerical simulation of unsteady rotor wakes p 1032 A92-56352
BARRAL, M.
The advantages of digital engine control as compared with traditional systems (hydraulic or pneumatic) p 1070 A92-56338
BARTHELEMY, J. P.
Organization and technical status of the NH90 European helicopter programme p 1016 A92-56306
BASCH, R. E., JR.
Severe turbulence and maneuvering from airline flight records
[AIAA PAPER 92-4341] p 1078 A92-55330
BASS, HENRY
Steady state risetimes of shock waves in the atmosphere p 1140 N92-33882
BASTOS-NETTO, DEMETRIO
Some thermodynamical aspects in the optimization of supersonic combustors p 1065 A92-53486
The behaviour of the pressure temperature and density in an inviscid unsteady transonic axisymmetric flow with shock waves p 1018 A92-53553
BATES, PRESTON R.
Damage tolerance analysis for rotorcraft - What the issues are p 1058 A92-56336
BATES, WILLIAM F., JR.
New materials drive high-performance aircraft p 1105 A92-55134
BATILL, S. M.
The design of a subsonic low-noise, low-turbulence wind tunnel for acoustic measurements
[AIAA PAPER 92-3883] p 1094 A92-56726
BAUER, STEVEN X. S.
Assessment of passive porosity with free and fixed separation on a tangent ogive forebody
[AIAA PAPER 92-4494] p 1081 A92-55363
BAULD, N. R., JR.
Global/local interlaminar stress analysis of a grid-stiffened composite panel
[NASA-CR-190822] p 1125 N92-33139
BAUMONT, FRANCOISE S.
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG p 1050 N92-33356
BAURLE, R. A.
An assumed joint-Beta PDF approach for supersonic turbulent combustion
[AIAA PAPER 92-3844] p 1113 A92-54199
BAVUSO, SALVATORE J.
HiRel - Reliability/availability integrated workstation tool p 1120 A92-56257
BAYSAL, OKTAY
Computing high-speed flows past an oscillating cylinder near a vertical wall
[AIAA PAPER 92-4653] p 1028 A92-55397
BEALE, D. K.
Development and validation of a freejet technique for inlet-engine compatibility testing
[AIAA PAPER 92-3921] p 1033 A92-56752
BEALE, DAVID K.
An acceptance process for the evaluation of inlet distortion
[AIAA PAPER 92-3918] p 1032 A92-56750
BEARDEN, DAVID A.
Damage tolerant design of critical aircraft structural components
[AIAA PAPER 92-4041] p 1123 A92-56860
BEAUCHAMP, CHARLES H.
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131
BEAUCHAMP, GARY M.
The design and development of a portable, DSP micro-processor based, high-accuracy data acquisition system
[NRC-32146] p 1134 N92-32851
BECK, W. H.
The high enthalpy shock tunnel in Goettingen
[AIAA PAPER 92-3942] p 1104 A92-56772
BECKWITH, I. E.
Supersonic and hypersonic quiet tunnel technology at NASA Langley
[AIAA PAPER 92-3908] p 1094 A92-56743
BELLAVIA, DAVID C.
On the anomalies in single-jet hover suckdown data
[NASA-TM-102261] p 1038 N92-33306
On the estimation of jet-induced fountain lift and additional suckdown in hover for two-jet configurations
[NASA-TM-102268] p 1040 N92-33618
BELTON, PAMELA S.
Experimental study of a generic high-speed civil transport
[NASA-TM-4382] p 1040 N92-33631
BELTRAN, LUIS R.
Advanced nozzle and engine components test facility
[AIAA PAPER 92-3993] p 1099 A92-56816
BEN-ASHER, JOSEPH Z.
Optimal trajectories for an unmanned air-vehicle in the horizontal plane
[AIAA PAPER 92-4344] p 1079 A92-55333
BENDER, B. S.
The compound helicopter - A concept revisited p 1058 A92-56341
BENNETT, JOHN C.
Computational and experimental investigation of annulus heat transfer with swirl
[AIAA PAPER 92-4060] p 1119 A92-56143
BENNETT, ROBERT M.
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter
[NASA-TM-104211] p 1042 N92-34147
BERG, RICHARD L.
Performance of insulated pavements at Newton Fields, Jackman, Maine
[CRREL-92-9] p 1101 N92-32903
BERMAN, MORTON B.
Developing robust support structures for high-technology subsystems: The AH-64 Apache helicopter
[AD-A252773] p 1017 N92-33499

BETTS, JOHN T.
The application of direct transcription to commercial aircraft trajectory optimization
[AIAA PAPER 92-4528] p 1077 A92-55246
BEVER, GLENN A.
The development of an airborne information management system for flight test
[NASA-TM-104251] p 1065 N92-32866
BEZIAC, G.
Organization and technical status of the NH90 European helicopter programme p 1016 A92-56306
BIANCHI, ALFREDO
Time Resolved Lidar Fluorosensor operating from helicopter p 1121 A92-56296
BIELAWA, RICHARD L.
Rotary wing structural dynamics and aeroelasticity
[ISBN 1-56347-031-4] p 1052 A92-54550
BIEZAD, DANIEL J.
Enlisting industry support for a flight controls design lab
[AIAA PAPER 92-4560] p 1141 A92-55272
BIGGERS, S. B.
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
BILIMORIA, KARL D.
An integrated development of the equations of motion for elastic hypersonic flight vehicles
[AIAA PAPER 92-4605] p 1077 A92-55283
BILL, ROBERT C.
Summary highlights of the Advanced Rotorcraft Transmission (ART) program
[AIAA PAPER 92-3362] p 1051 A92-54026
BIRCKELBAW, LOURDES G.
Ski jump takeoff performance predictions for a mixed-flow, remote-lift STOVL aircraft
[NASA-TM-103866] p 1060 N92-32887
BJORKELO, KENNETH
Effective maintenance practices to manage system aging p 1119 A92-56215
BLACKSTOCK, DAVID T.
Model experiment to study the effect of turbulence on risetime and waveform of N waves
p 1139 N92-33881
BLADOS, WALTER R.
An international aerospace information system: A cooperative opportunity
[NASA-TM-108171] p 1142 N92-33237
BLAKE, WILLIAM B.
Development of a high-angle-of-attack stability and control prediction code
[AIAA PAPER 92-4354] p 1079 A92-55340
BLANCHA, BARRY
Comparison of frequency domain and time domain laser velocimeter signal processors p 1114 A92-54314
BOATMAN, JOE F.
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
BOBBITT, RICHARD B.
Escape strategies for turboprop aircraft in microburst windshear p 1084 A92-56151
BODHAINE, BARRY A.
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
BOECKING, KLAUS F.
Airborne experimental FLIR program
p 1064 N92-32447
BOERRIGTER, H. L.
Quantitative heat transfer measurements in hypersonic wind tunnels by means of infrared thermography
p 1115 A92-54321
BOERSTOEL, J. W.
New concepts for multi-block grid generation for flow domains around complex aerodynamic configurations
[NLR-TP-91046-U] p 1037 N92-32730
BOFFADOSSI, M.
Numerical simulation of unsteady rotor wakes
p 1032 A92-56352
BOGDANOFF, DAVID W.
Flow characterization in the NASA Ames 16-inch Shock Tunnel
[AIAA PAPER 92-3810] p 1090 A92-54180
BOHON, HERMAN L.
Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, part 1
[NASA-CP-3087-PT-1] p 1106 N92-32513
BOLDI, D.
Supportability evaluation of thermoplastic and thermoset composites p 1108 N92-32576
BOLMS, H. T.
Conception of a UHB engine simulator for the essential characteristics of a true-scale engine
p 1090 A92-54322
BOND, C. D.
Lightning strike tests of composite connectors
[AD-A252281] p 1044 N92-33249
BOOLE, P. W.
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
BOOTH, EARL R., JR.
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344
BORCHERS, INGO U.
The Dornier 328 Acoustic Test Cell (ATC) for interior *noise tests and selected test results*
[AIAA PAPER 92-2164] p 1137 N92-32951
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
BORGER, J.
A simulator evaluation of various manual control concepts for fly-by-wire transport aircraft
[AIAA PAPER 92-4328] p 1073 A92-55172
BORST, ROBERT G.
E-6 flutter investigation and experience
[AIAA PAPER 92-4601] p 1077 A92-55280
BOSSERT, DAVID E.
Design of robust Quantitative Feedback Theory controllers for pitch attitude hold systems
[AIAA PAPER 92-4409] p 1075 A92-55203
BOUSSIOS, C.
Active control of compressor surge and stall
[AD-A252771] p 1126 N92-33498
BOWLES, T.
Smart structures in the active control of blade vortex interaction p 1085 A92-56314
BOYD, J. E.
Detection of honeycomb damage using hexagonal grid discontinuities
[DREP-89-9] p 1109 N92-32846
BOYLE, R. J.
Three-dimensional Navier-Stokes heat transfer predictions for turbine blade rows
[AIAA PAPER 92-3068] p 1020 A92-54003
BRADLEY, M. K.
A code validation strategy and facility for nonequilibrium, reacting flows
[AIAA PAPER 92-3970] p 1098 A92-56796
BRADLEY, R.
Creation of a living specification for an experimental helicopter active flight control system through incremental simulation p 1057 A92-56312
The identification of coupled flapping/inflow models for hovering flight p 1058 A92-56335
BRADLEY, SUZANNE
Simulation test and evaluation of TCAS 2 logic version 6.04
[DOT/FAA/RD-92/23] p 1048 N92-33098
BRAEUNLING, W.
Conception of a UHB engine simulator for the essential characteristics of a true-scale engine
p 1090 A92-54322
BRAGG, MICHAEL B.
Predicting droplet impingement on yawed wings
p 1043 A92-56180
BRAUN, D.
Mission oriented investigation of handling qualities through simulation p 1059 A92-56353
BRAY, ROBERT M.
Aerodynamic analysis of the Pioneer unmanned air vehicle
[AIAA PAPER 92-4635] p 1027 A92-55382
BRENNAN, JAMES R.
Designing to cost effectiveness - Enhancing quality
p 1119 A92-56209
BRENNAN, M.
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
BRIGHT, MICHELLE M.
Piloted evaluation of an integrated propulsion and flight control simulator
[NASA-TM-105797] p 1088 N92-34107
BRINSON, P. R.
Experimental investigation of helicopter coupled rotor/body control p 1086 A92-56318
BRISKI, MARK S.
Integrated test and evaluation for hypervelocity systems
[AIAA PAPER 92-3901] p 1017 A92-56736
BRISTOL, BRENT
Effects of material choices on brush seal performance
p 1116 A92-54650
BRITCHER, COLIN P.
Dynamics and control of a five degree-of-freedom magnetic suspension system
[NASA-CR-191259] p 1102 N92-34222
BROKOPP, RICHARD A.
Small engine components test facility compressor testing cell at NASA Lewis Research Center
[AIAA PAPER 92-3980] p 1098 A92-56806
BRONKHORST, EUGENE A.
Development of rating instruments and procedures for aviation mishap investigation
[AD-A253072] p 1044 N92-33288
BRONKHORST, TINA M.
Development of rating instruments and procedures for aviation mishap investigation
[AD-A253072] p 1044 N92-33288
BROOKS, THOMAS F.
BVI impulsive noise reduction by higher harmonic pitch *control - Results of a scaled model rotor experiment in* the DNW p 1136 A92-56344
BROUWER, W.
Real-time helicopter simulation using the blade element method p 1132 A92-56278
BROWN, DON
SATWG networked quality function deployment
p 1134 N92-33339
BROWN, T. M.
Degenerate four-wave mixing for measurement of NO2 and smoke concentration in jet engine exhaust
[AIAA PAPER 92-3658] p 1113 A92-54108
BROWNE, LINDSEY
Potential flow theory and operation guide for the panel code PMARC
[NASA-TM-102851] p 1036 N92-32422
BRUCKNER, ROBERT J.
Engine component instrumentation development facility at NASA Lewis Research Center
[AIAA PAPER 92-3995] p 1099 A92-56818
BRUNO, JOSEPH
Design, evaluation and experimental effort toward development of a high strain composite wing for Navy aircraft p 1107 N92-32514
BRUNS, JAMES E.
Full Navier-Stokes calculations on the installed F/A-18 inlet at a high angle of attack
[AIAA PAPER 92-3175] p 1020 A92-54012
BRYNESTAD, MARK A.
Investigation of the flight control requirements of a half-scale ducted fan unmanned aerial vehicle
[AD-A252730] p 1087 N92-32988
BUCCI, A.
CFRP stiffened panels under compression
p 1109 N92-33044
BUCKLOW, I. A.
Joining a Ni-based creep-resistant (ODS) alloy by brazing p 1116 A92-54867
Diffusion bonding a creep-resistant Fe-ODS alloy
p 1117 A92-54868
BUFFINGTON, JAMES M.
Gain scheduled linear PID autopilot for the AIAA Controls Design Challenge aircraft
[AIAA PAPER 92-4629] p 1078 A92-55304
BUGGELE, ALVIN E.
Engine component instrumentation development facility at NASA Lewis Research Center
[AIAA PAPER 92-3995] p 1099 A92-56818
BUIST, JAKOB
On the origin and acoustical behaviour of cloud cavitation
[ISBN-90-9004317-9] p 1125 N92-33066
BURCHAM, FRANK W., JR.
Flight testing and simulation of an F-15 airplane using throttles for flight control
[NASA-TM-104255] p 1087 N92-32864
BURGSMUELLER, W.
Application of electronically scanned pressure measurement system for engine simulation tests in the German-Dutch Wind Tunnel
[AIAA PAPER 92-4003] p 1122 A92-56826
BURKEN, JOHN J.
Flight-determined stability analysis of multiple-input-multiple-output control systems
[AIAA PAPER 92-4396] p 1074 A92-55196
BURSCH, PAUL
Field test of an advanced maintenance-system
p 1016 A92-56221
BURTSEV, B. N.
Aeroelasticity of a coaxial helicopter rotor
p 1057 A92-56309
BUSCHEK, H.
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
BUSHMAN, M. A.
In-flight performance diagnostic capability of an adaptive engine model
[AIAA PAPER 92-3746] p 1068 A92-54147
BUTLER, THOMAS W.
Buffet test in the National Transonic Facility
[AIAA PAPER 92-4032] p 1100 A92-56854
BUTTRILL, CAREY S.
Simulation model of a twin-tail, high performance airplane
[NASA-TM-107601] p 1088 N92-33537

BYRNE, J.
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-34019
BYRNES, C. I.
G-Field Control of nonlinear systems
[AIAA PAPER 92-4555] p 1131 A92-55267

C

CAHILL, DAVID M.
Development of an uncertainty methodology for multiple-channel instrumentation systems
[AIAA PAPER 92-3953] p 1133 A92-56781
CALISE, ANTHONY J.
Neural networks for feedback linearization in aircraft control
[AIAA PAPER 92-4391] p 1074 A92-55192
CAMBIER, JEAN-LUC
Numerical simulation of unsteady flow in a hypersonic shock tunnel facility
[AIAA PAPER 92-4029] p 1034 A92-56851
CAMPBELL, B. T.
Thermal paints for shock/boundary layer interaction in inlet flows
[AIAA PAPER 92-3626] p 1113 A92-54093
CAMPBELL, F. J.
Lightning strike tests of composite connectors
[AD-A252281] p 1044 N92-33249
CAMPBELL, RICHARD L.
Applications of a direct/iterative design method to complex transonic configurations
[NASA-TP-3234] p 1039 N92-33484
Experimental study of a generic high-speed civil transport
[NASA-TM-4382] p 1040 N92-33631
CAMPERCHIOLI, WILLIAM P.
Transonic turbine blade cascade testing facility
[AIAA PAPER 92-4034] p 1101 A92-56856
CANARD-CARUANA, S.
Experimental study of noise generation and propagation in a turbofan model p 1136 A92-56169
CANDEL, S.
Turbulent combustion modelling in a side dump ramjet combustor
[AIAA PAPER 92-3599] p 1112 A92-54075
CAPONE, FRANCIS J.
Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193
CARADONNA, F. X.
The computation and validation of hovering rotor performance p 1055 A92-56285
CARDOSI, K. M.
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
CARLSON, HARRY W.
Survey and analysis of research on supersonic drag-due-to-lift minimization with recommendations for wing design
[NASA-TP-3202] p 1040 N92-33656
CARLSON, JOHN R.
A nozzle internal performance prediction method
[NASA-TP-3221] p 1040 N92-33625
CARLSON, ROBERT L.
Damage tolerance analysis for rotorcraft - What the issues are p 1058 A92-56336
CAROLI, JOSEPH A.
A testability-dependent maintainability-prediction technique p 1120 A92-56222
CARR, H. R.
Joint study on the computerisation of in-field aero engines vibration diagnosis
[PNR-90799] p 1072 N92-33815
CARRAWAY, DEBRA L.
The use of silicon microsensors in smart skins for aerodynamic research p 1116 A92-54348
CARREIRO, LOUIS R.
Further studies of kinetic energy methods in high speed ramjet cycle analysis
[AIAA PAPER 92-3805] p 1069 A92-54177
CARSON, GEORGE T., JR.
Effect of afterbody geometry on aerodynamic characteristics of isolated nonaxisymmetric afterbodies at transonic Mach numbers
[NASA-TP-3236] p 1041 N92-33706
CASHON, JOHN L.
High temperature aircraft research furnace facilities
[NASA-CR-184384] p 1101 N92-33826
CASSATT, GARY G.
Development of thermoplastic components for structural validation p 1107 N92-32522
CASTRONUOVA, MAURICE
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480
CAUGHEY, DAVID A.
Improved calculation of transonic potential flow past swept wings p 1031 A92-56179
CAVOLOWSKY, JOHN A.
Flow characterization in the NASA Ames 16-inch Shock Tunnel
[AIAA PAPER 92-3810] p 1090 A92-54180
CAVONE, ANGELO A.
Signal processing schemes for Doppler global velocimetry p 1115 A92-54338
CEBECI, T.
Analysis of iced wings
[NASA-TM-105773] p 1042 N92-34144
CELIK, ZEKI Z.
Vortical flow control on a wing-body combination using tangential blowing
[AIAA PAPER 92-4430] p 1081 A92-55354
CERBE, T. M.
Short takeoff optimization for the XV-15 tiltrotor aircraft p 1056 A92-56302
CHADERJIAN, NEAL M.
Navier-Stokes prediction of large-amplitude delta-wing roll oscillations characterizing wing rock
[AIAA PAPER 92-4428] p 1080 A92-55352
CHADSEY, HAROLD
LORAN-C data reduction at the US Naval Observatory p 1050 N92-33358
CHAIMOVICH, M.
A generic harmonic rotor model for helicopter flight simulation p 1086 A92-56333
CHAMBERLIN, E.
Integrated Russian VLF/Omega receiver design
[PB92-193390] p 1051 N92-33809
CHAN, S. C.
Numerical study of the 3-D flowfield for a supersonic jet exiting into a hypersonic stream from a conical surface
[AIAA PAPER 92-3675] p 1022 A92-54118
CHANANI, G. R.
Supportability evaluation of thermoplastic and thermoset composites p 1108 N92-32576
CHANG, CHU-YIN
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
CHANG, JING-TANG
Transverse shear effect on flutter of composite panels p 1122 A92-56607
CHANG, R. C.
Forcing level effects of internal acoustic excitation on the improvement of airfoil performance p 1136 A92-56162
CHANG, TSU-SHUAN
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
CHANG, XIN-YU
Radiative heat transfer from nonequilibrium shock layer to a hypersonic reentry body p 1019 A92-53579
Three-dimensional calculation of radiative field in hypersonic air shock layers p 1023 A92-54498
CHAPDELAINE, E. R.
Statistics on aircraft gas turbine engine rotor failures that occurred in US commercial aviation during 1988
[DOT/FAA/CT-91/28] p 1071 N92-33105
CHAR, J. M.
Study on supersonic combustion in a hypersonic flight
[IAF PAPER 92-0661] p 1106 A92-57101
CHATTERJI, G. B.
Vision-based stereo ranging as an optimal control problem
[AIAA PAPER 92-4418] p 1045 A92-55211
CHAVEZ, FRANK R.
An integrated analytical aeropropulsive/aeroelastic model for the dynamic analysis of hypersonic vehicles
[AIAA PAPER 92-4567] p 1035 A92-57034
CHEATWOOD, FOY MCNEIL
An approximate viscous shock layer technique for calculating chemically reacting hypersonic flows about blunt-nosed bodies p 1041 N92-33837
CHEESEMAN, I. C.
A high speed edgewise rotor using circulation control only in the reversed flow area p 1059 A92-56347
CHEN, CHENG W.
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
CHEN, F.-J.
Supersonic and hypersonic quiet tunnel technology at NASA Langley
[AIAA PAPER 92-3908] p 1094 A92-56743
CHEN, GONG
Proof of concept of a magnetically coupled Stirling engine-driven heat pump
[DE92-017129] p 1129 N92-33271
CHEN, H. H.
Analysis of iced wings
[NASA-TM-105773] p 1042 N92-34144
CHEN, J.
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
CHEN, J.-Y.
Interaction between chemical reaction and turbulence in supersonic nonpremixed H2-air combustion p 1117 A92-54931
CHEN, M.
Electronics/avionics integrity - Definition, measurement and improvement p 1120 A92-56252
CHEN, O.
State-of-the-art materials for future gas turbine engines p 1070 A92-56122
CHEN, QING
Some important factors in turbulence in flight measurement p 1063 A92-54324
CHEN, SHILU
Stability and dynamic coupling of elastic vehicles with unsteady aerodynamic forces considered p 1102 A92-53545
CHEN, WEIPING
Stability, control and gust response characteristics of an ultralight freewing airplane
[AIAA PAPER 92-4342] p 1079 A92-55331
CHENG, C. W.
Reduction of the side force on pointed forebodies through add-on tip devices p 1024 A92-54918
CHENG, H. K.
Perspectives on hypersonic viscous and nonequilibrium flow research
[NASA-CR-190817] p 1039 N92-33413
CHENG, PETER
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
CHENG, PETER Y.
Automated procedures for aircraft aeroservoelastic compensation
[AIAA PAPER 92-4606] p 1077 A92-55284
CHENG, V. H. L.
Concepts for pilot interaction with an automated NOE obstacle-avoidance system
[AIAA PAPER 92-4472] p 1076 A92-55232
CHETTY, SHYAM
Computer aided evaluation of aircraft handling qualities and flight control system robustness
[AIAA PAPER 92-4423] p 1080 A92-55347
CHEUNG, SAMSON H.
Application of computational fluid dynamics to sonic boom near- and mid-field prediction p 1031 A92-56173
CHHOTE, L. SARAF
Criteria for use of seal coats on airport pavements
[DOT/FAA/RD-92/18] p 1102 N92-34247
CHINZEI, NOBUO
Conceptual design of scramjet engine p 1065 A92-53490
Scramjet engine and its flying test bed p 1066 A92-53492
Performance analysis of idealized scramjet p 1066 A92-53493
Flow measurements in scramjet inlets p 1102 A92-53565
CHISHOLM, JOHN D.
In-flight optimization of the total propulsion system
[AIAA PAPER 92-3744] p 1068 A92-54146
CHOCKIE, ALAN
Effective maintenance practices to manage system aging p 1119 A92-56215
CHOKANI, NDAONA
Numerical modeling of transonic juncture flow
[AIAA PAPER 92-4036] p 1035 A92-56858
CHOPRA, INDERJIT
Dynamics of helicopters with dissimilar blades in forward flight p 1056 A92-56288
CHOY, FRED K.
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
CHRONOPOULOS, A. T.
Efficient iterative methods for the transonic small disturbance equation p 1025 A92-54933
CHRUSCIEL, G. T.
Approximate aerodynamic analysis of jet interaction
[AIAA PAPER 92-4640] p 1027 A92-55387
CICCOLI, M. C.
Efficient methods for inviscid non-equilibrium hypersonic flow fields p 1024 A92-54571

CINCOTTA, MANUAL
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131
CLARK, EDWARD L.
Calibration of hemispherical-head flow angularity probes
[AIAA PAPER 92-4005] p 1122 A92-56828
CLEMENTS, A.
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG
p 1050 N92-33356
CLYMER, JOHN R.
Discrete event fuzzy airport control
p 1046 A92-55973
COCKRELL, DAVID J.
Small two-dimensional surface excrescences on aircraft wings approaching separation p 1031 A92-56170
COHEN, DOROTHEA
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
COLE, STANLEY R.
Aeroelastic effects of spoiler surfaces on a low-aspect-ratio rectangular wing p 1030 A92-56154
COLE, T. C.
Degenerate four-wave mixing for measurement of NO2 and smoke concentration in jet engine exhaust
[AIAA PAPER 92-3658] p 1113 A92-54108
COLE, W. A.
Degenerate four-wave mixing for measurement of NO2 and smoke concentration in jet engine exhaust
[AIAA PAPER 92-3658] p 1113 A92-54108
COMBS, S. R.
Flight management system of the F-117A
p 1082 A92-55910
CONCILIO, A.
Active vibrations and noise control for turboprop application research program activities
p 1138 N92-32962
CONDIT, PHIL
777 - The airlines' higher-order technology airplane
p 1052 A92-55104
CONLEY, JOSEPH L.
User's manual for AeroFcn: A FORTRAN program to compute aerodynamic parameters
[NASA-TM-104237] p 1133 N92-32507
CONNELLY, JOHN DAVID
The dynamics of flexible multibody systems: A finite segment approach p 1128 N92-34036
CONSOLI, ROBERT D.
Application of advanced multidisciplinary analysis and optimization methods to vehicle design synthesis
p 1054 A92-56160
CONWAY, JOHN T.
Further development of the CANAERO computer code to include propulsor modelling
[DREA-CR-90-425] p 1038 N92-32811
COPPENBARGER, R. A.
Concepts for pilot interaction with an automated NOE obstacle-avoidance system
[AIAA PAPER 92-4472] p 1076 A92-55232
COREY, PHILIP D.
Discrete event fuzzy airport control
p 1046 A92-55973
CORSIGLIA, VICTOR R.
On the anomalies in single-jet hover suckdown data
[NASA-TM-102261] p 1038 N92-33306
Dynamic response of induced pressures, suckdown, and temperatures for two tandem jet STOVL configurations
[NASA-TM-103934] p 1039 N92-33581
On the estimation of jet-induced fountain lift and additional suckdown in hover for two-jet configurations
[NASA-TM-102268] p 1040 N92-33618
COTTER, GLADYS A.
An international aerospace information system: A cooperative opportunity
[NASA-TM-108171] p 1142 N92-33237
COULTON, DAVID G.
Recent developments in data acquisition and control systems at the Aircraft Research Association Limited
p 1091 A92-54323
COVINGTON, C. E.
V-22 propulsion system design p 1070 A92-56300
CRAMER, EVIN J.
The application of direct transcription to commercial aircraft trajectory optimization
[AIAA PAPER 92-4528] p 1077 A92-55246
CRAMER, S. G.
Supportability evaluation of thermoplastic and thermoset composites p 1108 N92-32576
CRASSIDIS, JOHN L.
Robust control design of an automatic carrier landing system
[AIAA PAPER 92-4619] p 1077 A92-55296
CRAVEY, ROBIN L.
Finite difference time domain grid generation from AMC helicopter models
[NASA-TM-107679] p 1128 N92-34017
CRAWFORD, CHARLES C., JR.
Damage tolerance analysis for rotorcraft - What the issues are p 1058 A92-56336
CRESPI, G.
Aluminium-lithium alloys - Application on helicopters
p 1106 A92-56326
CRICELLI, A. S.
A time-dependent tip loss formula for rotor blade dynamic analysis p 1057 A92-56310
CRIVELLI VISCONTI, I.
Structural design and testing results of composite landing gear components p 1057 A92-56328
CRUZ, CHRISTOPHER I.
Predicted aerodynamic characteristics for HL-20 lifting-body using the aerodynamic preliminary analysis system (APAS)
[AIAA PAPER 92-3941] p 1033 A92-56771
CUNNINGHAM, ATLEE M., JR.
Understanding and development of a prediction method of transonic limit cycle oscillation characteristics of fighter aircraft
[AIAA PAPER 92-4501] p 1026 A92-55369
CURLETT, BRIAN P.
A graphical user-interface for propulsion system analysis
[NASA-TM-105696] p 1134 N92-33894
CURLISS, D. B.
Fluid effects: Thermoset and thermoplastic matrix composites p 1110 N92-33049
CURRAN, EDWARD T.
Further studies of kinetic energy methods in high speed ramjet cycle analysis
[AIAA PAPER 92-3805] p 1069 A92-54177
CURRIER, JEFFREY M.
Analysis of the onset of dynamic stall
p 1024 A92-54919
CURTISS, H. C.
A simulation study of tiltrotor vertical takeoff procedures using conventional and variable diameter rotor systems
p 1056 A92-56301
CURTISS, H. C., JR.
On the calculation of the response of helicopters to control inputs
[NASA-CR-190812] p 1088 N92-33536
CURTISS, HOWARD C., JR.
Approximations for inclusion of rotor lag dynamics in helicopter flight dynamics models p 1060 A92-56354

D

D'AZZO, J. J.
Automatic formation flight control
[AIAA PAPER 92-4473] p 1076 A92-55233
DALLEMAGNE, P. C.
Comparison between computational and experimental data for a hypersonic laser propelled vehicle
[AIAA PAPER 92-3808] p 1023 A92-54179
DALPIAZ, G.
Monitoring fatigue cracks in gears
p 1116 A92-54496
DALY, P.
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
DANBERG, JAMES E.
Analysis of the flight performance of the 155 mm M864 base burn projectile
[BRL-TR-3083] p 1041 N92-33699
DANIELS, W. A.
Turbine disk cavity aerodynamics and heat transfer
p 1124 N92-32265
DANSBERRY, BRYAN E.
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter
[NASA-TM-104211] p 1042 N92-34147
DARDEN, CHRISTINE M.
High-Speed Research: Sonic Boom, volume 1
[NASA-CP-3172] p 1061 N92-33874
DARDIS, WILLIAM J.
An acceptance process for the evaluation of inlet distortion
[AIAA PAPER 92-3918] p 1032 A92-56750
DARGAN, J. L.
Automatic formation flight control
[AIAA PAPER 92-4473] p 1076 A92-55233
DAVIS, D. D., JR.
Detailed analysis and test correlation of a stiffened composite wing panel p 1121 A92-56324
DAVIS, S.
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301
[AD-A252912] p 1126 N92-33501
DEANGELIS, V. MICHAEL
Thermal-structural test facilities at NASA Dryden
[NASA-TM-104249] p 1062 N92-34202
DEATON, JERRY W.
Residual strength of repaired graphite/epoxy laminates after 5 years of outdoor exposure p 1108 N92-32577
DEBONIS, JAMES R.
Full Navier-Stokes analysis of a two-dimensional mixer/ejector nozzle for noise suppression
[AIAA PAPER 92-3570] p 1067 A92-54059
DEDIEU, J. P.
AS 332 MKII - Development and certification
p 1059 A92-56343
DEICH, M. E.
Pulsation characteristics of one-phase and two-phase steam flows in Laval nozzles under off-design conditions
p 1019 A92-53882
DEJARNETTE, FRED R.
Boundary layer study on nozzle wall at hypersonic velocities
[AIAA PAPER 92-4013] p 1034 A92-56836
DEL ROSARIO, RUBEN
Advanced nozzle and engine components test facility
[AIAA PAPER 92-3993] p 1099 A92-56816
DEL ROSO, RICHARD L.
Advanced nozzle and engine components test facility
[AIAA PAPER 92-3993] p 1099 A92-56816
DELEEUW, J. H.
An evaluation of decelerating IFR approaches utilizing a helicopter flight simulator
[CTN-92-60348] p 1048 N92-32845
DELERY, JEAN
Experimental investigation of the reflection of a shock wave on a heated surface in presence of a turbulent boundary layer p 1023 A92-54569
DELERY, JEAN M.
Physics of vortical flows p 1031 A92-56166
DELUCIA, R. A.
Statistics on aircraft gas turbine engine rotor failures that occurred in US commercial aviation during 1988
[DOT/FAA/CT-91/28] p 1071 N92-33105
DELUISI, JOHN J.
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
DENBRAVEN, WIM
Design and evaluation of an advanced air-ground data-link system for air traffic control
[NASA-TM-103899] p 1050 N92-33407
DESAUTEL, D.
Development and integration of modern laboratories in aerospace education
[AIAA PAPER 92-4022] p 1141 A92-56844
DESIDERI, J. A.
Efficient methods for inviscid non-equilibrium hypersonic flow fields p 1024 A92-54571
DEUR, J. M.
Applied analytical combustion/emissions research at the NASA Lewis Research Center - A progress report
[AIAA PAPER 92-3338] p 1067 A92-54025
DEVILBISS, DAVID W.
Preliminary results from the White Sands Missile Range sonic boom propagation experiment
p 1140 N92-33884
DEXTER, H. B.
New materials drive high-performance aircraft
p 1105 A92-55134
DEXTER, H. BENSON
Flight service environmental effects on composite materials and structures p 1110 N92-33054
DICICCO, L. D.
Description of a pressure measurement technique for obtaining surface static pressures of a radial turbine
[AIAA PAPER 92-4006] p 1123 A92-56829
DIDONE, M.
A module-level testing environment for safety-critical software systems p 1132 A92-56293
DIETL, LOTHAR
Test and integration concept for complex helicopter avionic systems p 1064 A92-56292
DIGIROLAMO, R.
Flight control law synthesis using neural network theory
[AIAA PAPER 92-4390] p 1074 A92-55191
DIMICCO, R. G.
A new look at surface flow visualization to provide insight into complex fluid dynamic behavior
p 1090 A92-54307
DIRLIK, S. P.
Experimental evaluation of a 50-percent thick airfoil with blowing and suction boundary layer control
[AIAA PAPER 92-4500] p 1026 A92-55368

DISARIO, R.
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
DISIMILE, P. J.
A new look at surface flow visualization to provide insight into complex fluid dynamic behavior
p 1090 A92-54307
DIXON, CHARLES J.
Development of a high-angle-of-attack stability and control prediction code
[AIAA PAPER 92-4354] p 1079 A92-55340
DOBYNS, ALAN
Turning up the heat on aircraft structures
p 1052 A92-55131
DODD, ROBERT S.
A review and discussion of flight management system incidents reported to the aviation safety reporting system
[AD-A252438] p 1043 N92-32941
DOLLING, D. S.
An experimental examination of the effects of incoming boundary layer modifications on the dynamics of a turbulent compression corner interaction
[AIAA PAPER 92-3667] p 1022 A92-54111
DONAHUE, D. J.
Development of the full-envelope Performance Seeking Control algorithm
[AIAA PAPER 92-3748] p 1068 A92-54148
DONZELLI, G.
Aluminium-lithium alloys - Application on helicopters
p 1106 A92-56326
DORATO, P.
Applications of robust control theory - Educational implications
[AIAA PAPER 92-4559] p 1131 A92-55271
DORMAN, J. I.
Flight simulation modeling in support of engine/airframe integration p 1055 A92-56279
DORNHEIM, MICHAEL A.
Japan pushes high speed research
p 1015 A92-53434
Instrumentation key to NASP combustor tests
p 1092 A92-55100
DOWELL, E. H.
Flutter and stall response of a helicopter blade with structural nonlinearity p 1055 A92-56178
DOWNING, J. MICAH
Lateral spread of sonic boom measurements from US Air Force boomfile flight tests p 1140 N92-33883
DREHER, G.
Stability failure of sandwich structures
[MBB-UD-0613-92-PUB] p 1111 N92-33994
DRUMMOND, COLIN K.
Preliminary dynamic tests of a flight-type ejector
[AIAA PAPER 92-3261] p 1066 A92-54020
DRUMMOND, J. P.
An assumed joint-Beta PDF approach for supersonic turbulent combustion
[AIAA PAPER 92-3844] p 1113 A92-54199
DUDLEY, MICHAEL R.
Potential flow theory and operation guide for the panel code PMARC
[NASA-TM-102851] p 1036 N92-32422
DUGAN, JOANNE B.
Modular techniques for dynamic fault-tree analysis
p 1120 A92-56241
HiRel - Reliability/availability integrated workstation tool p 1120 A92-56257
DUPRIEZ, F.
Flutter models: Their design, manufacture, and ground testing p 1089 N92-34164
DURHAM, MICHAEL H.
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter
[NASA-TM-104211] p 1042 N92-34147
DURHAM, WAYNE C.
Constrained control allocation
[AIAA PAPER 92-4550] p 1131 A92-55262
Nonlinear model-following control application to airplane control (1992 AIAA Controls Design Challenge)
[AIAA PAPER 92-4625] p 1077 A92-55302

E

EAGLE, KENNETH H.
Redundancy design philosophy for catastrophic loss protection p 1119 A92-56202
EARLS, MICHAEL
Experience with Ada on the F-18 High Alpha Research Vehicle Flight Test Program
[NASA-TM-104259] p 1062 N92-34039
EATON, R. A.
The impact of air transport on the environment
[PNR-90876] p 1129 N92-33751
EBERHARDT, SCOTT
Optimization of a 2D scramjet-vehicle using CFD and simplified approximate flow analysis techniques
[AIAA PAPER 92-3673] p 1022 A92-54116
ECHIN, A. I.
Viscosity characteristics of synthetic aviation oils at low temperatures p 1105 A92-53875
EDINGTON, LARRY
PAYCOS, a multidisciplinary sizing code for hypersonic vehicles
[AIAA PAPER 92-4564] p 1132 A92-55376
EDWARDS, R. W.
An approach for increasing aeroelastic divergence dynamic pressure of wind-tunnel models
[AIAA PAPER 92-4002] p 1099 A92-56825
EDWARDS, THOMAS A.
Application of computational fluid dynamics to sonic boom near- and mid-field prediction
p 1031 A92-56173
EGUCHI, KUNIHISA
Key design considerations for scramjet powered space plane p 1066 A92-53491
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
EHRENFRIED, K.
Sound produced by vortex-airfoil interaction
p 1136 A92-56345
EIBERT, MAX
Laser-radar based obstacle avoidance system for helicopters p 1064 A92-56295
EICH, T.
Particle image velocimetry measurements of the aerodynamics of a wind turbine p 1115 A92-54337
EICK, C. D.
Experimental modeling of film-cooled axial turbine tip seals
[AIAA PAPER 92-4058] p 1119 A92-56141
EISLER, G. R.
A guidance law for hypersonic descent to a point
[AIAA PAPER 92-4303] p 1104 A92-55311
EITELBERG, G.
The high enthalpy shock tunnel in Goettingen
[AIAA PAPER 92-3942] p 1104 A92-56772
ELALDI, F.
Processing and environmental effects on mechanical properties of composite repairs
[NRC-LTR-ST-1826] p 1109 N92-32791
ELDER, R. L.
Radial inflow turbine study
[AD-A252783] p 1127 N92-33538
ELDREDGE, DONALD
A review and discussion of flight management system incidents reported to the aviation safety reporting system
[AD-A252438] p 1043 N92-32941
ELIZAROV, A. M.
Aerodynamic airfoils design by quasi-solutions method of inverse boundary-value problems
p 1020 A92-53998
ELLIOTT, J. K.
Computational and experimental studies of flow in multi-lobed forced mixers
[AIAA PAPER 92-3568] p 1112 A92-54057
ELLIOTT, JOE W.
Comparison of frequency domain and time domain laser velocimeter signal processors p 1114 A92-54314
ELLIOTT, S. J.
Active control of sound transmission through stiff lightweight composite fuselage constructions
p 1137 N92-32957
ELSENAAR, A.
An experimental study of the flow over a sharp-edged delta wing at subsonic and transonic speeds
[NLR-TP-91117-U] p 1037 N92-32732
EMBORG, URBAN
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
ENDE, H.
Millisecond aerodynamic force measurement with side-jet model in the ISL shock tunnel
[AIAA PAPER 92-3963] p 1097 A92-56790
ENGLER, R. H.
Aerodynamic assessment of an optical pressure measurement system (OPMS) by comparison with conventional pressure measurements in a high speed wind tunnel p 1114 A92-54304
ENYA, SHINTARO
Fundamental studies on Marangoni convection related to Bridgman crystal growth p 1111 A92-53758
EPSTEIN, A. H.
Active control of compressor surge and stall
[AD-A252771] p 1126 N92-33498
ERCOLINE, WILLIAM R.
The utility of analog vertical velocity information during instrument flight with a Head-Up Display (HUD)
[AD-A252863] p 1065 N92-33277
ERKELENS, L. J. J.
Development of new flight procedures for the Microwave Landing System (MLS)
[NLR-TP-91156-U] p 1047 N92-32830
ERVIN, CAY A.
Improving reliability and maintainability through process management p 1141 A92-56212
ERWIN, D. A.
A code validation strategy and facility for nonequilibrium, reacting flows
[AIAA PAPER 92-3970] p 1098 A92-56796
ERWIN, DANIEL
Experimental unsteady pressures on an oscillating cascade with supersonic leading edge locus
[AIAA PAPER 92-4035] p 1035 A92-56857
ERZBERGER, HEINZ
CTAS: Computer intelligence for air traffic control in the terminal area
[NASA-TM-103959] p 1044 N92-33080
Analysis of delay reducing and fuel saving sequencing and spacing algorithms for arrival traffic
[NASA-TM-103880] p 1044 N92-33194
ESCHBAUMER, HERMANN
Repair procedures for advanced composites for helicopters p 1016 A92-56277
ESFAHANIAN, VAHID
Computation and stability analysis of laminar flow over a blunt cone in hypersonic flow p 1041 N92-33839
ESKER, BARBARA S.
Experimental performance of three design factors for ventral nozzles for SSTOVL aircraft
[AIAA PAPER 92-3789] p 1069 A92-54168
Internal reversing flow in a tailpipe offtake configuration for SSTOVL aircraft
[AIAA PAPER 92-3790] p 1069 A92-54169
ESTRADA ALVES, CARLOS F.
Some thermodynamical aspects in the optimization of *supersonic combustors* p 1065 A92-53486
The behaviour of the pressure temperature and density in an inviscid unsteady transonic axisymmetric flow with shock waves p 1018 A92-53553
EVANS, RICHARD H.
The utility of analog vertical velocity information during instrument flight with a Head-Up Display (HUD)
[AD-A252863] p 1065 N92-33277
EVERHART, JOEL L.
Test description and preliminary pitot-pressure surveys for Langley Test Technique Demonstrator at Mach 6
[AIAA PAPER 92-3940] p 1096 A92-56770
EWALD, B.
The cryogenic balance design and balance calibration methods
[AIAA PAPER 92-4001] p 1122 A92-56824
EXLEY, J. T.
Mixed flow compressor surge margin gain using a manifolded diffuser system
[AIAA PAPER 92-3753] p 1068 A92-54151

F

FAN, S.
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
FANG, K. C.
Tow-tank study of *nonlinear aerodynamics of a 2-D* airfoil
[AIAA PAPER 92-4499] p 1026 A92-55367
FAWCETT, P. A.
A multi-diagnostic approach to testing V/STOL craft
[AIAA PAPER 92-4008] p 1099 A92-56831
FEESS, W. A.
Evaluation of GPS/UTC steering performance
p 1049 N92-33353
FEFERMAN, BEN
Inspection of fabricated fuselage panels using electronic shearography
[DOT/FAA/CT-TN92/26] p 1127 N92-33627
FENTON, B. C.
Statistics on aircraft gas turbine engine rotor failures that occurred in US commercial aviation during 1988
[DOT/FAA/CT-91/28] p 1071 N92-33105
FEZOUI, L.
Efficient methods for inviscid non-equilibrium hypersonic flow fields p 1024 A92-54571
FINELLI, GEORGE B.
Analysis of data from a DO-178A software development process p 1134 N92-32880
FISCHER, W.-G.
Design and development of test rigs for main rotor and main rotor transmission of a helicopter in the 6-ton-class
p 1093 A92-56280

FISHER, C. J.
Flow contamination and flow quality in arc heaters used for hypersonic testing
[AIAA PAPER 92-4028] p 1100 A92-56850
FLANDRO, G. A.
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
FLEISCHMANN, A.
AS 332 MKII - Development and certification
p 1059 A92-56343
FOLEY, S. M.
A multi-diagnostic approach to testing V/STOL craft
[AIAA PAPER 92-4008] p 1099 A92-56831
FONT, G. I.
Force production mechanisms of a tangential jet on bodies at high alpha
[AIAA PAPER 92-4648] p 1082 A92-55393
FORKEY, J.
Rayleigh imaging and flow tagging in ground test facilities p 1115 A92-54330
FOSTER, STEPHEN P.
Ideal efficiency of propellers based on Theodorsen's theory: A review and computer study, with extended plus simplified charts
[UTIAS-TN-271] p 1071 N92-33102
FRANK, ROBERT S.
High-speed cinematography of supersonic mixing layers
[AIAA PAPER 92-3545] p 1112 A92-54044
FRANKLIN, J. A.
Collaborative research on V/STOL control system/cockpit display tradeoffs under the NASA/MOD joint aeronautical program
[NASA-TM-103910] p 1087 N92-32788
FRENCH, MARK
Demonstration of structural optimization applied to wind-tunnel model design p 1119 A92-56181
FRIDMAN, A. G.
High-temperature metal matrix composite
p 1105 A92-53878
FRIEDMANN, P. P.
Coupled rotor-fuselage vibration reduction with multiple frequency blade pitch control p 1085 A92-56315
FRIEDRICH, H.-E.
Examples of advanced near-net shape manufacturing techniques for aerospace
[MBB-Z-0399-91-PUB] p 1125 N92-32742
FRIEDRICHS, R.
Automatic control of test parameters for intake measurements in a low-speed wind tunnel
p 1091 A92-54341
FUJIEDA, HIROTOSHI
A low speed wind tunnel investigation of a joined-wing aircraft with an overhanging fin p 1030 A92-56078
A low speed wind tunnel investigation of the direct side force control of a joined-wing aircraft with overhanging fin p 1084 A92-56079
FUJII, KENJI
Synthesis of gust load alleviation with flutter margin augmentation p 1082 A92-56021
Generalized aerodynamics analysis by the boundary element method p 1030 A92-56050
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
FUJIMOTO, AKIRA
Wind tunnel test of M = 2.5 mixed compression inlet
p 1028 A92-56008
FUJIMOTO, T.
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729
FUJITA, MITSUHIRO
An experimental program concerning a satellite data link for oceanic ATC p 1046 A92-56093
FUJITA, TOSHIMI
A low speed wind tunnel investigation of a joined-wing aircraft with an overhanging fin p 1030 A92-56078
A low speed wind tunnel investigation of the direct side force control of a joined-wing aircraft with overhanging fin p 1084 A92-56079
FUJITSUNA, Y.
A conceptual study for future engine test facility
[AIAA PAPER 92-3992] p 1099 A92-56815
FUJIWARA, GENKICHI
Fatigue cracking threshold prediction of transport airplanes p 1118 A92-56094
FUJIWARA, KENJI
Scramjet engine and its flying test bed
p 1066 A92-53492
FUJIWARA, TOSHI
Detailed numerical analysis of standing oblique detonation p 1111 A92-53550
Radiative heat transfer from nonequilibrium shock layer to a hypersonic reentry body p 1019 A92-53579
Thermally and chemically nonequilibrium hypersonic flow in three-dimensional geometry
p 1019 A92-53580
Three-dimensional calculation of radiative field in hypersonic air shock layers p 1023 A92-54498
FUJIWARA, TSUTOMU
Key design considerations for scramjet powered space plane p 1066 A92-53491
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
FUKUSHIMA, SOUNOSUKE
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS
p 1047 A92-56118
FULTON, KEN
CIS engines - The range revealed. II
p 1069 A92-54546
FUNABIKI, KATSUSHI
Effect of streamwise pressure gradient on the supersonic mixing layer p 1025 A92-54936
FUNABIKI, KOHEI
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
FUNG, K.-Y.
Analysis of the onset of dynamic stall
p 1024 A92-54919
FUNK, R. B.
A multi-diagnostic approach to testing V/STOL craft
[AIAA PAPER 92-4008] p 1099 A92-56831
FUSARO, ROBERT L.
Liquid lubricants for advanced aircraft engines
[NASA-TM-104531] p 1109 N92-32863

G

GAITONDE, DATTA
An examination of several high resolution schemes applied to complex problems in high speed flows
[AD-A250814] p 1124 N92-32632
GALBRAITH, R. A. MCD.
Measurements of the dynamic stall vortex convection speed p 1032 A92-56351
GALLOPS, G. W.
In-flight performance diagnostic capability of an adaptive engine model
[AIAA PAPER 92-3746] p 1068 A92-54147
Performance benefits of adaptive in-flight propulsion system optimization
[AIAA PAPER 92-3749] p 1068 A92-54149
GALLOTTI, ALBERTO
Time Resolved Lidar Fluorosensor operating from helicopter p 1121 A92-56296
GANN, R. G.
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301
[AD-A252912] p 1126 N92-33501
GAONKAR, GOPAL H.
Computational aspects of helicopter trim analysis and damping levels from Floquet theory
[NASA-CR-190736] p 1087 N92-33107
GARBER, DONALD P.
Advanced subsonic transport approach noise: The relative contribution of airframe noise
[NASA-TM-104112] p 1140 N92-34148
GARDNER, JUDITH A.
Discrete event fuzzy airport control
p 1046 A92-55973
GARG, SANJAY
Propulsion system performance resulting from an Integrated Flight/Propulsion Control design
[AIAA PAPER 92-4602] p 1069 A92-55281
GARRARD, WILLIAM L.
Robust dynamic inversion control laws for aircraft control
[AIAA PAPER 92-4329] p 1073 A92-55173
Robustness of a helicopter flight control system designed using eigenstructure assignment
[AIAA PAPER 92-4469] p 1076 A92-55229
GARRIS, C. A.
Flow induction by pressure forces
[AIAA PAPER 92-3571] p 1067 A92-54060
GARRISON, T. J.
Structure of crossing-shock wave/turbulent boundary-layer interactions
[AIAA PAPER 92-3670] p 1022 A92-54113
GARRONE, ANGELO
An overview of the planned aerospace test facilities at Capua, Italy
[AIAA PAPER 92-3944] p 1097 A92-56773
GARTENBERG, EHUD
Problems and solutions for transition detection in cryogenic wind tunnels by infrared imaging
p 1090 A92-54319
GARVEY, DENNIS M.
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
GARZON, SHERRY B.
Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, part 1
[NASA-CP-3087-PT-1] p 1106 N92-32513
GASPERAS, GEDIMINIS
High speed transition prediction
[NASA-CR-190836] p 1039 N92-33424
GATES, THOMAS S.
Isothermal aging of IM7/8320 and IM7/5260
[NASA-TM-107666] p 1110 N92-33423
GATLIN, DONALD
The F-18 high alpha research vehicle: A high-angle-of-attack testbed aircraft
[NASA-TM-104253] p 1060 N92-33404
GAUTHIER, BENOIT
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131
GAZZANIGA, JOHN A.
Wind tunnel performance results of swirl recovery vanes as tested with an advanced high speed propeller
[AIAA PAPER 92-3770] p 1068 A92-54159
GEORGE, A.
Millisecond aerodynamic force measurement with side-jet model in the ISL shock tunnel
[AIAA PAPER 92-3963] p 1097 A92-56790
GHAZI, MUHAMMAD A.
Effect of atmospheric disturbances on airplane response
[AIAA PAPER 92-4340] p 1078 A92-55329
GHOSH, AJOY K.
Parameter estimation of an augmented airplane with unsteady aerodynamics modelling p 1073 A92-53546
GIBB, JAMES
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[AIAA PAPER 92-3177] p 1020 A92-54013
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[NASA-TM-105672] p 1128 N92-34112
GIEL, P. W.
Three-dimensional Navier-Stokes heat transfer predictions for turbine blade rows
[AIAA PAPER 92-3068] p 1020 A92-54003
GILLARD, WILLIAM J.
High angle-of-attack control enhancement on a forward swept wing aircraft
[AIAA PAPER 92-4427] p 1080 A92-55351
GILLETTE, D.
Continuous flying quality improvement - The measure and the payoff
[AIAA PAPER 92-4327] p 1073 A92-55171
GIONFRIDDO, THOMAS A.
Analysis of sonic boom data to quantify distortions of shock profiles p 1139 N92-33879
GLEASON, DANIEL
Flight test results using a low order equivalent systems technique to estimate flying qualities
[AIAA PAPER 92-4425] p 1080 A92-55349
GLESK, I.
Rayleigh imaging and flow tagging in ground test facilities p 1115 A92-54330
GODDARD, K.
Re-engining for real stage 3 compliance
[PNR-90872] p 1072 N92-33748
GOELZENLEUCHTER, HORST
Test and integration concept for complex helicopter avionic systems p 1064 A92-56292
GOERANSSON, PETER
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
GOGINENI, SIVARAM
Experimental observations of instability modes in a rectangular jet p 1135 A92-54908
GOLDTHORPE, S.
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
GOLIA, C.
Stokes flows in superposed immiscible liquids with horizontal heating
[IAF PAPER 92-0909] p 1123 A92-57288
GOLOVIZNIN, V. P.
Interaction between a body flying at a supersonic velocity and a point explosion p 1019 A92-53867
GOLOVKINA, T. E.
High-temperature metal matrix composite
p 1105 A92-53878

GOMAN, M.
Stochastic self-induced roll oscillations of slender delta wing at high angles of attack
[AIAA PAPER 92-4498] p 1081 A92-55366
State-space representation of aerodynamic characteristics of an aircraft at high angels of attack
[AIAA PAPER 92-4651] p 1028 A92-55395
GOODALL, COLIN
Bird ingestion into large turbofan engines
[DOT/FAA/CT-91/17] p 1043 N92-33005
GOODSELL, AGA M.
Euler/experiment correlation of a generic fighter
p 1031 A92-56164
GOTO, NORIHIRO
An identification procedure for a system with a choice of feedback structures p 1132 A92-55426
GRAEWE, E.
The cryogenic balance design and balance calibration methods
[AIAA PAPER 92-4001] p 1122 A92-56824
GRAHAM, G. M.
Tow-tank study of nonlinear aerodynamics of a 2-D airfoil
[AIAA PAPER 92-4499] p 1026 A92-55367
GRAHAM, ROBERT G.
Implementation of a personal computer based parameter estimation program
[AD-A252914] p 1061 N92-33502
GRANT, I.
Particle image velocimetry measurements of the aerodynamics of a wind turbine p 1115 A92-54337
GRANT, TED
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480
GREEN, INGE S.
Vibro-acoustic FE analyses of the Saab 2000 aircraft
p 1137 N92-32952
GREEN, R. B.
Measurements of the dynamic stall vortex convection speed p 1032 A92-56351
GREEN, STUART
Aspects of compression in aerospace composites: Future requirements p 1109 N92-33036
GREENWOOD, STUART W.
The application of imaging sensors to aircraft landings in adverse weather p 1045 A92-54902
GREGOREK, G. M.
Experimental unsteady pressures on an oscillating cascade with supersonic leading edge locus
[AIAA PAPER 92-4035] p 1035 A92-56857
GREITZER, E. M.
Computational and experimental studies of flow in multi-lobed forced mixers
[AIAA PAPER 92-3568] p 1112 A92-54057
Active control of compressor surge and stall
[AD-A252771] p 1126 N92-33498
GRELLA, RAY
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program
[AD-A247886] p 1108 N92-32629
GRIFFIN, O. HAYDEN, JR.
Global/local methods research using the CSM testbed
p 1107 N92-32528
GRIFFITH, WAYLAND C.
A fine-wire thermocouple probe for measurement of stagnation temperatures in real gas hypersonic flows of nitrogen p 1114 A92-54317
Boundary layer study on nozzle wall at hypersonic velocities
[AIAA PAPER 92-4013] p 1034 A92-56836
GRONSKI, ROBERT S.
Small engine components test facility compressor testing cell at NASA Lewis Research Center
[AIAA PAPER 92-3980] p 1098 A92-56806
GROSS, K.
Integrated Russian VLF/Omega receiver design
[PB92-193390] p 1051 N92-33809
GRUDLER, P.
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG
p 1050 N92-33356
GRUNNET, J. L.
A model study on diffuser pressure recovery in NAL *scramjet test facility with simulated hydrogen* combustion
[AIAA PAPER 92-3979] p 1071 A92-56805
GUBAREV, B. A.
Design method of a helicopter cockpit
p 1058 A92-56337
GUEZ, ALLON
On-line identification and control of linearized aircraft dynamics p 1082 A92-55911
GUGLIELMO, JAMES J.
High-speed cinematography of supersonic mixing layers
[AIAA PAPER 92-3545] p 1112 A92-54044
GUNDY-BURLET, KAREN L.
Computations of unsteady multistage compressor flows in a workstation environment
[NASA-TM-103839] p 1071 N92-32452
GUNN, JAMES A.
Performance evaluation of a transonic wind tunnel compressor
[AIAA PAPER 92-3927] p 1096 A92-56758
GURUSWAMY, GURU P.
Vortical flow computations on a flexible blended wing-body configuration p 1024 A92-54922
Navier-Stokes computations for oscillating control surfaces
[AIAA PAPER 92-4431] p 1026 A92-55355
Unsteady shock-vortex interaction on a flexible delta wing p 1030 A92-56157
GUTMARK, E.
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
GUYTON, ROBERT W.
High angle-of-attack control enhancement on a forward swept wing aircraft
[AIAA PAPER 92-4427] p 1080 A92-55351

H

HACKETT, CHARLES M.
Computational and numerical analysis of hypersonic nozzle flows with comparisons to wind tunnel calibration *data*
[AIAA PAPER 92-4011] p 1033 A92-56834
HACKSTEIN, H. JOSEF
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951
HAFTKA, RAPHAEL T.
Initial postbuckling response of an unsymmetrically laminated rectangular plate p 1108 N92-32586
HAGA, KAZUO
Study of potassium turbine electric generator system
p 1129 N92-33794
HAH, C.
Navier-Stokes analysis of three-dimensional unsteady flows inside turbine stages
[AIAA PAPER 92-3211] p 1021 A92-54016
A critical evaluation of a three-dimensional Navier-Stokes CFD as a tool to design supersonic turbine stages p 1124 N92-32268
HAHN, K.-U.
ATTAS flight test and simulation results of the advanced gust management system LARS
[AIAA PAPER 92-4343] p 1079 A92-55332
HAJ, ANWAR MOHAMMED
Dynamics and control of a five degree-of-freedom magnetic suspension system
[NASA-CR-191259] p 1102 N92-34222
HALSMER, ROBERT A.
Smoothing CFM56 engine removal rate at USAir
[AIAA PAPER 92-3928] p 1070 A92-56759
HAM, NORMAN D.
Research on measurement and control of helicopter rotor response using blade-mounted accelerometers 1990-91 p 1057 A92-56316
HAMAI, SHOHEI
Titanium alloy casting for aerospace
p 1106 A92-56103
HAMID, S.
Radial inflow turbine study
[AD-A252783] p 1127 N92-33538
HAMMERTON, P. W.
Leading-edge receptivity for blunt-nose bodies
[NASA-CR-190563] p 1036 N92-32648
HANAGUD, S.
Smart structures in the active control of blade vortex interaction p 1085 A92-56314
HANATANI, K.
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
HANAWA, KIRK
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729
HANSMAN, JOHN
A data fusion algorithm for multi-sensor microburst hazard assessment
[AIAA PAPER 92-4339] p 1063 A92-55328
HANSON, W.
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG
p 1050 N92-33356
HARADA, K.
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
HARADA, WASASHI
Optimal design of wing shape by use of *neural-network* p 1054 A92-56112
HARDING, J. W.
Flight simulation modeling in support of engine/airframe integration p 1055 A92-56279
HARIGAE, MASATOSHI
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS
p 1047 A92-56118
HARLOFF, GARY J.
Navier-Stokes analysis and experimental data comparison of compressible flow in a diffusing S-duct
[NASA-TM-105683] p 1072 N92-33746
HARRIS, J. S.
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301
[AD-A252912] p 1126 N92-33501
HARRIS, R. H.
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301
[AD-A252912] p 1126 N92-33501
HARRISON, J. M.
Flight simulation modeling in support of engine/airframe integration p 1055 A92-56279
HARTMANN, K.
Aerodynamic assessment of an optical pressure measurement system (OPMS) by comparison with conventional pressure measurements in a high speed wind *tunnel* p 1114 A92-54304
HARVEY, GILES
The Rolls-Royce Trent
[PNR-90875] p 1061 N92-33750
HASEGAWA, TAKAHISA
Application of automation for structural-composites production p 1119 A92-56109
HASEGAWA, YASUMICHI
A calculation method to predict helicopter noise and its verification p 1135 A92-56074
HASHIDA, YOSHIKAZU
Space plane navigation simulation
p 1103 A92-53603
HASHIDATE, MASATAKA
Low-speed wind tunnel testing for the high-speed propeller at high shaft angle of attack
p 1030 A92-56054
HASHIDATE, N.
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055
HASSAN, H. A.
An assumed joint-Beta PDF approach for supersonic turbulent combustion
[AIAA PAPER 92-3844] p 1113 A92-54199
HAUCK, HELMUTH
The German Hypersonics Technology Programme - Status report 1992
[IAF PAPER 92-0867] p 1105 A92-57258
HAVENER, GEORGE
Holographic and PLIF measurements of free-flight hypervelocity flows in the AEDC Range G facility
[AIAA PAPER 92-3935] p 1122 A92-56765
HAWKSHAW, JOHN K.
Fire bombing and fire bombers
[CA-PATENT-1-268-164] p 1061 N92-33582
HAY, J.
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
HAYAKAWA, K.
A model study on diffuser pressure recovery in NAL scramjet test facility with simulated hydrogen combustion
[AIAA PAPER 92-3979] p 1071 A92-56805
HAYASHI, H.
Working together in the development of the B777
p 1015 A92-56080
HAYASHI, MASANORI
Experimental investigation on turbulent phenomena in three-dimensional shock wave/turbulent boundary layer interaction induced by blunt fin p 1018 A92-53557
HAYASHI, Y.
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test
p 1093 A92-56114
HAYASHI,KOICHI
Numerical study on the secondary jet into a supersonic flow p 1018 A92-53556
HAYHURST, KELLY J.
Analysis of data from a DO-178A software development process p 1134 N92-32880

HE, JIA J.
The research of reducing 3-D low supersonic shock wave reflection in a 2-D transonic flexible walls adaptive wind tunnel
[AIAA PAPER 92-3924] p 1095 A92-56755
HECHT, Y.
Response of helicopter blades to a sharp collective increase p 1084 A92-56282
HEDDERGOTT, A.
Application of a wall pressure method in a wind tunnel test section with adjustable longitudinal slots p 1091 A92-54336
HEFFNER, MICHAEL
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063
HEGEN, G. H.
Application of electronically scanned pressure measurement system for engine simulation tests in the German-Dutch Wind Tunnel
[AIAA PAPER 92-4003] p 1122 A92-56826
HEIMERDINGER, M. W.
Supportability evaluation of thermoplastic and thermoset composites p 1108 N92-32576
HEISER, W.
Investigation of a plate-ramp-configuration by means of laser Doppler anemometry at Mach 2.95
[AIAA PAPER 92-3956] p 1097 A92-56784
The trisonic wind tunnel Muenchen and its involvement in the German SAeNGER-programme
[AIAA PAPER 92-4019] p 1100 A92-56841
HEISER, WILLIAM H.
Improvements in teaching aircraft engine design
[AIAA PAPER 92-3758] p 1141 A92-54152
HENDRICKS, G.
Active control of compressor surge and stall
[AD-A252771] p 1126 N92-33498
HENDRICKS, R. C.
A finite-volume numerical method to calculate fluid forces and rotordynamic coefficients in seals
[AIAA PAPER 92-3712] p 1113 A92-54132
HENFLING, JOHN F.
Calibration of hemispherical-head flow angularity probes
[AIAA PAPER 92-4005] p 1122 A92-56828
HERGERT, DENNIS W.
Buffet test in the National Transonic Facility
[AIAA PAPER 92-4032] p 1100 A92-56854
HERMANSON, J. C.
Structure and penetration of a transverse fluid jet injected at supercritical pressure in supersonic flow
[AIAA PAPER 92-3652] p 1113 A92-54105
HERON, K. H.
Path identification in structural acoustics p 1059 A92-56346
HERRING, FRED M.
Buffet test in the National Transonic Facility
[AIAA PAPER 92-4032] p 1100 A92-56854
HESS, R. A.
An framework for robust flight control design using constrained optimization
[AIAA PAPER 92-4603] p 1131 A92-55282
Flight simulator fidelity assessment in a rotorcraft lateral translation maneuver
[AIAA PAPER 92-4424] p 1092 A92-55348
HESS, RICHARD F.
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
HESS, RONALD W.
Advanced airframe structural materials: A primer and cost estimating methodology
[AD-A253371] p 1062 N92-34182
HETSKO, JEAN
Accomplishments under the Airport Improvement Program, FY 1991
[AD-A253046] p 1101 N92-33434
HILL, GARY C.
Improving designer productivity
[AIAA PAPER 92-1187] p 1130 A92-54285
HILLESHEIMER, M.
Optimization of two stage reusable space transportation systems with rocket and airbreathing propulsion concepts
[IAF PAPER 92-0863] p 1104 A92-57254
HINDEL, JAMES T.
Low energy ice protection for helicopters p 1059 A92-56348
HIRABAYASHI, N.
New 1.27-m leg of the National Aerospace Laboratory hypersonic wind tunnel p 1092 A92-56003
HIRAOKA, KATSUMI
Effect of streamwise pressure gradient on the supersonic mixing layer p 1025 A92-54936
HIRAOKA, KOICHI
Roles of wind tunnel tests and CFD analyses in the design of energy-efficient SST
[AIAA PAPER 92-3923] p 1133 A92-56754
HIRNER, TIMOTHY J.
Automated procedures for aircraft aeroservoelastic compensation
[AIAA PAPER 92-4606] p 1077 A92-55284
HIROSE, HIDEHIRO
Design and wind tunnel test of low-Reynolds-number airfoil p 1029 A92-56047
HIRSHMAN, S. P.
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
HOADLEY, SHERWOOD T.
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
HOCKADAY, STEPHEN
Human factors issues in the use of artificial intelligence in air traffic control. October 1990 Workshop
[NASA-CR-190925] p 1051 N92-34203
HODGE, JEFFREY S.
The Langley 15-inch Mach 6 High Temperature Tunnel
[AIAA PAPER 92-3938] p 1096 A92-56768
HODGKINSON, J.
Continuous flying quality improvement - The measure and the payoff
[AIAA PAPER 92-4327] p 1073 A92-55171
HOEIJMAKERS, H. W. M.
Modeling and numerical simulation of vortex flow in aerodynamics
[NLR-TP-91154-U] p 1037 N92-32673
An experimental study of the flow over a sharp-edged delta wing at subsonic and transonic speeds
[NLR-TP-91117-U] p 1037 N92-32732
HOFFLER, KEITH D.
Simulation model of a twin-tail, high performance airplane
[NASA-TM-107601] p 1088 N92-33537
HOFFMAN, KNUT
Pilots noise exposure during a Boeing 747-400 round trip: Ambient noise and acoustic-head recording and analysis of data p 1137 N92-32960
HOFFMANN, W.
Analysis of helicopter rotor-fuselage interference with time averaged pressure distribution p 1032 A92-56331
HOGAN, AUSTIN W.
Effects of the abrasiveness of test and training site soils on parachute life
[AD-A252389] p 1038 N92-32900
HOLDEN, M. S.
A database of aerothermal measurements in hypersonic flow for CFD validation
[AIAA PAPER 92-4023] p 1034 A92-56845
HOLL, DAVID
Parameter identification of AV-8B wingborne aerodynamics for flight simulator model updates
[AIAA PAPER 92-4506] p 1027 A92-55373
HOLLIS, BRIAN R.
A fine-wire thermocouple probe for measurement of stagnation temperatures in real gas hypersonic flows of nitrogen p 1114 A92-54317
HOLLY, L.
'A new proposal for an old problem' - The right engine for the right helicopter p 1070 A92-56281
HOLST, H.
Application of a wall pressure method in a wind tunnel test section with adjustable longitudinal slots p 1091 A92-54336
HOLTZ, H.
Evaluation of GPS/UTC steering performance p 1049 N92-33353
HONAMI, SHINJI
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
HONDA, TAKEKAZU
Development study on air turbo-ramjet engine for space plane p 1065 A92-53487
HOOMAN, HANS JUERGEN
Pilot noise exposure during a Boeing 747-400 round trip: Judgement of noise and analysis in respect to hearing impairment of pilots p 1138 N92-32961
HORN, D. D.
Flow contamination and flow quality in arc heaters used for hypersonic testing
[AIAA PAPER 92-4028] p 1100 A92-56850
HORNUNG, H. G.
The G-range impulse facility - A high-performance free-piston shock tunnel
[AIAA PAPER 92-3946] p 1097 A92-56774
HORNUNG, HANS G.
Performance data of the new free-piston shock tunnel at GALCIT
[AIAA PAPER 92-3943] p 1033 A92-56776
HORSTMAN, C. C.
Heat transfer measurements and CFD comparison of swept shock wave/boundary-layer interactions
[AIAA PAPER 92-3665] p 1021 A92-54110
HOSINO, HIDEO
On the effect of canards on NAL spaceplane model (0 order) in low speed area p 1030 A92-56052
HOSOKAWA, SHIGERU
Pre-flight physical simulation test of HIMES reentry test vehicle p 1103 A92-53640
HOSOKAWA, SHUNSUKE
Experimental study of convection effects around the phase charge interface p 1111 A92-53755
HOU, GENE W.
Methodology for calculating aerodynamic sensitivity derivatives p 1024 A92-54911
HOVEY, PETER W.
Engine bird ingestion experience of the Boeing 737 aircraft: Expanded data base
[DOT/FAA/CT-91/32] p 1045 N92-34151
HOWARD, RICHARD M.
Aerodynamic analysis of the Pioneer unmanned air vehicle
[AIAA PAPER 92-4635] p 1027 A92-55382
Escape strategies for turboprop aircraft in microburst windshear p 1084 A92-56151
HOWE, H. C.
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
HOZUMI, K.
New 1.27-m leg of the National Aerospace Laboratory hypersonic wind tunnel p 1092 A92-56003
HOZUMI, KOICHI
Aerodynamic studies on space plane configuration at hypersonic speed p 1019 A92-53641
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043
HOZUMI, KOKI
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS p 1047 A92-56118
HOZUMI, KOKUICHI
Aerodynamic study of H-II Orbiting Plane, HOPE p 1103 A92-53639
HOZUMI, KOUICHI
Aerodynamic heating characteristics of space planes tested by NAL hypersonic wind tunnel p 1017 A92-53547
HRACH, FRANK
Method of reducing drag in aerodynamic systems
[NASA-CASE-LEW-14791-1] p 1043 N92-34243
HRUSCH, LOUIS C.
Landing gear mechanism including runway-roughness restrictor assembly
[CA-PATENT-1-257-618] p 1061 N92-33585
HSIAO, F.-B.
Forcing level effects of internal acoustic excitation on the improvement of airfoil performance p 1136 A92-56162
HUANG, L. J.
Assessment of calculation methods for efficiency of straight fins of rectangular profile p 1121 A92-56374
HUBBARD, HARVEY H.
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers
[NASA-TM-104170] p 1138 N92-33160
HUBER, H.
The Eurofar program - An European overview on advanced VTOL civil transportation system p 1016 A92-56299
HULL, DAVID G.
A guidance law for hypersonic descent to a point
[AIAA PAPER 92-4303] p 1104 A92-55311
HUMI, MAYER
Drag computation by vortex methods p 1031 A92-56161
HUNTEN, KEITH
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program
[AD-A247886] p 1108 N92-32629
HUNTER, N.
Development and integration of modern laboratories in aerospace education
[AIAA PAPER 92-4022] p 1141 A92-56844
HUO, XIUFANG
Stability and dynamic coupling of elastic vehicles with unsteady aerodynamic forces considered p 1102 A92-53545

HURLBUT, F. C.
Rarefied gas research at Berkeley - Current studies and future potentials
[AIAA PAPER 92-3971] p 1098 A92-56797
HUSSEY, I. W.
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-34019
HUSSIEN, BASSAM
Vision-based range estimation using helicopter flight data
[NASA-TM-103930] p 1047 N92-32424
HUTIN, P. M.
Unsteady wind tunnel tests p 1089 N92-34166

I

IBOSHI, NAOHIRO
Measurements of blade flapping motion on a wind tunnel model p 1093 A92-56023
Structural optimization of a cantilevered beam subject to combined static loadings p 1118 A92-56024
IBRAHIM, MOUNIR
Use of an approximate similarity principle for the thermal scaling of a full-scale thrust augmenting ejector
[AIAA PAPER 92-3792] p 1069 A92-54171
ICHIHASHI, TAKAHIRO
Design and testing of a composite hingeless hub for rotary-wing aircraft p 1053 A92-56075
IDA, K.
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
IGUCHI, H.
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
IGUCHI, STEVE K.
Potential flow theory and operation guide for the panel code PMARC
[NASA-TM-102851] p 1036 N92-32422
IIDA, HIROSHI
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of MLS p 1047 A92-56117
IIZUKA, TOSHIO
Evaluation of a IMU with optical fiber gyros in dynamic windtunnel tests p 1104 A92-56121
IKEDA, YUTAKA
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
IKEUCHI, MASAYUKI
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS p 1047 A92-56118
IL'INSKII, N. B.
Aerodynamic airfoils design by quasi-solutions method of inverse boundary-value problems p 1020 A92-53998
IMLAY, SCOTT T.
Comparison of turbulence models for powered-lift flow fields
[AIAA PAPER 92-3674] p 1022 A92-54117
IMUTA, MAMORU
Mechanical properties of laminate aluminum matrix composites p 1106 A92-56102
INABA, MOTOYUKI
Concepts of flight experiments for HOPE development p 1103 A92-53635
INAGAKI, TOSHIHARU
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
Synthesis of a MLS automatic landing control law for the NAL experimental research aircraft Do-228 p 1084 A92-56062
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of MLS p 1047 A92-56117
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS p 1047 A92-56118
INATANI, YOSHIFUMI
Pre-flight physical simulation test of HIMES reentry test vehicle p 1103 A92-53640
INFIELD, D.
Particle image velocimetry measurements of the aerodynamics of a wind turbine p 1115 A92-54337
INOKUCHI, H.
Analysis of the main wing lift distribution of the STOL research aircraft Asuka p 1053 A92-56051
INOUE, KOICHI
Optimal design of wing shape by use of neural-network p 1054 A92-56112
INOUE, YASUTOSHI
Aerodynamic heating characteristics of space planes tested by NAL hypersonic wind tunnel p 1017 A92-53547
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043
IOANNOU, P. A.
Identification and control of aircraft dynamics using radial basis function neural networks
[AIAA PAPER 92-4393] p 1074 A92-55194
ISAJI, HAJIME
Wind tunnel test of M = 2.5 mixed compression inlet p 1028 A92-56008
ISHIDA, YOJI
High subsonic wind tunnel test of a two-dimensional hybrid-laminar-flow-control airfoil with slotted surface p 1029 A92-56045
ISHIDE, AKIRE
An experimental program concerning a satellite data link for oceanic ATC p 1046 A92-56093
ISHII, M.
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729
ISHIKAWA, KAZUTOSHI
Synthesis of a MLS automatic landing control law for the NAL experimental research aircraft Do-228 p 1084 A92-56062
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS p 1047 A92-56118
ISHIKAWA, MUNENORI
An autorotation-entry control for a helicopter with a fuzzy controller p 1083 A92-56032
ISHIKAWA, TADASHI
A shock tunnel experiment on aerodynamic interference induced by RCS jet p 1029 A92-56042
ISHIMOTO, KATSUYA
Application of fuzzy control to aircraft guidance p 1083 A92-56033
ISLAM, M.
Tow-tank study of nonlinear aerodynamics of a 2-D airfoil
[AIAA PAPER 92-4499] p 1026 A92-55367
ISOGAI, KOJI
Research on aeroelastic tailoring at NAL p 1053 A92-56019
ITO, AKIHIRO
Flight simulator test of cockpit advisory system p 1054 A92-56115
ITO, H.
Tohoku University low-turbulence wind tunnel
[AIAA PAPER 92-3913] p 1095 A92-56746
ITO, JUNICHI
Development of an automatic drilling system. II p 1118 A92-56107
ITO, T.
Supersonic wind tunnel test of airintake/airframe integrated models p 1028 A92-56006
ITO, TETSUICHI
Concepts of flight experiments for HOPE development p 1103 A92-53635
Aerodynamic study of H-II Orbiting Plane, HOPE p 1103 A92-53639
ITODA, NORIHIKO
Spaceplane aerodynamic heating and thermal protection design method p 1102 A92-53578
ITTY, I. P.
The vortical structure in the wake during dynamic stall
[AIAA PAPER 92-4496] p 1026 A92-55364
IUSO, G.
Skin friction measurements in 3-D boundary layers p 1092 A92-54351
IWAGAMI, S.
A model study on diffuser pressure recovery in NAL scramjet test facility with simulated hydrogen combustion
[AIAA PAPER 92-3979] p 1071 A92-56805
IWAHORI, YUTAKA
Propeller-nacelle whirl flutter analysis and wind tunnel test p 1052 A92-56016
IWAI, MINORU
Configuration of flexible-skirts for an ACV and its CAD p 1118 A92-56036
IWAKI, TAKEO
Study on international cooperative test facilities for future SST/HST
[AIAA PAPER 92-3945] p 1097 A92-56775
IWASAKI, AKIHITO
A low speed wind tunnel investigation of a joined-wing aircraft with an overhanging fin p 1030 A92-56078
A low speed wind tunnel investigation of the direct side force control of a joined-wing aircraft with overhanging fin p 1084 A92-56079
IWASAKI, AKIRA
Experimental study of convection effects around the phase charge interface p 1111 A92-53755
IZUMIKAWA, MUNEO
A preliminary study of a supersonic wind tunnel for a ram jet test facility p 1089 A92-53564
IZYGON, MICHEL
Advanced software development workstation: Effectiveness of constraint-checking
[NASA-CR-190712] p 1134 N92-32865

J

JACKSON, A. G.
Turbine engine hot-part temperature measurement techniques
[AIAA PAPER 92-3960] p 1122 A92-56788
JACOBS, P. A.
Approximate Riemann solver for hypervelocity flows p 1117 A92-54934
JACOBS, S. W.
Development of the full-envelope Performance Seeking Control algorithm
[AIAA PAPER 92-3748] p 1068 A92-54148
JANKOWSKI, M. A.
Structural assessment of ultralightweight composites p 1107 N92-32525
JARBOE, T. R.
Formation and sustainment of a very low aspect ratio tokamak using coaxial helicity injection: Helicity Injected Torus (HIT) experiment
[DE92-014311] p 1136 N92-32595
JECKO, B.
Mechanisms of high-current pulses in lightning and long-spark stepped leaders p 1116 A92-54678
JOHNS, ROBERT
Turning up the heat on aircraft structures p 1052 A92-55131
JOHNSON, B. V.
Turbine disk cavity aerodynamics and heat transfer p 1124 N92-32265
JOHNSON, ERIC R.
Initial postbuckling response of an unsymmetrically laminated rectangular plate p 1108 N92-32586
JONES, KENNETH M.
Boundary layer study on nozzle wall at hypersonic velocities
[AIAA PAPER 92-4013] p 1034 A92-56836
JOSHI, PRAKASH B.
Laser-driven hypersonic air-breathing propulsion simulator
[AIAA PAPER 92-3922] p 1095 A92-56753
JUDD, JON
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program
[AD-A247886] p 1108 N92-32629
JULLIARD, J.
Experimental study of noise generation and propagation in a turbofan model p 1136 A92-56169
JUNE, REID B.
New materials drive high-performance aircraft p 1105 A92-55134

K

KAINUMA, FUMIKAZU
A physical approach to the estimation of aerodynamic characteristics from flight data p 1030 A92-56058
KAISER, E. O.
V-22 propulsion system design p 1070 A92-56300
KAJOKA, HIROSHI
Evaluation of a IMU with optical fiber gyros in dynamic windtunnel tests p 1104 A92-56121
KAKINUMA, ASAO
Design and testing of a composite hingeless hub for rotary-wing aircraft p 1053 A92-56075
KALKHORAN, I.
Hypersonic shock tunnel testing for undergraduate laboratory instruction
[AIAA PAPER 92-4021] p 1100 A92-56843
KAM, MOSHE
Neural networks for feedback linearization in aircraft control
[AIAA PAPER 92-4391] p 1074 A92-55192
KAMATA, YUKIO
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
KAMPA, K.
Mission oriented investigation of handling qualities through simulation p 1059 A92-56353
KAN, HAN PIN
Out of plane analysis for composite structures p 1107 N92-32527

Damage tolerance certification methodology for composite structures p 1108 N92-32579
KANAI, KIMIO
Design of a flight control system using a feedback-error-learning-type neural network p 1132 A92-56067
KANDA, HIROSHI
On the structure of unsteady shock induced separation of the transonic airfoil in the NAL two-dimensional wind tunnel p 1029 A92-56010
Evaluation of sidewall interference in the NAL two-dimensional transonic wind tunnel p 1092 A92-56011
BGK1 airfoil oilflow tests in the NAL two-dimensional wind tunnel. II p 1029 A92-56044
High subsonic wind tunnel test of a two-dimensional hybrid-laminar-flow-control airfoil with slotted surface p 1029 A92-56045
KANDA, TAKESHI
Performance analysis of idealized scramjet p 1066 A92-53493
Flow measurements in scramjet inlets p 1102 A92-53565
KANDIL, OSAMA A.
Active control of asymmetric vortical flows around cones using injection and heating [AIAA PAPER 92-4426] p 1025 A92-55350
Computation of vortex wake flows and control of their effects on trailing wings [AIAA PAPER 92-4429] p 1025 A92-55353
KANE, DAVID M.
Structural assessment of ultralightweight composites p 1107 N92-32525
KANEKO, A.
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055
KANEKO, O.
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS [NIFS-110] p 1138 N92-33743
KANEMATSU, EMI
Rarefied gas numerical wind tunnel p 1017 A92-53552
KANMURI, AKIO
Performance analysis of idealized scramjet p 1066 A92-53493
KAPTEIN, DICK
Active synchrophasing of propeller unbalance p 1138 N92-32963
KARPEL, MORDECHAY
Multidisciplinary optimization of aeroservoelastic systems using reduced-size models p 1054 A92-56176
KATAOKA, HAJIME
Study of potassium turbine electric generator system p 1129 N92-33794
KATAOKA, HIROYUKI
An experimental study on variable pressure hydraulic flight control system p 1084 A92-56119
KATAYANAGI, RYOJI
MIMO state-feedback control system considering phase stability by -90 deg phase-locus method p 1084 A92-56066
KATO, KANICHIRO
A note on thrust control for jetliner during approach p 1053 A92-56061
KATOU, KAZUNOBU
Design of a flight control system using a feedback-error-learning-type neural network p 1132 A92-56067
KATSURAHARA, TADASHI
A hypersonic wind tunnel test of a mixed-compression air inlet model p 1028 A92-56007
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043
KATZ, JOSEPH
Potential flow theory and operation guide for the panel code PMARC [NASA-TM-102851] p 1036 N92-32422
KAUPS, K.
Analysis of iced wings [NASA-TM-105773] p 1042 N92-34144
KAUTZ, EDWARD F.
Out of plane analysis for composite structures p 1107 N92-32527
Damage tolerance certification methodology for composite structures p 1108 N92-32579
KAWABATA, HITOSHI
Hypersonic flows with air chemistry over a reentry vehicle at high altitudes p 1017 A92-53549
KAWACHI, KEIJI
Optimal control of helicopters following power failure [AIAA PAPER 92-4471] p 1076 A92-55231
A calculation method to predict helicopter noise and its verification p 1135 A92-56074
Optimal control of tiltrotor aircraft following power failure p 1085 A92-56303
KAWAGUCHI, JUN'ICHIRO
Pre-flight physical simulation test of HIMES reentry test vehicle p 1103 A92-53640
KAWAHARA, HIROYASU
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
Flight simulator test of cockpit advisory system p 1054 A92-56115
KAWAHATA, NAGAKATU
Gust response and cross wind performance of a hovercraft with vertical wings p 1118 A92-56034
KAWAI, M.
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
KAWAMOTO, IWAO
Aerodynamic study of H-II Orbiting Plane, HOPE p 1103 A92-53639
KAWAMURA, NAOKO
Propeller-nacelle whirl flutter analysis and wind tunnel test p 1052 A92-56016
KAY, I. W.
Structure and penetration of a transverse fluid jet injected at supercritical pressure in supersonic flow [AIAA PAPER 92-3652] p 1113 A92-54105
KAYABA, S.
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test p 1093 A92-56114
KAYABA, SHIGEO
Measurements of longitudinal static aerodynamic coefficients with cable mount system p 1093 A92-56013
KEENER, EARL R.
Experimental results for a hypersonic nozzle/afterbody flow field [AIAA PAPER 92-3915] p 1032 A92-56747
KEHOE, MICHAEL W.
Getting up to speed in hypersonic structures p 1117 A92-55127
KELLOGG, GARY
Rapid development of the X-31 simulation to support flight-testing [NASA-TM-104256] p 1060 N92-33149
KELLY, P. G.
Results of a perturbation analysis correlating flows entering and exiting an aircraft inlet system [AIAA PAPER 92-3624] p 1021 A92-54091
KEMPEL, ROBERT
The F-18 high alpha research vehicle: A high-angle-of-attack testbed aircraft [NASA-TM-104253] p 1060 N92-33404
KERSCHEN, E. J.
Leading-edge receptivity for blunt-nose bodies [NASA-CR-190563] p 1036 N92-32648
KESTLER, MAUREEN A.
Performance of insulated pavements at Newton Fields, Jackman, Maine [CRREL-92-9] p 1101 N92-32903
KHARCHENKO, A. V.
An approach to the organization of an adaptive man-machine system for flight vehicle control p 1133 A92-57445
KHODADOUST, ABDI
Effect of a simulated glaze ice shape on the aerodynamic performance of a rectangular wing [AIAA PAPER 92-4042] p 1035 A92-56861
KHRABROV, A.
Stochastic self-induced roll oscillations of slender delta wing at high angles of attack [AIAA PAPER 92-4498] p 1081 A92-55366
State-space representation of aerodynamic characteristics of an aircraft at high angels of attack [AIAA PAPER 92-4651] p 1028 A92-55395
KIDA, TERUHIKO
Three-dimensional numerical analysis of impinging circular jet - Discrete vortex method p 1029 A92-56040
KILGORE, D. R.
Transfer function between airborne VLF transmit and receive loop antenna p 1045 A92-54754
KILGORE, W. A.
Control of large cryogenic tunnels [AIAA PAPER 92-3930] p 1096 A92-56761
KIM, BYOUNG S.
Neural networks for feedback linearization in aircraft control [AIAA PAPER 92-4391] p 1074 A92-55192
KIM, JAY C.
Computational and experimental investigation of annulus heat transfer with swirl [AIAA PAPER 92-4060] p 1119 A92-56143
KIM, WON-JONG
Application of recursive partially unknown system identification to aerodynamic coefficients estimation [AIAA PAPER 92-4504] p 1081 A92-55371
KIM, Y.
Electronics/avionics integrity - Definition, measurement and improvement p 1120 A92-56252
KIM, YOUNG
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
KIMMEL, K. R.
Experimental evaluation of a 50-percent thick airfoil with blowing and suction boundary layer control [AIAA PAPER 92-4500] p 1026 A92-55368
KIMURA, TAKASI
Flight control system design using H(infinity) optimal control p 1083 A92-56030
KIMURA, YUKIKO
Rarefied gas numerical wind tunnel p 1017 A92-53552
KING, MING-DAH
Experimental investigation of the stability of a clearance-excited rotor system with optimal parameters p 1114 A92-54223
KIRCHNER, DIETER
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG p 1050 N92-33356
KLEIN, VLADISLAV
Aerodynamic parameters of the X-31 drop model estimated from flight-data at high angles of attack [AIAA PAPER 92-4357] p 1080 A92-55343
KLEINLE, MARK
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964
KNIGHT, D. D.
Structure of crossing-shock wave/turbulent boundary-layer interactions [AIAA PAPER 92-3670] p 1022 A92-54113
KNIGHT, NORMAN F., JR.
Global/local methods research using the CSM testbed p 1107 N92-32528
Computational methods for global/local analysis [NASA-TM-107591] p 1125 N92-33104
KOBAYASHI, H.
A conceptual study for future engine test facility [AIAA PAPER 92-3992] p 1099 A92-56815
KOBAYASHI, OSAMU
A physical approach to the estimation of aerodynamic characteristics from flight data p 1030 A92-56058
KOBAYASHI, R.
Tohoku University low-turbulence wind tunnel [AIAA PAPER 92-3913] p 1095 A92-56746
KOBAYASHI, TOMOYUKI
Fabrication test and evaluation of graphite/PMR-15 polyimide for HOPE primary structure p 1105 A92-53516
KOECHLER, CLAUDIO
Time Resolved Lidar Fluorosensor operating from helicopter p 1121 A92-56296
KOENIG, R.
ATTAS flight test and simulation results of the advanced gust management system LARS [AIAA PAPER 92-4343] p 1079 A92-55332
KOESTER, KENNETH L.
Talons 95 GHz radar sensor for autonomous landing guidance p 1063 A92-55908
KOGA, KAZUYA
An experimental study on variable pressure hydraulic flight control system p 1084 A92-56119
KOHAMA, Y.
Tohoku University low-turbulence wind tunnel [AIAA PAPER 92-3913] p 1095 A92-56746
KOHDA, TAKEHISA
Optimal design of wing shape by use of neural-network p 1054 A92-56112
KOHL, RONALD H.
Development of local nonintrusive measurements of inlet and exhaust flows for the ground testing of air-breathing engines [AIAA PAPER 92-3899] p 1122 A92-56735
KOJIMA, TOSHIRO
Aeronautical satellite communications system p 1046 A92-56089
KOLAR, R.
A time-dependent tip loss formula for rotor blade dynamic analysis p 1057 A92-56310
KOLARIK, W.
Electronics/avionics integrity - Definition, measurement and improvement p 1120 A92-56252
KOLONAY, RAYMOND M.
Demonstration of structural optimization applied to wind-tunnel model design p 1119 A92-56181
KOMATSU, N.
Measurement of position and attitude using laser and retro-reflectors p 1047 A92-56120

KOMERATH, N. M.
A multi-diagnostic approach to testing V/STOL craft
[AIAA PAPER 92-4008] p 1099 A92-56831
KOMERATH, NARAYANAN M.
Image processing in the undergraduate fluid dynamics laboratory
[AIAA PAPER 92-4020] p 1141 A92-56842
KOMODA, MASAKI
An investigation of the automation of emergency landings for helicopters p 1083 A92-56026
Multiaxis control in longitudinal mode of aircraft p 1083 A92-56027
KOMURO, TOMOYUKI
Flow measurements in scramjet inlets p 1102 A92-53565
KONDO, HIROHUMI
On the effect of canards on NAL spaceplane model (0 order) in low speed area p 1030 A92-56052
KONDRATENKOV, V. A.
Using the simulation modeling method to estimate the reliability of the crew-flight vehicle system p 1133 A92-57444
KOOI, J. W.
Application of electronically scanned pressure measurement system for engine simulation tests in the German-Dutch Wind Tunnel
[AIAA PAPER 92-4003] p 1122 A92-56826
KOPCHENOV, V. I.
The enhancement of the mixing and combustion processes in supersonic flow applied to scramjet engine
[AIAA PAPER 92-3428] p 1112 A92-54029
KORIVI, VAMSHI M.
Methodology for calculating aerodynamic sensitivity derivatives p 1024 A92-54911
KORKAN, KENNETH
Experimental study of performance degradation of a rotating system in the NASA Lewis RC icing tunnel
[NASA-CR-190684] p 1102 N92-34141
KORTE, JOHN J.
CAN-DO, CFD-based Aerodynamic Nozzle Design and Optimization program for supersonic/hypersonic wind tunnels
[AIAA PAPER 92-4009] p 1033 A92-56832
KOSHELYAEVSKY, N. B.
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
KOSTOPOULOS, V.
Jet fuel absorption and dynamic mechanical analysis of carbon fibre composites p 1110 N92-33050
KOTAKE, MUTSUO
Experimental investigation of the boundary layer in a corner formed by two circular arc airfoils p 1029 A92-56046
KOURA, KATSUHIKA
Rarefied gas numerical wind tunnel p 1017 A92-53552
KOWAL, BRIAN F.
C-17 flight control system overview p 1082 A92-55906
KOYAMA, T.
New 1.27-m leg of the National Aerospace Laboratory hypersonic wind tunnel p 1092 A92-56003
KOYAMA, TADAO
Aerodynamic heating characteristics of space planes tested by NAL hypersonic wind tunnel p 1017 A92-53547
KRAEUTLE, K.
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
KRASOVSKAIA, I. V.
Interaction between a body flying at a supersonic velocity and a point explosion p 1019 A92-53867
KRAUSS, R. H.
A clean air continuous flow propulsion facility
[AIAA PAPER 92-3912] p 1094 A92-56745
KRAVETZ, J.
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
KRISHEN, KUMAR
Issues in developing control zones for international space operations p 1141 A92-56602
KROLL, NORBERT
An examination of several high resolution schemes applied to complex problems in high speed flows
[AD-A250814] p 1124 N92-32632
KROTHAPALLI, ANJANEYULU
Experimental observations of instability modes in a rectangular jet p 1135 A92-54908
KRUCZYNSKI, D. L.
Experimental and computational investigation of scaling phenomena in a large caliber ram accelerator
[AIAA PAPER 92-3245] p 1103 A92-54019
KUBE, ROLAND
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344
KUBO, YOSHIHARU
An autorotation-entry control for a helicopter with a fuzzy controller p 1083 A92-56032
KUBOTA, HIROTOSHI
Spaceplane aerodynamic heating and thermal protection design method p 1102 A92-53578
Study on international cooperative test facilities for future SST/HST
[AIAA PAPER 92-3945] p 1097 A92-56775
KUCZERA, HERIBERT
The German Hypersonics Technology Programme - Status report 1992
[IAF PAPER 92-0867] p 1105 A92-57258
KUDLICK, D. A.
Approximate aerodynamic analysis of jet interaction
[AIAA PAPER 92-4640] p 1027 A92-55387
KUDO, ISAO
Experimental study of convection effects around the phase charge interface p 1111 A92-53755
KUDOU, KENJI
Flow measurements in scramjet inlets p 1102 A92-53565
KUHLENSCHMIDT, SHARON
Human factors issues in the use of artificial intelligence in air traffic control. October 1990 Workshop
[NASA-CR-190925] p 1051 N92-34203
KUHN, RICHARD E.
On the anomalies in single-jet hover suckdown data
[NASA-TM-102261] p 1038 N92-33306
Dynamic response of induced pressures, suckdown, and temperatures for two tandem jet STOVL configurations
[NASA-TM-103934] p 1039 N92-33581
On the estimation of jet-induced fountain lift and additional suckdown in hover for two-jet configurations
[NASA-TM-102268] p 1040 N92-33618
KUMAGAI, TATSUO
A preliminary study of a supersonic wind tunnel for a ram jet test facility p 1089 A92-53564
KUMAKURA, IKUO
Research on aeroelastic tailoring at NAL p 1053 A92-56019
KUMAR, AJAY
CAN-DO, CFD-based Aerodynamic Nozzle Design and Optimization program for supersonic/hypersonic wind tunnels
[AIAA PAPER 92-4009] p 1033 A92-56832
KUMAR, RAMOHALLI
Free-radicals aided combustion with scramjet applications
[IAF PAPER 92-0659] p 1106 A92-57100
KUMAR, V. R.
Criteria for use of seal coats on airport pavements
[DOT/FAA/RD-92/18] p 1102 N92-34247
KUNC, J. A.
A code validation strategy and facility for nonequilibrium, reacting flows
[AIAA PAPER 92-3970] p 1098 A92-56796
KUNDU, K. P.
Applied analytical combustion/emissions research at the NASA Lewis Research Center - A progress report
[AIAA PAPER 92-3338] p 1067 A92-54025
KUNZ, R.
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
KURANAGA, SEISHI
Experimental investigation on turbulent phenomena in three-dimensional shock wave/turbulent boundary layer interaction induced by blunt fin p 1018 A92-53557
KURNIAWAN, ANTONIUS S.
Thermal mechanical analysis of sprag clutches
[NASA-CR-190686] p 1128 N92-34207
KUROSAKA, T.
A model study on diffuser pressure recovery in NAL scramjet test facility with simulated hydrogen combustion
[AIAA PAPER 92-3979] p 1071 A92-56805
Numerical prediction of the flow characteristics in an arc wind tunnel
[AIAA PAPER 92-4016] p 1100 A92-56838
KUSHMAN, KEITH L.
Integrated test and evaluation for hypervelocity systems
[AIAA PAPER 92-3901] p 1017 A92-56736
KUT'ENKOV, V. A.
High-temperature metal matrix composite p 1105 A92-53878
KUWAHARA, KEIICHI
Fundamental studies on Marangoni convection related to Bridgman crystal growth p 1111 A92-53758
KUWANO, N.
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055
KVATERNIK, RAYMOND G.
DAMVIBS looks at rotorcraft vibration p 1052 A92-55128
KWON, O.
A critical evaluation of a three-dimensional Navier-Stokes CFD as a tool to design supersonic turbine stages p 1124 N92-32268

L

LACAS, F.
Turbulent combustion modelling in a side dump ramjet combustor
[AIAA PAPER 92-3599] p 1112 A92-54075
LACEY, J.
The high enthalpy shock tunnel in Goettingen
[AIAA PAPER 92-3942] p 1104 A92-56772
LAGANELLI, ANTHONY L.
Hypersonic wind tunnel nozzle study
[AIAA PAPER 92-4012] p 1033 A92-56835
LAKSHMINARAYANA, B.
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
LANCIOTTI, A.
Effects of spectrum variations on fatigue crack growth p 1123 A92-57399
LANG, M. A.
MD-80 aft cabin noise control: A case history p 1137 N92-32950
LANGER, H. J.
Correlation of flight, tunnel and prediction data on a helicopter main rotor p 1059 A92-56350
LANGLEY, R. S.
A dynamic stiffness technique for the vibration analysis of stiffened shell structures p 1123 A92-56866
LARIGALDIE, S.
Mechanisms of high-current pulses in lightning and long-spark stepped leaders p 1116 A92-54678
LARSEN, PETER N.
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
LARSON, TERRY J.
High angle-of-attack flush airdata sensing system p 1064 A92-56172
LASTER, M. L.
The G-range impulse facility - A high-performance free-piston shock tunnel
[AIAA PAPER 92-3946] p 1097 A92-56774
LAWRENCE, SCOTT L.
Application of computational fluid dynamics to sonic boom near- and mid-field prediction p 1031 A92-56173
LAZZERI, L.
Effects of spectrum variations on fatigue crack growth p 1123 A92-57399
LE, JEANETTE
Experience with Ada on the F-18 High Alpha Research Vehicle Flight Test Program
[NASA-TM-104259] p 1062 N92-34039
LEACH, B. W.
A Kalman filter integrated navigation design for the IAR Twin Otter Atmospheric Research Aircraft
[NRC-32148] p 1048 N92-32849
The use of Kalman filtering techniques to improve the accuracy of flight test data
[NRC-32139] p 1064 N92-32850
LEATHERWOOD, J. D.
Application of magnitude estimation scaling to the assessment of subjective loudness response to simulated sonic booms
[NASA-TM-107657] p 1138 N92-33719
LEATHERWOOD, JACK D.
Subjective loudness response to simulated sonic booms p 1140 N92-33885
LECCE, LEONARDO V.
Active vibrations and noise control for turboprop application research program activities p 1138 N92-32962
LEE, D. K.
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
LEE, DAL H.
Application of recursive partially unknown system identification to aerodynamic coefficients estimation
[AIAA PAPER 92-4504] p 1081 A92-55371
LEE, JANG G.
Application of recursive partially unknown system identification to aerodynamic coefficients estimation
[AIAA PAPER 92-4504] p 1081 A92-55371
LEE, JOSEPH W.
Signal processing schemes for Doppler global velocimetry p 1115 A92-54338

LEE, S.
Processing and environmental effects on mechanical properties of composite repairs
[NRC-LTR-ST-1826] p 1109 N92-32791
LEE, Y.
Heat transfer measurements and CFD comparison of swept shock wave/boundary-layer interactions
[AIAA PAPER 92-3665] p 1021 A92-54110
Swept shock/boundary layer interaction experiments in support of CFD code validation
[NASA-CR-190583] p 1036 N92-32494
LEINGANG, JOHN L.
Further studies of kinetic energy methods in high speed ramjet cycle analysis
[AIAA PAPER 92-3805] p 1069 A92-54177
LEITH, D. J.
The identification of coupled flapping/inflow models for hovering flight p 1058 A92-56335
LEITH, J. R.
The vortical structure in the wake during dynamic stall
[AIAA PAPER 92-4496] p 1026 A92-55364
LEMAY, SCOTT P.
Vortex flow visualization using colored and fluorescent dyes on flat plate delta wing with leading edge extension
[AD-A251139] p 1036 N92-32651
LEMPERT, W. R.
Rayleigh imaging and flow tagging in ground test facilities p 1115 A92-54330
LEPICOVSKY, JAN
Engine component instrumentation development facility at NASA Lewis Research Center
[AIAA PAPER 92-3995] p 1099 A92-56818
LERBS, S.
The trisonic wind tunnel Muenchen and its involvement in the German SAeNGER-programme
[AIAA PAPER 92-4019] p 1100 A92-56841
LESIEUR, M.
Numerical simulation of turbulence at the back of the airplane
[ETN-92-91664] p 1037 N92-32769
LESTER, H. C.
Active control of interior noise in a large scale cylinder using piezoelectric actuators p 1137 N92-32958
LEVIN, EUGENE
H-N2 interaction energies, transport cross sections, and collision integrals p 1135 A92-54660
LEWANDOWSKI, WLODZIMIERZ
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
LEWANDOWSKI, WLODZIMIERZ W.
The need for GPS standardization
p 1049 N92-33351
Precise GPS ephemerides from DMA and NGS tested by time transfer p 1049 N92-33355
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG
p 1050 N92-33356
LEWY, S.
Experimental study of noise generation and propagation in a turbofan model p 1136 A92-56169
LI, FENG-HSI
Static and dynamic flow visualization studies of two double-delta wing models at high angles of attack
[AD-A252878] p 1040 N92-33678
LI, HUA X.
The research of reducing 3-D low supersonic shock wave reflection in a 2-D transonic flexible walls adaptive wind tunnel
[AIAA PAPER 92-3924] p 1095 A92-56755
LI, YIDONG
The flow field characteristics about a fighter configuration at high angles of attack
[AIAA PAPER 92-4358] p 1025 A92-55344
LIBBY, P. A.
Theories of turbulent combustion in high speed flows
[AD-A253032] p 1111 N92-33624
LIBESKIND, MARK
Design, evaluation and experimental effort toward development of a high strain composite wing for Navy aircraft p 1107 N92-32514
LIEBST, BRAD S.
An algorithm for robust eigenstructure assignment using the Linear Quadratic Regulator
[AIAA PAPER 92-4478] p 1131 A92-55237
LIGRANI, P. M.
Surface heat transfer and flow properties of vortex arrays induced artificially and from centrifugal instabilities
p 1121 A92-56371
LINDLEY, CHARLES A.
Combined exo/endoatmospheric transport alternatives
[IAF PAPER 92-0663] p 1104 A92-57102
LIPKENS, BART
Model experiment to study the effect of turbulence on risetime and waveform of N waves
p 1139 N92-33881
LIU, A.
Particle image velocimetry measurements of the aerodynamics of a wind turbine p 1115 A92-54337
LIU, C. H.
Active control of asymmetric vortical flows around cones using injection and heating
[AIAA PAPER 92-4426] p 1025 A92-55350
Computation of vortex wake flows and control of their effects on trailing wings
[AIAA PAPER 92-4429] p 1025 A92-55353
LIU, H. Z.
Fault diagnostics on jet engine starting
p 1116 A92-54345
LIU, T.
Thermal paints for shock/boundary layer interaction in inlet flows
[AIAA PAPER 92-3626] p 1113 A92-54093
LIVNE, ELI
Optimization of a 2D scramjet-vehicle using CFD and simplified approximate flow analysis techniques
[AIAA PAPER 92-3673] p 1022 A92-54116
LIVNEH, RAFAEL
New literal approximations for the longitudinal dynamic characteristics of flexible flight vehicles
[AIAA PAPER 92-4411] p 1075 A92-55205
LO, C. F.
Blockage correction in three-dimensional wind tunnel testing based on the wall signature method
[AIAA PAPER 92-3925] p 1095 A92-56756
LO, EDMOND Y.
Laser-driven hypersonic air-breathing propulsion simulator
[AIAA PAPER 92-3922] p 1095 A92-56753
LOCKE, W.
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-34019
LOEWY, R. G.
Dynamic analysis of rotor blades with root retention design variations p 1054 A92-56156
LOFARO, RONALD JOHN
Workshop on Aeronautical Decision Making (ADM). Volume 1: Executive summary
[DOT/FAA/RD-92/14-VOL-1] p 1142 N92-33305
LOMKOV, K. E.
The enhancement of the mixing and combustion processes in supersonic flow applied to scramjet engine
[AIAA PAPER 92-3428] p 1112 A92-54029
LONG, MARY J.
Experimental investigation of an ejector-powered free-jet facility
[AIAA PAPER 92-3569] p 1090 A92-54058
LOOMIS, MARK P.
Flow characterization in the NASA Ames 16-inch Shock Tunnel
[AIAA PAPER 92-3810] p 1090 A92-54180
LOOMIS, WILLIAM R.
Liquid lubricants for advanced aircraft engines
[NASA-TM-104531] p 1109 N92-32863
LOPEZ, ISAAC
Transonic turbine blade cascade testing facility
[AIAA PAPER 92-4034] p 1101 A92-56856
LORCH, D. R.
MD-80 aft cabin noise control: A case history
p 1137 N92-32950
LOSCHKE, R. C.
Flight management system of the F-117A
p 1082 A92-55910
LOTH, ERIC
High-speed cinematography of supersonic mixing layers
[AIAA PAPER 92-3545] p 1112 A92-54044
LOW, EICHER
Robustness of a helicopter flight control system designed using eigenstructure assignment
[AIAA PAPER 92-4469] p 1076 A92-55229
Design of helicopter flight control systems for hover and low speed using eigenstructure assignment
p 1061 N92-33952
LOWELL, T. A.
Analysis of airframe/engine interactions for a STOVL aircraft with integrated flight/propulsion control
[AIAA PAPER 92-4623] p 1052 A92-55300
LU, HONGYU
The flow field characteristics about a fighter configuration at high angles of attack
[AIAA PAPER 92-4358] p 1025 A92-55344
LU, ZHIYONG
The flow field characteristics about a fighter configuration at high angles of attack
[AIAA PAPER 92-4358] p 1025 A92-55344
LUCJANEK, WIESLAW
Simulation of helicopter see-saw rotor motion
p 1055 A92-56287
LUM, K. K.
The design and development of a portable, DSP micro-processor based, high-accuracy data acquisition system
[NRC-32146] p 1134 N92-32851
LUO, J.
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
LURIA, FRANK
High angle-of-attack control enhancement on a forward swept wing aircraft
[AIAA PAPER 92-4427] p 1080 A92-55351
LUTON, J. A.
Numerical simulations of flutter and its suppression by active control
[AIAA PAPER 92-4652] p 1082 A92-55396
LUTZE, FREDERICK H.
Nonlinear model-following control application to airplane control (1992 AIAA Controls Design Challenge)
[AIAA PAPER 92-4625] p 1077 A92-55302
LY, UY-LOI
Control design of a UH-60 rotorcraft via CLTR and direct optimization
[AIAA PAPER 92-4470] p 1076 A92-55230
LYNE, GEORGE W.
A testability-dependent maintainability-prediction *technique* p 1120 A92-56222
LYONS, DANIEL F.
Aerodynamic analysis of the Pioneer unmanned air vehicle
[AIAA PAPER 92-4635] p 1027 A92-55382
LYRINTZIS, A. S.
Efficient iterative methods for the transonic small disturbance equation p 1025 A92-54933

M

MACDERMOTT, W. N.
Flow contamination and flow quality in arc heaters used *for hypersonic testing*
[AIAA PAPER 92-4028] p 1100 A92-56850
MACE, W. D., JR.
Comparison of frequency domain and time domain laser velocimeter signal processors p 1114 A92-54314
MACK, M. D.
High Reynolds number testing in support of transport airplane development
[AIAA PAPER 92-3982] p 1099 A92-56807
MACKALL, DALE
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
MACPHERSON, J. I.
The use of Kalman filtering techniques to improve the accuracy of flight test data
[NRC-32139] p 1064 N92-32850
MAEKAWA, SHOUZO
Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance
p 1029 A92-56009
MAEKAWA, SYOZO
Experimental study on three-dimensional shock wave-turbulent boundary layer interaction induced by protuberance p 1019 A92-53997
MAGNESS, CHARLES LEE
Unsteady response of the leading-edge vortices on a pitching delta wing p 1041 N92-33851
MAHADEVAN, R.
High-speed cinematography of supersonic mixing layers
[AIAA PAPER 92-3545] p 1112 A92-54044
MAHLER, M. A.
Out of plane analysis for composite structures
p 1107 N92-32527
MAINE, TRINDEL
Flight testing and simulation of an F-15 airplane using throttles for flight control
[NASA-TM-104255] p 1087 N92-32864
MAITA, M.
Airbreathing engine selection criteria for SSTO propulsion system
[IAF PAPER 92-0658] p 1071 A92-57099
MAJIDZADEH, KAMRAN
Criteria for use of seal coats on airport pavements
[DOT/FAA/RD-92/18] p 1102 N92-34247
MAK, A.
Reduction of the side force on pointed forebodies through add-on tip devices p 1024 A92-54918
MALLOY, DONALD J.
Test data models to characterize turbine engine operation in altitude test facilities
[AIAA PAPER 92-3917] p 1095 A92-56749

MALSBURY, T.
Flight simulator fidelity assessment in a rotorcraft lateral translation maneuver
[AIAA PAPER 92-4424] p 1092 A92-55348
MANGOLD, SUSAN J.
A review and discussion of flight management system incidents reported to the aviation safety reporting system
[AD-A252438] p 1043 N92-32941
MANN, MICHAEL J.
Survey and analysis of research on supersonic drag-due-to-lift minimization with recommendations for wing design
[NASA-TP-3202] p 1040 N92-33656
MANNING, CLARKE O.
Flight test results using a low order equivalent systems technique to estimate flying qualities
[AIAA PAPER 92-4425] p 1080 A92-55349
MANNING, JEROME E.
Use of SEA to predict structure-borne noise in aircraft
p 1137 N92-32955
MANNING, T. A.
Computational and experimental studies of flow in multi-lobed forced mixers
[AIAA PAPER 92-3568] p 1112 A92-54057
MARCOCCI, L.
A module-level testing environment for safety-critical software systems p 1132 A92-56293
MARTIN, RODERICK H.
Isothermal aging of IM7/8320 and IM7/5260
[NASA-TM-107666] p 1110 N92-33423
MARTIN, VINCENT
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
MARTINDALE, W. R.
Performance evaluation of a transonic wind tunnel compressor
[AIAA PAPER 92-3927] p 1096 A92-56758
MARVIN, JOSEPH G.
CFD validation experiments for hypersonic flows
[AIAA PAPER 92-4024] p 1034 A92-56846
MASAKI, SHOJU
Current repair technologies for jet engine components
p 1016 A92-56085
MASUE, TATSUYA
Efficiency and accuracy in helicopter hovering performance calculation p 1053 A92-56072
MASUYA, GORO
Conceptual design of scramjet engine
p 1065 A92-53490
Scramjet engine and its flying test bed
p 1066 A92-53492
Performance analysis of idealized scramjet
p 1066 A92-53493
Flow measurements in scramjet inlets
p 1102 A92-53565
MASUZAWA, HIDEO
Flight simulator test of cockpit advisory system
p 1054 A92-56115
MATHENY, NEIL
The F-18 high alpha research vehicle: A high-angle-of-attack testbed aircraft
[NASA-TM-104253] p 1060 N92-33404
MATHEW, M. B.
Dynamic analysis of rotor blades with root retention design variations p 1054 A92-56156
MATHIEU, G.
Millisecond aerodynamic force measurement with side-jet model in the ISL shock tunnel
[AIAA PAPER 92-3963] p 1097 A92-56790
MATSON, ROBERT E.
Smoothing CFM56 engine removal rate at USAir
[AIAA PAPER 92-3928] p 1070 A92-56759
MATSUDA, MASAMI
Application of fuzzy control to aircraft guidance
p 1083 A92-56033
MATSUHAMA, M.
A conceptual study for future engine test facility
[AIAA PAPER 92-3992] p 1099 A92-56815
MATSUHAMA, MASAAKI
Key design considerations for scramjet powered space plane p 1066 A92-53491
MATSUMOTO, K.
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
MATSUMOTO, KOHTARO
Flight simulator test of cockpit advisory system
p 1054 A92-56115
MATSUMOTO, M.
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729
MATSUNO, KENICHI
BGK1 airfoil oilflow tests in the NAL two-dimensional wind tunnel. II p 1029 A92-56044
MATSUO, AKIKO
Detailed numerical analysis of standing oblique detonation p 1111 A92-53550
MATSUO, HIDEO
Planning method of skirt systems for small ACVs
p 1118 A92-56038
MATSUO, KENSUKE
Planning method of skirt systems for small ACVs
p 1118 A92-56038
MATSUSHIMA, K.
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
MATSUSHIMA, KOICHI
Space plane navigation simulation
p 1103 A92-53603
MATSUSHITA, HIROSHI
Synthesis of gust load alleviation with flutter margin augmentation p 1082 A92-56021
MATSUSHITA, MITSUNORI
Generalized aerodynamics analysis by the boundary element method p 1030 A92-56050
MATSUURA, TSUKASA
A consideration on air traffic control processing capability in terminal area p 1047 A92-56110
MATTERN, DUANE
Propulsion system performance resulting from an Integrated Flight/Propulsion Control design
[AIAA PAPER 92-4602] p 1069 A92-55281
MATTINGLY, JACK D.
Improvements in teaching aircraft engine design
[AIAA PAPER 92-3758] p 1141 A92-54152
MAUS, J. R.
The G-range impulse facility - A high-performance free-piston shock tunnel
[AIAA PAPER 92-3946] p 1097 A92-56774
MAY, D. N.
MD-80 aft cabin noise control: A case history
p 1137 N92-32950
MAY, NOAL D.
Exposures from headset interference tones
[AD-A247175] p 1136 N92-32697
MAYHEW, ELLEN R.
An acceptance process for the evaluation of inlet distortion
[AIAA PAPER 92-3918] p 1032 A92-56750
MAZZUCCHELLI, C.
The achievement of aerodynamic goals on the EH101 project through the 'single site' concept
p 1058 A92-56342
MBA, M. N.
The computation and validation of hovering rotor performance p 1055 A92-56285
MCARDLE, JACK G.
Internal reversing flow in a tailpipe offtake configuration for SSTOVL aircraft
[AIAA PAPER 92-3790] p 1069 A92-54169
MCCALLUM, A. T.
A study of helicopter rotor/fuselage response in low-speed manoeuvres - Comparison of theory with flight p 1086 A92-56334
MCCLEARY, SUSAN L.
Computational methods for global/local analysis
[NASA-TM-107591] p 1125 N92-33104
MCCLURE, W. B.
An experimental examination of the effects of incoming boundary layer modifications on the dynamics of a turbulent compression corner interaction
[AIAA PAPER 92-3667] p 1022 A92-54111
MCCROSKEY, W. J.
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
MCDANIEL, J. C., JR.
A clean air continuous flow propulsion facility
[AIAA PAPER 92-3912] p 1094 A92-56745
MCDANIEL, S.
Application of magnitude estimation scaling to the assessment of subjective loudness response to simulated sonic booms
[NASA-TM-107657] p 1138 N92-33719
MCENTEE, J.
Proof of concept of a magnetically coupled Stirling engine-driven heat pump
[DE92-017129] p 1129 N92-33271
MCGRAW, SANDRA M.
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
MCINTYRE, T. J.
The high enthalpy shock tunnel in Goettingen
[AIAA PAPER 92-3942] p 1104 A92-56772
MCKELVEY, MICHAEL H.
Engineering reliability and maintainability review - A regimen for discovering production deficiencies
p 1120 A92-56254
MCKILLIP, ROBERT M., JR.
Research on measurement and control of helicopter rotor response using blade-mounted accelerometers 1990-91 p 1057 A92-56316
MCKILLIP, ROBERT, JR.
Approximations for inclusion of rotor lag dynamics in helicopter flight dynamics models p 1060 A92-56354
MCLAUGHLIN, MICHAEL P.
Safety study of TCAS 2 for logic version 6.04
[DOT/FAA/RD-92/22] p 1047 N92-32537
MCLVER, DOUGLAS W.
Developing robust support structures for high-technology subsystems: The AH-64 Apache helicopter
[AD-A252773] p 1017 N92-33499
MCMASTERS, J. H.
High Reynolds number testing in support of transport airplane development
[AIAA PAPER 92-3982] p 1099 A92-56807
MCQUADE, PETER D.
Optimization of a 2D scramjet-vehicle using CFD and simplified approximate flow analysis techniques
[AIAA PAPER 92-3673] p 1022 A92-54116
MEAKIN, ROBERT L.
Computations of the unsteady flow about a generic wing/pylon/finned-store configuration
[AIAA PAPER 92-4568] p 1027 A92-55377
MEDEPALLI, SUDHAKAR
A Lie Bracket solution of the optimal thrust magnitude on a singular arc in atmospheric flight
[AIAA PAPER 92-4345] p 1079 A92-55334
MEERWIJK, L.
Real-time helicopter simulation using the blade element method p 1132 A92-56278
MEIER, G. E. A.
Sound produced by vortex-airfoil interaction
p 1136 A92-56345
MEIJER, JOS J.
Understanding and development of a prediction method of transonic limit cycle oscillation characteristics of fighter aircraft
[AIAA PAPER 92-4501] p 1026 A92-55369
MEISNER, JOHN W.
Field test of an advanced maintenance-system
p 1016 A92-56221
MELCONIAN, JERRY O.
The VRT gas turbine combustor - Phase II
[AIAA PAPER 92-3471] p 1067 A92-54035
MEN'SHOV, I. S.
Increasing the accuracy of the Godunov scheme for calculating steady-state supersonic gas flows by solving the generalized Riemann problem p 1035 A92-57499
MENEGHETTI, U.
Monitoring fatigue cracks in gears
p 1116 A92-54496
MENGERT, P.
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
MENON, P. K. A.
Vision-based stereo ranging as an optimal control problem
[AIAA PAPER 92-4418] p 1045 A92-55211
MERCER, B. P.
Technology exploitation for in-service support of future rotorcraft p 1016 A92-56327
MERCURIO, U.
CFRP stiffened panels under compression
p 1109 N92-33044
MESSERSCHMID, E.
Optimization of two stage reusable space transportation systems with rocket and airbreathing propulsion concepts
[IAF PAPER 92-0863] p 1104 A92-57254
MESSITT, D. G.
Comparison between computational and experimental data for a hypersonic laser propelled vehicle
[AIAA PAPER 92-3808] p 1023 A92-54179
METCALFE, M. T.
The impact of air transport on the environment
[PNR-90876] p 1129 N92-33751
METZGER, D. E.
Experimental modeling of film-cooled axial turbine tip seals
[AIAA PAPER 92-4058] p 1119 A92-56141
METZGER, MICHAEL A.
Notes on the use of fusible temperature indicators to bound the temperature of hot graphite in the NAVSWC hypervelocity wind tunnel facility p 1090 A92-54315
MEYER, J.
Effects of the roll angle on cruciform wing-body configurations at high incidences
[AIAA PAPER 92-4356] p 1079 A92-55342
Pulsating spanwise blowing on a fighter aircraft
[AIAA PAPER 92-4359] p 1025 A92-55345

MEYER, T. G.
Life prediction and constitutive models for engine hot section anisotropic materials program
[NASA-CR-189223] p 1072 N92-33479
MEYER, THOMAS J.
Robust identification of nonlinear aerodynamic model structure
[AIAA PAPER 92-4503] p 1081 A92-55370
MEYERS, JAMES F.
Signal processing schemes for Doppler global velocimetry p 1115 A92-54338
MIAGKOV, IU. A.
Oscillations of an anisotropic rotor on an elastic anisotropic support p 1057 A92-56311
MIKAMI, TADASHI
Experimental investigation of the boundary layer in a corner formed by two circular arc airfoils p 1029 A92-56046
MIKAMI, TATSUO
Space plane navigation simulation p 1103 A92-53603
MIKI, YOICHIRO
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
MIKI, YOUICHIRO
Key design considerations for scramjet powered space plane p 1066 A92-53491
MILES, R.
Rayleigh imaging and flow tagging in ground test facilities p 1115 A92-54330
MILHOLEN, WILLIAM E., II
Numerical modeling of transonic juncture flow
[AIAA PAPER 92-4036] p 1035 A92-56858
MILLER, C. G., III
Hypersonic aerodynamic/aerothermodynamic testing capabilities at Langley Research Center
[AIAA PAPER 92-3937] p 1096 A92-56767
MILLER, D. C.
An improved compressor performance prediction model
[PNR-90873] p 1072 N92-33749
MILLER, L. S.
A simple three component velocity measurement method using a rotated split-film sensor p 1115 A92-54333
MISHIWAKI, OSAMU
Present status of Al-Li alloys p 1106 A92-56105
MITANI, TOHRU
A preliminary study of a supersonic wind tunnel for a ram jet test facility p 1089 A92-53564
MITRY, SAMEH A.
Transfer function between airborne VLF transmit and receive loop antenna p 1045 A92-54754
MITSUDA, M.
Numerical prediction of the flow characteristics in an arc wind tunnel
[AIAA PAPER 92-4016] p 1100 A92-56838
MITSUMA, HIDEHIKO
Fabrication test and evaluation of graphite/PMR-15 polyimide for HOPE primary structure p 1105 A92-53516
MIURA, YOSIHIRO
Gust response and cross wind performance of a hovercraft with vertical wings p 1118 A92-56034
MIWA, HITOSHI
On the structure of unsteady shock induced separation of the transonic airfoil in the NAL two-dimensional wind tunnel p 1029 A92-56010
BGK1 airfoil oilflow tests in the NAL two-dimensional wind tunnel. II p 1029 A92-56044
MIYABA, HIROSHI
Concepts of flight experiments for HOPE development p 1103 A92-53635
MIYAJIMA, H.
A model study on diffuser pressure recovery in NAL scramjet test facility with simulated hydrogen combustion
[AIAA PAPER 92-3979] p 1071 A92-56805
MIYAKE, SHO
HOPE re-entry experimental vehicle p 1103 A92-55098
MIYAZAWA, YOSHIKAZU
Multiple delay model approach applied to the AIAA 1922 Controls Design Challenge
[AIAA PAPER 92-4630] p 1078 A92-55305
Synthesis of gust load alleviation with flutter margin augmentation p 1082 A92-56021
Robust control system design with multiple model approach p 1083 A92-56029
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
MODI, V. J.
Reduction of the side force on pointed forebodies through add-on tip devices p 1024 A92-54918
MOES, TIMOTHY R.
High angle-of-attack flush airdata sensing system p 1064 A92-56172
MOHLER, STANLEY H., JR.
Predicting droplet impingement on yawed wings p 1043 A92-56180
MONGIA, HUKAM C.
The VRT gas turbine combustor - Phase II
[AIAA PAPER 92-3471] p 1067 A92-54035
MONTA, WILLIAM J.
Test description and preliminary pitot-pressure surveys for Langley Test Technique Demonstrator at Mach 6
[AIAA PAPER 92-3940] p 1096 A92-56770
MONTAGUE, T.
Integrated Russian VLF/Omega receiver design
[PB92-193390] p 1051 N92-33809
MONTAZEL, X.
Turbulent combustion modelling in a side dump ramjet combustor
[AIAA PAPER 92-3599] p 1112 A92-54075
MONTESARCHIO, B.
Structural design and testing results of composite landing gear components p 1057 A92-56328
MONTI, RODOLFO
Detecting 3-D, turbulent separation regions using unsteady computerized thermographic technique p 1023 A92-54308
MOOK, D. J.
Robust control design of an automatic carrier landing system
[AIAA PAPER 92-4619] p 1077 A92-55296
Robust identification of nonlinear aerodynamic model structure
[AIAA PAPER 92-4503] p 1081 A92-55370
MOOK, DEAN T.
Numerical simulations of flutter and its suppression by active control
[AIAA PAPER 92-4652] p 1082 A92-55396
MOORE, GARY
United States Air Force summer research program 1991. Volume 1: Program management report
[AD-A248763] p 1142 N92-32338
MOORE, JOAN G.
Effects of curvature and rotation on turbulence in the NASA low-speed centrifugal compressor impeller p 1124 N92-32292
MOORE, JOHN
Effects of curvature and rotation on turbulence in the NASA low-speed centrifugal compressor impeller p 1124 N92-32292
MOOZ, WILLIAM E.
Developing robust support structures for high-technology subsystems: The AH-64 Apache helicopter
[AD-A252773] p 1017 N92-33499
MORAN, FRANCIS J.
A workstation-based evaluation of a far-field route planner for helicopters
[NASA-TM-102882] p 1051 N92-33609
MORGAN, R. G.
Effects of oxygen dissociation on hypervelocity combustion experiments
[AIAA PAPER 92-3964] p 1098 A92-56791
MORIMOTO, MITSUO
A320 flight control from the pilot's point of view p 1083 A92-56028
MORIMOTO, S.
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729
MORIMOTO, TOSIYUKI
Three-dimensional numerical analysis of impinging circular jet - Discrete vortex method p 1029 A92-56040
MORITA, S.
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
MORIYAMA, KAZUO
An identification procedure for a system with a choice of feedback structures p 1132 A92-55426
MORRIS, CHARLES E. K., JR.
Technologies for the National Aero-Space Plane
[IAF PAPER 92-0868] p 1105 A92-57259
MOSELLE, J. R.
A database of aerothermal measurements in hypersonic flow for CFD validation
[AIAA PAPER 92-4023] p 1034 A92-56845
MOSKOW, HARRY J.
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964
MOTODA, TOSHIKAZU
An identification procedure for a system with a choice of feedback structures p 1132 A92-55426
MOULDEN, TREVOR H.
A double chaotic attractor in transonic flow p 1019 A92-53561
MOURTOS, N.
Development and integration of modern laboratories in aerospace education
[AIAA PAPER 92-4022] p 1141 A92-56844
MU, J. S.
Study on supersonic combustion in a hypersonic flight
[IAF PAPER 92-0661] p 1106 A92-57101
MUDFORD, N. R.
Unsteady shock propagation in a steady flow nozzle expansion p 1023 A92-54489
MUELLER, R. H. G.
A small light-weight rotor platform for ground observation and pollution control p 1057 A92-56329
MUELLER, T. J.
The design of a subsonic low-noise, low-turbulence wind tunnel for acoustic measurements
[AIAA PAPER 92-3883] p 1094 A92-56726
MUGGLI, W.
'A new proposal for an old problem' - The right engine for the right helicopter p 1070 A92-56281
MULGUND, SANDEEP S.
Optimal recovery from microburst wind shear
[AIAA PAPER 92-4338] p 1078 A92-55327
MULLEN, ROBERT L.
Thermal mechanical analysis of sprag clutches
[NASA-CR-190686] p 1128 N92-34207
MUNDUS, BERNHARD
Influence of the swirl producing construction in the flow and reaction field of turbulent diffusion flames
[ETN-92-92103] p 1127 N92-33916
MUNRO, BRUCE C.
Nonlinear model-following control application to airplane control (1992 AIAA Controls Design Challenge)
[AIAA PAPER 92-4625] p 1077 A92-55302
MUNTZ, E. P.
A code validation strategy and facility for nonequilibrium, reacting flows
[AIAA PAPER 92-3970] p 1098 A92-56796
MURAKAMI, A.
Supersonic wind tunnel test of airintake/airframe integrated models p 1028 A92-56006
MURAKAMI, AKIRA
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
MURAKAMI, ATSUO
Flow measurements in scramjet inlets p 1102 A92-53565
MURAKAMI, YOSHITAKA
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of MLS p 1047 A92-56117
MURAO, RINICHI
On the maneuvering tests of an ACV model p 1118 A92-56035
Configuration of flexible-skirts for an ACV and its CAD p 1118 A92-56036
MURATA, MASAAKI
Space plane navigation simulation p 1103 A92-53603
MURATA, MASAKI
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
MURAYAMA, TOSHI
Thermally and chemically nonequilibrium hypersonic flow in three-dimensional geometry p 1019 A92-53580
MURAYAMA, TOSHIYUKI
Three-dimensional calculation of radiative field in hypersonic air shock layers p 1023 A92-54498
MUROTA, K.
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test p 1093 A92-56114
MUROTA, KATSUICHI
Measurements of longitudinal static aerodynamic coefficients with cable mount system p 1093 A92-56013
MUROTSU, YOSHISADA
A development of hypermedia type database system for instruction of aircraft conceptual design p 1132 A92-56113
MURPHY, JAY
Comparison of frequency domain and time domain laser velocimeter signal processors p 1114 A92-54314
MURRAY-SMITH, D. J.
The identification of coupled flapping/inflow models for hovering flight p 1058 A92-56335
MURTHY, DURBHA V.
FREPS - A forced response prediction system for turbomachinery blade rows
[AIAA PAPER 92-3072] p 1130 A92-54006

Aeroelastic modal characteristics of mistuned blade assemblies - Mode localization and loss of eigenstructure p 1117 A92-54921

MURTHY, S. N. B.
Flowpath and sensitivity analyses of high speed propulsion systems
[AIAA PAPER 92-3806] p 1069 A92-54178

MYRABO, L. N.
Comparison between computational and experimental data for a hypersonic laser propelled vehicle
[AIAA PAPER 92-3808] p 1023 A92-54179

N

NADER, BLAIR A.
Issues in developing control zones for international space operations p 1141 A92-56602

NAGAHATA, M.
Flutter analysis and wind tunnel test with respect to a low-aspect-ratio wing with free-rotational control surface p 1052 A92-56014
Whirl flutter analysis and application to aircraft design p 1053 A92-56017

NAGAHATA, MASASHI
Propeller-nacelle whirl flutter analysis and wind tunnel test p 1052 A92-56016

NAGAHITA, MASASHI
Analysis and wind tunnel test of low aspect wing gust load alleviation p 1053 A92-56020

NAGAMATSU, H. T.
Comparison between computational and experimental data for a hypersonic laser propelled vehicle
[AIAA PAPER 92-3808] p 1023 A92-54179

NAGANO, KOUTAROU
Analysis of spacecraft entry into Mars atmosphere p 1105 N92-33763

NAGAO, T.
Helicopter rotor testing using scaled model p 1093 A92-56076

NAGAO, TORU
An experimental study on variable pressure hydraulic flight control system p 1084 A92-56119

NAGAOKA, SAKAE
Height keeping performance requirements for reducing vertical separation minima used for air traffic control p 1046 A92-56081

NAGARAJA, K. S.
The wind tunnel, its evolution for aerospace test purposes, perspective for curriculum development
[AIAA PAPER 92-4017] p 1100 A92-56839

NAGASHIMA, TOMOARI
Measurements of blade flapping motion on a wind tunnel model p 1093 A92-56023
Structural optimization of a cantilevered beam subject to combined static loadings p 1118 A92-56024
Optimization approach for helicopter maneuverability with a point mass model p 1083 A92-56025

NAGATI, M. G.
An efficient algorithm for optimal aircraft trajectories
[AIAA PAPER 92-4412] p 1076 A92-55206

NAGAYASU, M.
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test p 1093 A92-56114

NAGAYASU, MASAHIKO
Flight simulator test of cockpit advisory system p 1054 A92-56115
Evaluation of a IMU with optical fiber gyros in dynamic windtunnel tests p 1104 A92-56121

NAGESH BABU, G. L.
Smart structures in the active control of blade vortex interaction p 1085 A92-56314

NAKA, M.
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596

NAKADATE, M.
Helicopter rotor testing using scaled model p 1093 A92-56076

NAKAJIMA, KEN
Analysis of spacecraft entry into Mars atmosphere p 1105 N92-33763

NAKAJIMA, TOMOYA
Three-dimensional numerical analysis of impinging circular jet - Discrete vortex method p 1029 A92-56040

NAKAMICHI, JIRO
Research on aeroelastic tailoring at NAL p 1053 A92-56019

NAKAMURA, MASARU
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116

NAKAMURA, S.
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055

NAKAMURA, SYUNRO
A potential flow theory of two-dimensional bifurcated curtain jets. II p 1118 A92-56039

NAKAMURA, YUKINOBU
Improvement of atmospheric flight performance of a space vehicle through H infinity-control theory p 1130 A92-53785

NAKANISHI, HIDEKI
Roles of wind tunnel tests and CFD analyses in the design of energy-efficient SST
[AIAA PAPER 92-3923] p 1133 A92-56754

NAKAO, SHIGEHIDE
Experimental investigation on turbulent phenomena in three-dimensional shock wave/turbulent boundary layer interaction induced by blunt fin p 1018 A92-53557
Experimental study on three-dimensional shock wave-turbulent boundary layer interaction induced by protuberance p 1019 A92-53997
Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance p 1029 A92-56009

NAKATANI, HIROSHI
Mechanical properties of laminate aluminum matrix composites p 1106 A92-56102

NAKAUCHI, YASUO
Preliminary airfoil testing experience in the NDA cryogenic wind tunnel p 1091 A92-54326

NAKAYAMA, HIROTOSHI
Mechanical properties of laminate aluminum matrix composites p 1106 A92-56102

NALLASAMY, M.
Unsteady blade pressures on a propfan - Predicted and measured compressibility effects
[AIAA PAPER 92-3774] p 1023 A92-54161

NANNONI, F.
Correlation of flight, tunnel and prediction data on a helicopter main rotor p 1059 A92-56350

NARAYANSWAMI, N.
Structure of crossing-shock wave/turbulent boundary-layer interactions
[AIAA PAPER 92-3670] p 1022 A92-54113

NARKIEWICZ, JANUSZ
Simulation of helicopter see-saw rotor motion p 1055 A92-56287

NARUO, YOSHIHIRO
Development study on air turbo-ramjet engine for space plane p 1065 A92-53487
Tests results on Air Turbo Ramjet for a future space plane
[IAF PAPER 92-0657] p 1071 A92-57098

NASR, HATEM
Study objectives: Will commercial avionics do the job? Improvements needed? p 1065 N92-33340

NAUMANN, K. W.
Millisecond aerodynamic force measurement with side-jet model in the ISL shock tunnel
[AIAA PAPER 92-3963] p 1097 A92-56790

NEKOHASHI, TOSHIFUMI
Structural optimization of a cantilevered beam subject to combined static loadings p 1118 A92-56024
Optimization approach for helicopter maneuverability with a point mass model p 1083 A92-56025

NELSON, B. A.
Formation and sustainment of a very low aspect ratio tokamak using coaxial helicity injection: Helicity Injected Torus (HIT) experiment
[DE92-014311] p 1136 N92-32595

NELSON, P. A.
Active control of sound transmission through stiff lightweight composite fuselage constructions p 1137 N92-32957

NELSON, ROBERT C.
A discrete vortex model for predicting wing rock of slender wings
[AIAA PAPER 92-4497] p 1026 A92-55365
Wind tunnel blockage effects on slender wings undergoing large amplitude motions
[AIAA PAPER 92-3926] p 1096 A92-56757

NEUHART, DAN H.
A laser fluorescence anemometer system for the Langley 16- by 24-inch water tunnel p 1092 A92-54347

NEUMAN, FRANK
Analysis of delay reducing and fuel saving sequencing and spacing algorithms for arrival traffic
[NASA-TM-103880] p 1044 N92-33194

NEUMANN, RICHARD D.
The wind tunnel test 'system' of 1995 - Cost effective experimentation through a fusion of related technologies p 1091 A92-54342
Hypersonic wind tunnel nozzle study
[AIAA PAPER 92-4012] p 1033 A92-56835

NEWELL, DOUGLAS F.
Hypervelocity Wind Tunnel 9 control system p 1092 A92-54343

NEWFIELD, MARK E.
Flow characterization in the NASA Ames 16-inch Shock Tunnel
[AIAA PAPER 92-3810] p 1090 A92-54180

NEWMAN, J. C., JR.
Effects of constraint on crack growth under aircraft spectrum loading
[NASA-TM-107677] p 1128 N92-34178

NGUYEN, H. L.
Applied analytical combustion/emissions research at the NASA Lewis Research Center - A progress report
[AIAA PAPER 92-3338] p 1067 A92-54025

NGUYEN, HUNG L.
The VRT gas turbine combustor - Phase II
[AIAA PAPER 92-3471] p 1067 A92-54035

NI, X. Q.
Fault diagnostics on jet engine starting p 1116 A92-54345

NICHOLAS, O. P.
Collaborative research on V/STOL control system/cockpit display tradeoffs under the NASA/MOD joint aeronautical program
[NASA-TM-103910] p 1087 N92-32788

NICKS, ORAN
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063

NICOL, DAVID M.
Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483

NIESL, GEORG
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344

NIEUWPOORT, A. M. H.
A simulator evaluation of various manual control concepts for fly-by-wire transport aircraft
[AIAA PAPER 92-4328] p 1073 A92-55172

NIIMI, KENJI
An experimental program concerning a satellite data link for oceanic ATC p 1046 A92-56093

NIINO, MASAYUKI
Conceptual design of scramjet engine p 1065 A92-53490

NIKIFOROVA, L. N.
The solution of the helicopter flight dynamics tasks by the methods of optimal control theory p 1085 A92-56284

NINO, MASAYUKI
Scramjet engine and its flying test bed p 1066 A92-53492

NISHIDA, MICHIO
Hypersonic flows with air chemistry over a reentry vehicle at high altitudes p 1017 A92-53549

NISHIMURA, HIROFUMI
Estimation of aircraft inertial characteristics using maximum likelihood estimation p 1084 A92-56057

NISIOKA, JUN
An experimental study on variable pressure hydraulic flight control system p 1084 A92-56119

NISSLEY, D. M.
Life prediction and constitutive models for engine hot section anisotropic materials program
[NASA-CR-189223] p 1072 N92-33479

NISTLER, NOEL F.
A learning enhanced flight control system for high performance aircraft
[AD-A252520] p 1086 N92-32435

NITSCHE, W.
Shock detection on airfoils by means of piezo foil- and hot film arrays p 1115 A92-54334

NITTA, KYOKO
Motion analysis of 2-dimensional flat plate in ground effect p 1030 A92-56053

NIVEN, A. J.
Measurements of the dynamic stall vortex convection speed p 1032 A92-56351

NIWA, M.
Measurement of position and attitude using laser and retro-reflectors p 1047 A92-56120

NIWA, NOBUO
Wind tunnel test of M = 2.5 mixed compression inlet p 1028 A92-56008

NOBBS, S. G.
Development of the full-envelope Performance Seeking Control algorithm
[AIAA PAPER 92-3748] p 1068 A92-54148

NODA, J.
Supersonic wind tunnel test of airintake/airframe integrated models p 1028 A92-56006

NODERER, KEITH D.
Aerodynamic parameters of the X-31 drop model estimated from flight-data at high angles of attack
[AIAA PAPER 92-4357] p 1080 A92-55343
NOGUCHI, MASAYOSHI
High subsonic wind tunnel test of a two-dimensional hybrid-laminar-flow-control airfoil with slotted surface
p 1029 A92-56045
NOGUCHI, TOSHIHIKO
Engine condition monitoring system for B747-400
p 1064 A92-56082
NOMOTO, HIDEKI
A hypersonic wind tunnel test of a mixed-compression air inlet model p 1028 A92-56007
NOMURA, S.
New 1.27-m leg of the National Aerospace Laboratory hypersonic wind tunnel p 1092 A92-56003
NOMURA, SHIGEAKI
Aerodynamic studies on space plane configuration at hypersonic speed p 1019 A92-53641
NONAKA, O.
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test
p 1093 A92-56114
NONAKA, OSAMU
On improvements of three-dimensional position measuring system for dynamic wind tunnel testing
p 1093 A92-56012
NORDWALL, BRUCE D.
Modified Doppler detects wind shear more reliably
p 1015 A92-55099
NORLIN, KENNETH
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
NOWLIN, BRENT C.
Description of a pressure measurement technique for obtaining surface static pressures of a radial turbine
[AIAA PAPER 92-4006] p 1123 A92-56829
NOZUMI, KOKI
Synthesis of a MLS automatic landing control law for the NAL experimental research aircraft Do-228
p 1084 A92-56062
NUSCA, M. J.
Experimental and computational investigation of scaling phenomena in a large caliber ram accelerator
[AIAA PAPER 92-3245] p 1103 A92-54019

O

O'ROURKE, MATTHEW J.
A simulation model for tail rotor failure
[AIAA PAPER 92-4633] p 1081 A92-55380
OBAYASHI, S.
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
OBAYASHI, SHIGERU
Navier-Stokes computations for oscillating control surfaces
[AIAA PAPER 92-4431] p 1026 A92-55355
Unsteady shock-vortex interaction on a flexible delta wing p 1030 A92-56157
OBERMEIER, F.
Sound produced by vortex-airfoil interaction
p 1136 A92-56345
OBUKATA, M.
Helicopter rotor testing using scaled model
p 1093 A92-56076
OCHI, YOSHIMASA
Design of a flight control system using a feedback-error-learning-type neural network
p 1132 A92-56067
Application of restructurable flight control system using nonlinear control to an airliner p 1084 A92-56068
OCHIAI, JUN-ICHI
Fundamental studies on Marangoni convection related to Bridgman crystal growth p 1111 A92-53758
ODGERS, J.
Acoustic control of combustor primary zone air-jet mixing
[AIAA PAPER 92-3651] p 1067 A92-54104
OGATA, TAKASHI
Change and reliability of the DC-9-81 digital flight guidance system p 1084 A92-56086
OHKAMI, Y.
Airbreathing engine selection criteria for SSTO propulsion system
[IAF PAPER 92-0658] p 1071 A92-57099
OHMOMO, MITSUHARA
Development of ITS90 small gas turbine engine
p 1070 A92-55500
OHMORI, SHINGO
History of aeronautical satellite communications
p 1046 A92-56088
OHMORI, YASUNORI
Conceptual design of scramjet engine
p 1065 A92-53490
OHNO, MASAHIRO
Flight control system design using H(infinity) optimal control p 1083 A92-56030
OHTA, HIROBUMI
Motion analysis of 2-dimensional flat plate in ground effect p 1030 A92-56053
Estimation of aircraft inertial characteristics using maximum likelihood estimation p 1084 A92-56057
OKAYAMA, YUICHI
Numerical simulation of supersonic unsteady flow using a panel method p 1030 A92-56048
OKIISHI, T. H.
An experimental investigation of the flow in a diffusing S-duct
[AIAA PAPER 92-3622] p 1021 A92-54090
OKUBA, T.
Measurement of position and attitude using laser and retro-reflectors p 1047 A92-56120
OKUNO, YOSHINORI
Optimal control of helicopters following power failure
[AIAA PAPER 92-4471] p 1076 A92-55231
Optimal launch trajectory of a hypersonic research vehicle
[AIAA PAPER 92-4302] p 1103 A92-55310
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of MLS
p 1047 A92-56117
Optimal control of tiltrotor aircraft following power failure p 1085 A92-56303
OKUNUKI, T.
Measurements of turbulence in hypersonic flow
p 1092 A92-56005
OKURA, K.
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055
OLEJAK, D.
Investigation of a plate-ramp-configuration by means of laser Doppler anemometry at Mach 2.95
[AIAA PAPER 92-3956] p 1097 A92-56784
ONISHI, T.
Optimization of composite material wing of fighter type aircrafts p 1053 A92-56018
ONO, TAKATSUGU
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of MLS
p 1047 A92-56117
ONODERA, H.
Double piston shock-wave valve p 1117 A92-54938
ONORATO, M.
Skin friction measurements in 3-D boundary layers
p 1092 A92-54351
ONOZUKA, SACHIKO
A consideration on air traffic control processing capability in terminal area p 1047 A92-56110
OONUMA, MASAHIKO
An experimental program concerning a satellite data link *for oceanic* ATC p 1046 A92-56093
OOTSUBO, AKIRA
Study of potassium turbine electric generator system
p 1129 N92-33794
ORMISTON, ROBERT A.
Finite-element analysis and multibody dynamics issues in rotorcraft dynamic analysis p 1055 A92-56286
First level release of 2GCHAS for comprehensive helicopter analysis p 1133 A92-56339
ORNGARD, GARY M.
A laser fluorescence anemometer system for the Langley 16- by 24-inch water tunnel
p 1092 A92-54347
OSHCHEPKOV, M. IU.
Pulsation characteristics of one-phase and two-phase steam flows in Laval nozzles under off-design conditions
p 1019 A92-53882
OSLAC, MICHAEL J.
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964
OSTER, REINHOLD
Computed tomography (CT) as a nondestructive test method used for composite helicopter components
p 1121 A92-56276
OSWALD, FRED B.
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
OTHMER, P.
Detonation duct gas generator demonstration program
[AIAA PAPER 92-3174] p 1066 A92-54011
OWEN, F. K.
A laser fluorescence anemometer system for the Langley 16- by 24-inch water tunnel
p 1092 A92-54347

P

PACHTER, M.
Automatic formation flight control
[AIAA PAPER 92-4473] p 1076 A92-55233
PADFIELD, G. D.
Creation of a living specification for an experimental helicopter active flight control system through incremental simulation p 1057 A92-56312
PADUANO, J.
Active control of compressor surge and stall
[AD-A252771] p 1126 N92-33498
PAGE, M.
Continuous flying quality improvement - The measure and the payoff
[AIAA PAPER 92-4327] p 1073 A92-55171
PAGNANO, G.
Current European research activities in helicopter interactional aerodynamics p 1058 A92-56330
Correlation of flight, tunnel and prediction data on a helicopter main rotor p 1059 A92-56350
PAILLARD, JACQUES
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
PAIPETIS, S. A.
Jet fuel absorption and dynamic mechanical analysis of carbon fibre composites p 1110 N92-33050
PALASIS, D.
Development of a conceptual design method for rotary-wing aircraft using digital computers
p 1058 A92-56340
PALAZOGLU, A.
An framework for robust flight control design using constrained optimization
[AIAA PAPER 92-4603] p 1131 A92-55282
PALKIN, V. A.
The study of experimental turboramjets
[AIAA PAPER 92-3720] p 1067 A92-54135
PALLISTER, KEITH
Comparison of recent results from different wind tunnel facilities along with comparisons of measured flight results and wind tunnel based predictions
[AIAA PAPER 92-3985] p 1060 A92-56809
PALUCH, B.
A finite element method for shear stresses calculation in composite blade models p 1121 A92-56322
PALUMBO, DANIEL L.
Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483
PAONESSA, A.
Active vibrations and noise control for turboprop application research program activities
p 1138 N92-32962
PAPAS, P.
Structure and penetration of a transverse fluid jet injected at supercritical pressure in supersonic flow
[AIAA PAPER 92-3652] p 1113 A92-54105
PAPAVASSILIOU, I.
Coupled rotor-fuselage vibration reduction with multiple frequency blade pitch control p 1085 A92-56315
PAPAVERGOS, PANAYIOTIS G.
Spray nozzle for fire control
[CA-PATENT-APPL-SN-2-011-94] p 1125 N92-32856
PARK, CHOONG S.
A development of hypermedia type database system for instruction of aircraft conceptual design
p 1132 A92-56113
PARK, CHUL
Laboratory simulation of aerothermodynamic phenomena - A review
[AIAA PAPER 92-4025] p 1104 A92-56847
PARKER, JON
Comparison of recent results from different wind tunnel facilities along with comparisons of measured flight results and wind tunnel based predictions
[AIAA PAPER 92-3985] p 1060 A92-56809
PARR, T.
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
PARRISH, RUSSELL V.
Computational algorithms for increased control of depth-viewing volume for stereo three-dimensional graphic displays
[NASA-TM-4379] p 1065 N92-34109
PARTRIDGE, HARRY
H-N2 interaction energies, transport cross sections, and collision integrals p 1135 A92-54660

PATTERSON-HINE, F. A.
Modular techniques for dynamic fault-tree analysis p 1120 A92-56241
PAUL, GREG
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program
[AD-A247886] p 1108 N92-32629
PAUL, P. C.
Out of plane analysis for composite structures p 1107 N92-32527
PAUS, M.
A general approach to optimal real-time guidance of dynamic systems based on nonlinear programming
[AIAA PAPER 92-4378] p 1131 A92-55182
PAWLIK, SIMON R., SR.
Development of rating instruments and procedures for aviation mishap investigation
[AD-A253072] p 1044 N92-33288
PEAKE, N.
The interaction between a high-frequency gust and a blade row p 1135 A92-54484
PENN, JAY
Combined exo/endoatmospheric transport alternatives
[IAF PAPER 92-0663] p 1104 A92-57102
PERNICKA, H.
Development and integration of modern laboratories in aerospace education
[AIAA PAPER 92-4022] p 1141 A92-56844
PERREY, G.
HEPO mission simulator - Development and usage for NH90 helicopter p 1094 A92-56313
PERUSEK, GAIL P.
Experimental performance of three design factors for ventral nozzles for SSTOVL aircraft
[AIAA PAPER 92-3789] p 1069 A92-54168
Use of an approximate similarity principle for the thermal scaling of a full-scale thrust augmenting ejector
[AIAA PAPER 92-3792] p 1069 A92-54171
PETERSON, B.
Integrated Russian VLF/Omega receiver design
[PB92-193390] p 1051 N92-33809
PETIT, GERARD
The need for GPS standardization p 1049 N92-33351
Precise GPS ephemerides from DMA and NGS tested by time transfer p 1049 N92-33355
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
PETTERS, DEAN P.
Further studies of kinetic energy methods in high speed ramjet cycle analysis
[AIAA PAPER 92-3805] p 1069 A92-54177
PHAM-VAN-DIEP, G.
A code validation strategy and facility for nonequilibrium, reacting flows
[AIAA PAPER 92-3970] p 1098 A92-56796
PHATAK, ANIL V.
Analysis of image-based navigation system for rotorcraft low-altitude flight p 1046 A92-55968
PICKETT, MARK T.
Flow quality studies of the NASA Lewis Research Center 8- by 6-foot supersonic/9- by 15-foot Low Speed Wind Tunnel
[AIAA PAPER 92-3916] p 1095 A92-56748
PIERCE, ALLAN D.
Wave equations and computational models for sonic boom propagation through a turbulent atmosphere p 1139 N92-33877
Simulations of sonic boom ray tube area fluctuations for propagation through atmospheric turbulence including caustics via a Monte Carlo method p 1139 N92-33878
PIERRE, CHRISTOPHE
Aeroelastic modal characteristics of mistuned blade assemblies - Mode localization and loss of eigenstructure p 1117 A92-54921
PINNINGTON, R. J.
Active control of sound transmission through stiff lightweight composite fuselage constructions p 1137 N92-32957
PIOU, JEAN E.
Robust sampled data eigenstructure assignment using the delta operator
[AIAA PAPER 92-4400] p 1075 A92-55200
PIPES, R. BYRON
Continuation of tailored composite structures of ordered staple thermoplastic material
[NASA-CR-189671] p 1110 N92-33613
PITZ, R. W.
Degenerate four-wave mixing for measurement of NO2 and smoke concentration in jet engine exhaust
[AIAA PAPER 92-3658] p 1113 A92-54108
Interaction between chemical reaction and turbulence in supersonic nonpremixed H2-air combustion p 1117 A92-54931
PLOT-LOCATELLI, SYLVIE
Research on some centered implicit methods for calculating transonic flows by solving Navier-Stokes equations
[ONERA-RSF-24/1408-AY-150A] p 1037 N92-32773
PLOTKIN, KENNETH J.
The effect of turbulence on the loudness of minimized sonic boom signatures p 1139 N92-33880
POINSOT, T.
Turbulent combustion modelling in a side dump ramjet combustor
[AIAA PAPER 92-3599] p 1112 A92-54075
POLANSKI, L.
The cryogenic balance design and balance calibration methods
[AIAA PAPER 92-4001] p 1122 A92-56824
POLLACK, M.
A simulation study of tiltrotor vertical takeoff procedures using conventional and variable diameter rotor systems p 1056 A92-56301
POLYCARPOU, M. M.
Identification and control of aircraft dynamics using radial basis function neural networks
[AIAA PAPER 92-4393] p 1074 A92-55194
POLZ, G.
Current European rotorcraft research activities on development of advanced CFD methods for the design of rotor blades (BRITE/EURAM 'DACRO' project) p 1032 A92-56332
POST, M. J.
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
POTASHEV, A. V.
Aerodynamic airfoils design by quasi-solutions method of inverse boundary-value problems p 1020 A92-53998
POVAROVA, K. B.
High-temperature metal matrix composite p 1105 A92-53878
PRABHU, DINESH K.
Numerical simulation of unsteady flow in a hypersonic shock tunnel facility
[AIAA PAPER 92-4029] p 1034 A92-56851
PRASAD, C. B.
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
PRASAD, J. V. R.
Smart structures in the active control of blade vortex interaction p 1085 A92-56314
Helicopter nonlinear flight control system development p 1085 A92-56317
PRESTON, J.
Continuous flying quality improvement - The measure and the payoff
[AIAA PAPER 92-4327] p 1073 A92-55171
PRIDGEON, SCOTT P.
Cost/benefit analysis of the AH-64 (Apache) helicopter Automated Test Equipment (ATE)
[AD-A252909] p 1101 N92-33398
PRIEL, BENI I.
The effect of gyro nonorthogonality error on gyrocompassing p 1045 A92-55955
PROBERT, BRIAN
Comparison of recent results from different wind tunnel facilities along with comparisons of measured flight results and wind tunnel based predictions
[AIAA PAPER 92-3985] p 1060 A92-56809
PRUFERT, M. B.
Turbine engine hot-part temperature measurement techniques
[AIAA PAPER 92-3960] p 1122 A92-56788
Turbine engine performance test and evaluation techniques
[AIAA PAPER 92-3977] p 1071 A92-56803
PRZEKWAS, A. J.
A finite-volume numerical method to calculate fluid forces and rotordynamic coefficients in seals
[AIAA PAPER 92-3712] p 1113 A92-54132
PUGH, EVAN R.
Laser-driven hypersonic air-breathing propulsion simulator
[AIAA PAPER 92-3922] p 1095 A92-56753

Q

QIU, Y. J.
Computational and experimental studies of flow in multi-lobed forced mixers
[AIAA PAPER 92-3568] p 1112 A92-54057
QUINLIVAN, RICHARD
C-17 flight control system overview p 1082 A92-55906

R

RADDATZ, J.
Analysis of helicopter rotor-fuselage interference with time averaged pressure distribution p 1032 A92-56331
RAFFA, ANTHONY
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131
RAISINGHANI, S. C.
Parameter estimation of an augmented airplane with unsteady aerodynamics modelling p 1073 A92-53546
RAMACHANDRAN, K.
The computation and validation of hovering rotor performance p 1055 A92-56285
RAMBONE, JAMES D.
ILS mathematical modeling study of an ILS localizer and glide slope proposed for runway 32R, Moffett Field Airport, California
[DOT/FAA/CT-TN92/28] p 1048 N92-33308
RAMESH, V.
Acoustic control of combustor primary zone air-jet mixing
[AIAA PAPER 92-3651] p 1067 A92-54104
RAMIZ, ANWAR
Dynamical scaling of a model unsteady separating flow p 1117 A92-54932
RAMOND, J. P.
The advantages of digital engine control as compared with traditional systems (hydraulic or pneumatic) p 1070 A92-56338
RAMSEY, JOHN
Experimental unsteady pressures on an oscillating cascade with supersonic leading edge locus
[AIAA PAPER 92-4035] p 1035 A92-56857
RAND, O.
Response of helicopter blades to a sharp collective increase p 1084 A92-56282
A generic harmonic rotor model for helicopter flight simulation p 1086 A92-56333
RANSOM, JONATHAN B.
Global/local methods research using the CSM testbed p 1107 N92-32528
Computational methods for global/local analysis
[NASA-TM-107591] p 1125 N92-33104
RAOL, J. R.
Computer aided evaluation of aircraft handling qualities and flight control system robustness
[AIAA PAPER 92-4423] p 1080 A92-55347
RAPP, HELMUT
Influence of cross section variations on the structural behaviour of composite rotor blades p 1121 A92-56320
RASHIDIAN, B.
An efficient algorithm for optimal aircraft trajectories
[AIAA PAPER 92-4412] p 1076 A92-55206
RASPET, RICHARD
Steady state risetimes of shock waves in the atmosphere p 1140 N92-33882
RASTY, J.
Electronics/avionics integrity - Definition, measurement and improvement p 1120 A92-56252
RAUSCH, VINCENT L.
Technologies for the National Aero-Space Plane
[IAF PAPER 92-0868] p 1105 A92-57259
RAY, RONALD J.
Effects of bleed air extraction of thrust levels on the F404-GE-400 turbofan engine
[AIAA PAPER 92-3092] p 1066 A92-54009
RE, RICHARD J.
Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193
REDDY, N. N.
Acoustic loads prediction on jet aircraft p 1136 N92-32949
REED, HELEN
Linear stability of supersonic cone boundary layers p 1024 A92-54910
REGENIE, VICTORIA
The F-18 high alpha research vehicle: A high-angle-of-attack testbed aircraft
[NASA-TM-104253] p 1060 N92-33404
REGENIE, VICTORIA A.
Experience with Ada on the F-18 High Alpha Research Vehicle Flight Test Program
[NASA-TM-104259] p 1062 N92-34039
REICHERT, B. A.
An experimental investigation of the flow in a diffusing S-duct
[AIAA PAPER 92-3622] p 1021 A92-54090
REICHERT, BRUCE A.
Navier-Stokes analysis and experimental data comparison of compressible flow in a diffusing S-duct
[NASA-TM-105683] p 1072 N92-33746

REICHERT, G.
Short takeoff optimization for the XV-15 tiltrotor aircraft p 1056 A92-56302
REID, L. D.
An evaluation of decelerating IFR approaches utilizing a helicopter flight simulator
[CTN-92-60348] p 1048 N92-32845
REINER, JAKOB
Robust dynamic inversion control laws for aircraft control
[AIAA PAPER 92-4329] p 1073 A92-55173
REINL, WERNER
Modern helicopter technologies at MBB and the application in future programmes p 1016 A92-56304
REISINGER, D.
Investigation of a plate-ramp-configuration by means of laser Doppler anemometry at Mach 2.95
[AIAA PAPER 92-3956] p 1097 A92-56784
The trisonic wind tunnel Muenchen and its involvement in the German SAeNGER-programme
[AIAA PAPER 92-4019] p 1100 A92-56841
RENAUD, J.
The Eurofar program - An European overview on advanced VTOL civil transportation system
p 1016 A92-56299
RENGER, KLAUS
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951
RESETAR, SUSAN A.
Advanced airframe structural materials: A primer and cost estimating methodology
[AD-A253371] p 1062 N92-34182
RESSLER, H.
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG
p 1050 N92-33356
RHODES, JAMES A.
Internal reversing flow in a tailpipe offtake configuration for SSTOVL aircraft
[AIAA PAPER 92-3790] p 1069 A92-54169
RIBNER, H. S.
Ideal efficiency of propellers based on Theodorsen's theory: A review and computer study, with extended plus simplified charts
[UTIAS-TN-271] p 1071 N92-33102
RICHTER, P.
Design and development of test rigs for main rotor and main rotor transmission of a helicopter in the 6-ton-class
p 1093 A92-56280
RICKETTS, RODNEY H.
Getting up to speed in hypersonic structures
p 1117 A92-55127
RIGBY, D. L.
Increased heat transfer to elliptical leading edges due to spanwise variations in the freestream momentum - Numerical and experimental results
[AIAA PAPER 92-3070] p 1020 A92-54005
RINALDI, STEPHEN F.
Hypervelocity Wind Tunnel 9 control system
p 1092 A92-54343
RIVERA, JOSE A., JR.
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter
[NASA-TM-104211] p 1042 N92-34147
RIZETTA, DONALD P.
Numerical simulation of slot injection into a turbulent supersonic stream p 1024 A92-54914
RIZZETTA, DONALD P.
Comparative numerical study of two turbulence models for airfoil static and dynamic stall
[AIAA PAPER 92-4649] p 1028 A92-55394
ROACH, R. L.
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
ROBBINS, MARC L.
Developing robust support structures for high-technology subsystems: The AH-64 Apache helicopter
[AD-A252773] p 1017 N92-33499
ROBELEN, DAVID B.
Model flight tests of a spin-resistant trainer configuration p 1054 A92-56158
ROBERTS, DONALD W.
Comparison of turbulence models for powered-lift flow fields
[AIAA PAPER 92-3674] p 1022 A92-54117
ROBERTS, LEONARD
Vortical flow control on a wing-body combination using *tangential blowing*
[AIAA PAPER 92-4430] p 1081 A92-55354
ROBINSON, LEICK D.
A numerical model for sonic boom propagation through an inhomogeneous, windy atmosphere
p 1138 N92-33876
ROBNIK, R.
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG
p 1050 N92-33356
ROGER, R. P.
Numerical study of the 3-D flowfield for a supersonic jet exiting into a hypersonic stream from a conical *surface*
[AIAA PAPER 92-3675] p 1022 A92-54118
ROGERS, J. C.
Advanced airframe structural materials: A primer and cost estimating methodology
[AD-A253371] p 1062 N92-34182
ROKUTANDA, ITARU
Tests results on Air Turbo Ramjet for a future space plane
[IAF PAPER 92-0657] p 1071 A92-57098
ROLFGEN, J. W.
G-Field Control of nonlinear systems
[AIAA PAPER 92-4555] p 1131 A92-55267
ROMAN, ALAN
Parameter identification of AV-8B wingborne aerodynamics for flight simulator model updates
[AIAA PAPER 92-4506] p 1027 A92-55373
ROSE, GAYLE E.
Wind tunnel performance results of swirl recovery vanes as tested with an advanced high speed propeller
[AIAA PAPER 92-3770] p 1068 A92-54159
ROSEN, A.
Dynamic analysis of rotor blades with root retention design variations p 1054 A92-56156
A generic harmonic rotor model for helicopter flight simulation p 1086 A92-56333
ROSEN, JAMES M.
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
ROSS, HOLLY M.
Model flight tests of a spin-resistant trainer configuration p 1054 A92-56158
ROSSOW, VERNON J.
Two-fence concept for efficient trapping of vortices on airfoils p 1031 A92-56165
ROSTAFINSKI, W.
Detonation duct gas generator demonstration program
[AIAA PAPER 92-3174] p 1066 A92-54011
ROUCHON, JEAN
Evaluation of the effects of the environment on the behavior of the primary structures of composite material aircraft in service: Historic and current situation
p 1110 N92-33048
ROUSSAUD, A.
Mechanisms of high-current pulses in lightning and long-spark stepped leaders p 1116 A92-54678
ROZHDESTVENSKII, MIKHAIL
Helicopter tail rotor stall flutter p 1056 A92-56290
RUAN, YEEFENG F.
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
RUBESIN, MORRIS W.
Assessment of compressibility corrections to the k-epsilon model in high-speed shear layers
p 1024 A92-54905
RUHMANN, DOUGLAS C.
New materials drive high-performance aircraft
p 1105 A92-55134
RUNYAN, R. B.
Thrust stand design principles
[AIAA PAPER 92-3976] p 1098 A92-56802
RUSNAK, ILAN
On-line identification and control of linearized aircraft dynamics p 1082 A92-55911
RUTKOWSKI, MICHAEL J.
First level release of 2GCHAS for comprehensive helicopter analysis p 1133 A92-56339
RUZICKA, GENE C.
Finite-element analysis and multibody dynamics issues in rotorcraft dynamic analysis p 1055 A92-56286
First level release of 2GCHAS for comprehensive helicopter analysis p 1133 A92-56339
RYALL, KATHLEEN
A graphical user-interface for propulsion system analysis
[NASA-TM-105696] p 1134 N92-33894
RYND, J. P., JR.
Thrust stand design principles
[AIAA PAPER 92-3976] p 1098 A92-56802

S

SAFF, C. R.
Out of plane analysis for composite structures
p 1107 N92-32527
SAFF, CHARLES
Turning up the heat on aircraft structures
p 1052 A92-55131
SAITO, HIROSHI
An investigation of the automation of emergency landings for helicopters p 1083 A92-56026
SAITO, K.
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055
SAITO, SHIGERU
Low-speed wind tunnel testing for the high-speed propeller at high shaft angle of attack
p 1030 A92-56054
SAITO, TERUO
Preliminary *airfoil testing experience in the NDA* cryogenic wind tunnel p 1091 A92-54326
SAITOH, TAMOTSU
Conceptual design of scramjet engine
p 1065 A92-53490
SAKAI, TOSHIHO
Synthesis of a MLS automatic landing control law for the NAL experimental research aircraft Do-228
p 1084 A92-56062
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
SAKAKIBARA, S.
New 1.27-m leg of the National Aerospace Laboratory hypersonic wind tunnel p 1092 A92-56003
SAKAKIBARA, SEIZOU
Aerodynamic study of H-II Orbiting Plane, HOPE
p 1103 A92-53639
SAKAKIBARA, TOSIO
Present status of Al-Li alloys p 1106 A92-56105
SAKAMOTO, AKIRA
Current status of R&D on materials for super/hypersonic transports p 1106 A92-56002
SAKAMOTO, Y.
Numerical prediction of the flow characteristics in an arc wind tunnel
[AIAA PAPER 92-4016] p 1100 A92-56838
SAKAMURA, YOSHITAKA
Hypersonic flows with air chemistry over a reentry vehicle at high altitudes p 1017 A92-53549
SAKATA, K.
Supersonic wind tunnel test of airintake/airframe integrated models p 1028 A92-56006
SAKATA, KIMIO
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
SAKURANAKA, NOBORU
A preliminary study of a supersonic wind tunnel for a ram jet test facility p 1089 A92-53564
SAMANIEGO, J. M.
Turbulent combustion modelling in a side dump ramjet combustor
[AIAA PAPER 92-3599] p 1112 A92-54075
SANDA, TOMIO
An example of whirl flutter analysis
p 1052 A92-56015
SANDERS, B.
Acoustic control of combustor primary zone air-jet mixing
[AIAA PAPER 92-3651] p 1067 A92-54104
SANGER, KENNETH B.
Out of plane analysis for composite structures
p 1107 N92-32527
SANKAR, L. N.
Numerical investigation of the effects of icing on fixed and rotary wing aircraft
[NASA-CR-190542] p 1044 N92-34105
SANTARE, MICHAEL H.
Continuation of tailored composite structures of ordered *staple thermoplastic material*
[NASA-CR-189671] p 1110 N92-33613
SAPORITI, A.
Current European research activities in helicopter interactional aerodynamics p 1058 A92-56330
SARAVIA, H. E.
Aerodynamic calculation of an elliptic ring wing
[AIAA PAPER 91-0068] p 1035 A92-57035
SARIC, WILLIAM S.
The ASU Transition Research Facility
[AIAA PAPER 92-3910] p 1094 A92-56744
SASA, S.
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test
p 1093 A92-56114
SASA, SHUICHI
On improvements of three-dimensional position measuring system for dynamic wind tunnel testing
p 1093 A92-56012
Evaluation of a IMU with optical fiber gyros in dynamic windtunnel tests p 1104 A92-56121

SASAKI, HIROSHI
Concepts of flight experiments for HOPE development p 1103 A92-53635
SASAKI, SHIGERU
Optimization approach for helicopter maneuverability with a point mass model p 1083 A92-56025
SASHIKUMA, HIROFUMI
An example of whirl flutter analysis p 1052 A92-56015
SASOH, AKIHIRO
Radiative heat transfer from nonequilibrium shock layer to a hypersonic reentry body p 1019 A92-53579
Three-dimensional calculation of radiative field in hypersonic air shock layers p 1023 A92-54498
SATIN, A. L.
Evaluation of GPS/UTC steering performance p 1049 N92-33353
SATO, HIROKI
A data processing system for oceanic air traffic control p 1046 A92-56090
SATO, HISASI
A low speed wind tunnel investigation of a joined-wing aircraft with an overhanging fin p 1030 A92-56078
A low speed wind tunnel investigation of the direct side force control of a joined-wing aircraft with overhanging fin p 1084 A92-56079
SATO, MAMORU
On the structure of unsteady shock induced separation of the transonic airfoil in the NAL two-dimensional wind tunnel p 1029 A92-56010
Evaluation of sidewall interference in the NAL two-dimensional transonic wind tunnel p 1092 A92-56011
BGK1 airfoil oilflow tests in the NAL two-dimensional wind tunnel. II p 1029 A92-56044
High subsonic wind tunnel test of a two-dimensional hybrid-laminar-flow-control airfoil with slotted surface p 1029 A92-56045
SATO, SHIGERU
A preliminary study of a supersonic wind tunnel for a ram jet test facility p 1089 A92-53564
Propeller-nacelle whirl flutter analysis and wind tunnel test p 1052 A92-56016
SATO, Y.
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
SATONAKA, K.
Selection of sampling rate for nonlinear flight trajectory controller of aircraft p 1084 A92-56070
SAVELLE, S. A.
Turbine engine performance test and evaluation techniques
[AIAA PAPER 92-3977] p 1071 A92-56803
SAWADA, TERUO
Numerical simulation of supersonic unsteady flow using a panel method p 1030 A92-56048
SCAGGS, NORMAN E.
Future requirements for hypersonic aerodynamic and aerothermodynamic facilities
[AIAA PAPER 92-3903] p 1094 A92-56738
Hypersonic wind tunnel nozzle study
[AIAA PAPER 92-4012] p 1033 A92-56835
SCANLAN, ROBERT H.
Aeroelasticity of bluff bodies p 1089 N92-34165
SCHADOW, K.
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
SCHAEFER, CHRISTOPH H.
Laser-radar based obstacle avoidance system for helicopters p 1064 A92-56295
SCHANK, JOHN F.
Developing robust support structures for high-technology subsystems: The AH-64 Apache helicopter
[AD-A252773] p 1017 N92-33499
SCHARPF, D. F.
The design of a subsonic low-noise, low-turbulence wind tunnel for acoustic measurements
[AIAA PAPER 92-3883] p 1094 A92-56726
SCHENEWERK, MARK S.
GPS orbit determination at the National Geodetic Survey p 1049 N92-33354
SCHERZ, CARL J.
C-17 flight control system overview p 1082 A92-55906
SCHIERMAN, JOHN D.
Analysis of airframe/engine interactions for a STOVL aircraft with integrated flight/propulsion control
[AIAA PAPER 92-4623] p 1052 A92-55300
SCHILLING, LAWRENCE
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
SCHIMKE, D.
Mission oriented investigation of handling qualities through simulation p 1059 A92-56353
SCHIMKE, S.
Analysis of iced wings
[NASA-TM-105773] p 1042 N92-34144
SCHMIDT, DAVID K.
Dynamics and control of hypersonic aeropropulsive/aeroelastic vehicles
[AIAA PAPER 92-4326] p 1073 A92-55170
New literal approximations for the longitudinal dynamic characteristics of flexible flight vehicles
[AIAA PAPER 92-4411] p 1075 A92-55205
An integrated development of the equations of motion for elastic hypersonic flight vehicles
[AIAA PAPER 92-4605] p 1077 A92-55283
An integrated analytical aeropropulsive/aeroelastic model for the dynamic analysis of hypersonic vehicles
[AIAA PAPER 92-4567] p 1035 A92-57034
SCHNEIDER, STEVEN P.
A quiet-flow Ludwieg tube for experimental study of high speed boundary layer transition
[AIAA PAPER 92-3885] p 1094 A92-56727
Aerodynamics laboratory education at Purdue University - Ground testing facilities
[AIAA PAPER 92-4018] p 1100 A92-56840
SCHNELL, RUSSELL C.
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
SCHOETTLE, U. M.
Optimization of two stage reusable space transportation systems with rocket and airbreathing propulsion concepts
[IAF PAPER 92-0863] p 1104 A92-57254
SCHRAGE, D. P.
Short takeoff optimization for the XV-15 tiltrotor aircraft p 1056 A92-56302
Helicopter nonlinear flight control system development p 1085 A92-56317
SCHROEDER, JOHN B.
Field test of an advanced maintenance-system p 1016 A92-56221
SCHUETTE, R.
A small light-weight rotor platform for ground observation and pollution control p 1057 A92-56329
SCHULTZ, KLAUS-J.
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344
SCHULZE, B.
Aerodynamic assessment of an optical pressure measurement system (OPMS) by comparison with conventional pressure measurements in a high speed wind tunnel p 1114 A92-54304
SCIAMMARELLA, CESAR A.
Electro optical system to measure strains at high temperature
[NASA-CR-190450] p 1127 N92-33696
SCOTT, JOHN E., JR.
Test facilities and instrumentation for research in rarefied gas dynamics - An historical perspective
[AIAA PAPER 92-3969] p 1098 A92-56795
SCOTT, R. F.
Processing and environmental effects on mechanical properties of composite repairs
[NRC-LTR-ST-1826] p 1109 N92-32791
SEELY, J. F.
Thrust stand design principles
[AIAA PAPER 92-3976] p 1098 A92-56802
SEGINER, A.
Pulsating spanwise blowing on a fighter aircraft
[AIAA PAPER 92-4359] p 1025 A92-55345
SEIBERT, G. L.
Nonintrusive measurements in fluid dynamic flows from Mach .0005 to 14 p 1090 A92-54311
SEINO, HIROSHI
Study of potassium turbine electric generator system p 1129 N92-33794
SEINO, YOSHINORI
Aircraft satellite communication systems p 1046 A92-56091
SEKELSKY, A.
Experimental evaluation of a 50-percent thick airfoil with blowing and suction boundary layer control
[AIAA PAPER 92-4500] p 1026 A92-55368
SEKIGUCHI, T.
Helicopter rotor testing using scaled model p 1093 A92-56076
SELLAR, M. R.
Re-engining for real stage 3 compliance
[PNR-90872] p 1072 N92-33748
SETTLES, G. S.
Heat transfer measurements and CFD comparison of swept shock wave/boundary-layer interactions
[AIAA PAPER 92-3665] p 1021 A92-54110
Structure of crossing-shock wave/turbulent boundary-layer interactions
[AIAA PAPER 92-3670] p 1022 A92-54113
Swept shock/boundary layer interaction experiments in support of CFD code validation
[NASA-CR-190583] p 1036 N92-32494
SFORZA, P. M.
Hypersonic shock tunnel testing for undergraduate laboratory instruction
[AIAA PAPER 92-4021] p 1100 A92-56843
SHAH, R. K.
Assessment of calculation methods for efficiency of straight fins of rectangular profile p 1121 A92-56374
SHANNON, JENIFER M.
An investigation of switched reluctance rotor position estimation using neural networks
[AD-A252846] p 1061 N92-33414
SHARAF, HAZEM H.
Active control of asymmetric vortical flows around cones using injection and heating
[AIAA PAPER 92-4426] p 1025 A92-55350
SHARMA, TILAK C.
New aircraft technologies - Challenges for dependability p 1120 A92-56225
SHARP, TIMOTHY J.
Improving reliability and maintainability through process management p 1141 A92-56212
SHEEN, JOHN
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
SHELLMAN, C. H.
Feasibility of measuring transverse electric noise at VLF and LF on an ice cap
[AD-A252280] p 1129 N92-33220
SHEPHERD, KEVIN P.
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers
[NASA-TM-104170] p 1138 N92-33160
SHERIDAN, PATRICK J.
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
SHERMAN, B.
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
SHIAU, LE-CHUNG
Transverse shear effect on flutter of composite panels p 1122 A92-56607
SHIH, CHIANG
Experimental observations of instability modes in a rectangular jet p 1135 A92-54908
SHILU, CHEN
Parameter identification of unsteady aerodynamic forces for elastic vehicles
[AIAA PAPER 92-4505] p 1027 A92-55372
SHIMIZU, TETSUO
Space plane navigation simulation p 1103 A92-53603
SHIMOMURA, T.
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test p 1093 A92-56114
SHIN, J.
Analysis of iced wings
[NASA-TM-105773] p 1042 N92-34144
SHINAGAWA, TAKASHI
Application of fuzzy control to aircraft guidance p 1083 A92-56033
SHINAGAWA, YUJI
Development of an automatic drilling system. II p 1118 A92-56107
SHINDO, S.
Supersonic wind tunnel test of airintake/airframe integrated models p 1028 A92-56006
SHINDO, SHIGEMI
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
SHINGU, HIROKIMI
Space plane navigation simulation p 1103 A92-53603
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS p 1047 A92-56118
SHIRAI, YUJIRO
Analysis and wind tunnel test of low aspect wing gust load alleviation p 1053 A92-56020
SHIRAISHI, KAZUO
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
SHIRAKAWA, KENICHI
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of MLS p 1047 A92-56117

SHOEMAKER, M.
A critical evaluation of a three-dimensional Navier-Stokes CFD as a tool to design supersonic turbine stages p 1124 N92-32268
SHONDER, J. A.
Proof of concept of a magnetically coupled Stirling engine-driven heat pump
[DE92-017129] p 1129 N92-33271
SHUART, M. J.
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
SHULTZ, JEFF
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
SHYU, R.-N.
Forcing level effects of internal acoustic excitation on the improvement of airfoil performance p 1136 A92-56162
SIEBERT, R.
Automatic control of test parameters for intake measurements in a low-speed wind tunnel p 1091 A92-54341
SILCOX, R. J.
Active control of interior noise in a large scale cylinder using piezoelectric actuators p 1137 N92-32958
SILVA, A.
A module-level testing environment for safety-critical software systems p 1132 A92-56293
SILVA, WALTER A.
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter
[NASA-TM-104211] p 1042 N92-34147
SIMEONIDES, G.
Quantitative heat transfer measurements in hypersonic wind tunnels by means of infrared thermography p 1115 A92-54321
SIMOMURA, TAKASHI
On improvements of three-dimensional position measuring system for dynamic wind tunnel testing p 1093 A92-56012
SIMON, DONALD L.
Piloted evaluation of an integrated propulsion and flight control simulator
[NASA-TM-105797] p 1088 N92-34107
SIMON, JAMES M.
Dynamic derivative data for high angle of attack simulation
[AIAA PAPER 92-4355] p 1079 A92-55341
SIMONI, M.
Correlation of flight, tunnel and prediction data on a helicopter main rotor p 1059 A92-56350
SIMPSON, M. A.
MD-80 aft cabin noise control: A case history p 1137 N92-32950
SIMPSON, ROBERT W.
Impacts of technology on the capacity needs of the US national airspace system
[NASA-CR-4470] p 1045 N92-34192
SINAY, LEON R.
Some thermodynamical aspects in the optimization of supersonic combustors p 1065 A92-53486
SINGH, D. J.
CAN-DO, CFD-based Aerodynamic Nozzle Design and Optimization program for supersonic/hypersonic wind tunnels
[AIAA PAPER 92-4009] p 1033 A92-56832
SINGH, SAHJENDRA N.
Invertibility and trajectory control for nonlinear maneuvers of aircraft
[AIAA PAPER 92-4410] p 1075 A92-55204
SIOCHI, EMILIE J.
Isothermal aging of IM7/8320 and IM7/5260
[NASA-TM-107666] p 1110 N92-33423
SIROTINSKII, B. S.
Composite blades for helicopter main and tail rotors developed by Mil Design Bureau p 1057 A92-56325
SKINN, DONALD A.
Engine bird ingestion experience of the Boeing 737 aircraft: Expanded data base
[DOT/FAA/CT-91/32] p 1045 N92-34151
SLAUERHOFF, J. F.
Application of electronically scanned pressure measurement system for engine simulation tests in the German-Dutch Wind Tunnel
[AIAA PAPER 92-4003] p 1122 A92-56826
SLOMSKI, J. F.
Experimental evaluation of a 50-percent thick airfoil with blowing and suction boundary layer control
[AIAA PAPER 92-4500] p 1026 A92-55368
SMITH, A. F.
Aluminium-lithium alloys - Application on helicopters p 1106 A92-56326
SMITH, C. F.
Full Navier-Stokes calculations on the installed F/A-18 inlet at a high angle of attack
[AIAA PAPER 92-3175] p 1020 A92-54012
SMITH, D. P.
Lightning strike tests of composite connectors
[AD-A252281] p 1044 N92-33249
SMITH, G. H.
Particle image velocimetry measurements of the aerodynamics of a wind turbine p 1115 A92-54337
SMITH, GARY M.
Field test of an advanced maintenance-system p 1016 A92-56221
SMITH, J.
Integration of wall interference assessment and wall adaptation
[NLR-TP-91119-U] p 1101 N92-32734
SMITH, JAMES E., JR.
High temperature aircraft research furnace facilities
[NASA-CR-184384] p 1101 N92-33826
SMITH, LEIGH ANN
Applications of a direct/iterative design method to complex transonic configurations
[NASA-TP-3234] p 1039 N92-33484
SMITH, MICHAEL S.
Holographic and PLIF measurements of free-flight hypervelocity flows in the AEDC Range G facility
[AIAA PAPER 92-3935] p 1122 A92-56765
SMITH, PHILIP N.
Vision-based range estimation using helicopter flight data
[NASA-TM-103930] p 1047 N92-32424
SMITH, R.
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
SNAPE, D. M.
The impact of air transport on the environment
[PNR-90876] p 1129 N92-33751
SNELL, S. A.
Preliminary assessment of the robustness of dynamic inversion based flight control laws
[AIAA PAPER 92-4330] p 1074 A92-55174
SNELL, SIDNEY ANTONY
Nonlinear dynamic-inversion flight control of supermaneuverable aircraft p 1062 N92-33953
SNYDER, PHILIP H.
Cooled high-temperature radial turbine program 2
[NASA-CR-189122] p 1073 N92-34236
SOBEL, KENNETH M.
Robust sampled data eigenstructure assignment using the delta operator
[AIAA PAPER 92-4400] p 1075 A92-55200
SOBIESZCZANSKI-SOBIESKI, JAROSLAW
Application of advanced multidisciplinary analysis and optimization methods to vehicle design synthesis p 1054 A92-56160
SOBOL', S. B.
Safety provision against 'ground resonance' free vibration of a coaxial helicopter p 1056 A92-56289
SOELTER, HARALD
A multivariable control concept for a gas turbine engine
[ETN-92-92104] p 1072 N92-33645
SOGA, K.
New 1.27-m leg of the National Aerospace Laboratory hypersonic wind tunnel p 1092 A92-56003
SOGA, KUNIO
A shock tunnel experiment on aerodynamic interference induced by RCS jet p 1029 A92-56042
SOGA, TOMOKATSU
The operational status of automated aircraft washing system p 1016 A92-56087
SOIZE, C.
Strong coupling between inviscid fluid and boundary layer of sharp leading edges: Two-dimensional stationary and turbulent cases for isolated profiles and guard vanes
[ONERA-RT-44/1621-RY-016-R] p 1125 N92-32776
SOLIES, U. P.
Flight measurements of downwash on the Ball-Bartoe Jetwing powered lift aircraft p 1054 A92-56174
SOLIMAN, M. M. E.
A high speed edgewise rotor using circulation control only in the reversed flow area p 1059 A92-56347
SOLLO, ANTONIO
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
SOLONIN, V. I.
The study of experimental turboramjets
[AIAA PAPER 92-3720] p 1067 A92-54135
SONNEBORN, W. G.
V-22 propulsion system design p 1070 A92-56300
SOSOUNOV, V. A.
The study of experimental turboramjets
[AIAA PAPER 92-3720] p 1067 A92-54135
SOTOZAKI, TOKUO
Grooved runway surface texture before and after rubber removal p 1093 A92-56111
SPAID, FRANK W.
Experimental results for a hypersonic nozzle/afterbody flow field
[AIAA PAPER 92-3915] p 1032 A92-56747
SPARROW, VICTOR W.
Simulations of sonic boom ray tube area fluctuations for propagation through atmospheric turbulence including caustics via a Monte Carlo method p 1139 N92-33878
SPAZZINI, P. G.
Skin friction measurements in 3-D boundary layers p 1092 A92-54351
SPEKREIJSE, S. P.
New concepts for multi-block grid generation for flow domains around complex aerodynamic configurations
[NLR-TP-91046-U] p 1037 N92-32730
SPIRKL, A.
'A new proposal for an old problem' - The right engine for the right helicopter p 1070 A92-56281
SPLETTSTOESSER, WOLF R.
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344
SRIDHAR, B.
Vision-based stereo ranging as an optimal control problem
[AIAA PAPER 92-4418] p 1045 A92-55211
SRIDHAR, BANAVAR
Analysis of image-based navigation system for rotorcraft low-altitude flight p 1046 A92-55968
Vision-based range estimation using helicopter flight data
[NASA-TM-103930] p 1047 N92-32424
SRINIVASAN, G. R.
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
STALKER, R. J.
Unsteady shock propagation in a steady flow nozzle expansion p 1023 A92-54489
STALLCOP, JAMES R.
H-N2 interaction energies, transport cross sections, and collision integrals p 1135 A92-54660
STARLEY, BRUCE B.
Damage tolerant design of critical aircraft structural components
[AIAA PAPER 92-4041] p 1123 A92-56860
STARNES, JAMES H., JR.
Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, part 1
[NASA-CP-3087-PT-1] p 1106 N92-32513
STEEN, GREGORY
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063
STEFKO, GEORGE L.
FREPS - A forced response prediction system for turbomachinery blade rows
[AIAA PAPER 92-3072] p 1130 A92-54006
STEHWIEN, WOLFGANG
Radar clutter classification
[ISBN-0-315-57981-1] p 1126 N92-33440
STEINBERG, MARC
A fuzzy logic based F/A-18 automatic carrier landing system
[AIAA PAPER 92-4392] p 1074 A92-55193
On-line identification and control of linearized aircraft dynamics p 1082 A92-55911
STEINLE, F. W., JR.
Blockage correction in three-dimensional wind tunnel testing based on the wall signature method
[AIAA PAPER 92-3925] p 1095 A92-56756
STENGEL, ROBERT F.
Optimal recovery from microburst wind shear
[AIAA PAPER 92-4338] p 1078 A92-55327
STEPHENS, DAVID G.
Fourth Aircraft Interior Noise Workshop
[NASA-CP-10103] p 1136 N92-32948
STEVENSON, SCOTT W.
Parameter identification of AV-8B wingborne aerodynamics for flight simulator model updates
[AIAA PAPER 92-4506] p 1027 A92-55373
STICH, HUBERT
Laser-radar based obstacle avoidance system for helicopters p 1064 A92-56295
STOWE, MIKE
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program
[AD-A247886] p 1108 N92-32629

STRACENER, JERRELL T.
Designing to cost effectiveness - Enhancing quality p 1119 A92-56209
STRAUB, F. K.
Flight simulation modeling in support of engine/airframe integration p 1055 A92-56279
STREBINGER, R. B.
The design of a subsonic low-noise, low-turbulence wind tunnel for acoustic measurements
[AIAA PAPER 92-3883] p 1094 A92-56726
STREBY, OLIVIER
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344
STROME, ROBERT W.
E-6 flutter investigation and experience
[AIAA PAPER 92-4601] p 1077 A92-55280
STUCKERT, GREG
Linear stability of supersonic cone boundary layers p 1024 A92-54910
STUDNEV, A.
Stochastic self-induced roll oscillations of slender delta wing at high angles of attack
[AIAA PAPER 92-4498] p 1081 A92-55366
SUBRAMANIAN, C. S.
Surface heat transfer and flow properties of vortex arrays induced artificially and from centrifugal instabilities p 1121 A92-56371
SUBRAMANIAN, S.
The design of a subsonic low-noise, low-turbulence wind tunnel for acoustic measurements
[AIAA PAPER 92-3883] p 1094 A92-56726
SUDANI, NORIKAZU
Evaluation of sidewall interference in the NAL two-dimensional transonic wind tunnel p 1092 A92-56011
BGK1 airfoil oilflow tests in the NAL two-dimensional wind tunnel. II p 1029 A92-56044
SUDO, NAOKI
An autorotation-entry control for a helicopter with a fuzzy controller p 1083 A92-56032
SUGIMOTO, HIROYUKI
Sensitivity analysis for structural optimization of helicopter rotor blades p 1053 A92-56073
SULLIVAN, B. M.
Application of magnitude estimation scaling to the assessment of subjective loudness response to simulated sonic booms
[NASA-TM-107657] p 1138 N92-33719
SULLIVAN, BRENDA M.
Subjective loudness response to simulated sonic booms p 1140 N92-33885
SULLIVAN, C. J.
The design of a subsonic low-noise, low-turbulence wind tunnel for acoustic measurements
[AIAA PAPER 92-3883] p 1094 A92-56726
SULLIVAN, J. P.
Thermal paints for shock/boundary layer interaction in inlet flows
[AIAA PAPER 92-3626] p 1113 A92-54093
SULLIVAN, JOHN P.
Aerodynamics laboratory education at Purdue University - Ground testing facilities
[AIAA PAPER 92-4018] p 1100 A92-56840
SUNAKAWA, MEGUMI
Current status of R&D on materials for super/hypersonic transports p 1106 A92-56002
SUTTAN, J.
Shock detection on airfoils by means of piezo foil- and hot film arrays p 1115 A92-54334
SUZUKI, MASAAKI
A320 flight control from the pilot's point of view p 1083 A92-56028
SUZUKI, NORIO
Aerodynamic study of H-II Orbiting Plane, HOPE p 1103 A92-53639
SUZUKI, S.
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test p 1093 A92-56114
SUZUKI, SEIZO
On improvements of three-dimensional position measuring system for dynamic wind tunnel testing p 1093 A92-56012
On the effect of canards on NAL spaceplane model (0 order) in low speed area p 1030 A92-56052
SUZUKI, SHINJI
Optimization of aeroelastic system with active control p 1083 A92-56022
Lateral control of spaceplane at hypersonic flight p 1104 A92-56069
SWINFORD, SCOTT
A new system for recording unstable aerodynamic phenomena in NAVSWC Hypervelocity Wind Tunnel No. 9 p 1091 A92-54325
SWOBODA, M.
Shock detection on airfoils by means of piezo foil- and hot film arrays p 1115 A92-54334

T

TACHIBANA, MASAKAZU
Navier-Stokes simulation for the winged space vehicle 'HOPE' at subsonic, transonic, and supersonic regimes p 1018 A92-53559
TADA, AKIRA
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
TAI, TSZE C.
Direct simulation of low-density flow over airfoils p 1030 A92-56159
TAJIMA, HIROHISA
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of MLS p 1047 A92-56117
TAKAGI, AKITO
Analysis and wind tunnel test of low aspect wing gust load alleviation p 1053 A92-56020
TAKAHAMA, MORLO
Flight control system design using H(infinity) optimal control p 1083 A92-56030
TAKAHASHI, MASAHIRO
Numerical study on the secondary jet into a supersonic flow p 1018 A92-53556
TAKAHIRA, KEN-ICHI
Wind tunnel test of M = 2.5 mixed compression inlet p 1028 A92-56008
TAKANASHI, SUSUMU
Navier-Stokes simulation for the winged space vehicle 'HOPE' at subsonic, transonic, and supersonic regimes p 1018 A92-53559
TAKANO, MASANORI
Numerical simulations of shock reflections by a TVD scheme p 1018 A92-53558
TAKAO, K.
Selection of sampling rate for nonlinear flight trajectory controller of aircraft p 1084 A92-56070
TAKEDA, HIROMICHI
Automatic function testing in the aircraft production p 1015 A92-56083
TAKI, MASATO
Sensitivity analysis for structural optimization of helicopter rotor blades p 1053 A92-56073
TAKIZAWA, M.
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test p 1093 A92-56114
TAKIZAWA, MINORU
On improvements of three-dimensional position measuring system for dynamic wind tunnel testing p 1093 A92-56012
Evaluation of a IMU with optical fiber gyros in dynamic windtunnel tests p 1104 A92-56121
TAKIZAWA, NAOTO
A low speed wind tunnel investigation of a joined-wing aircraft with an overhanging fin p 1030 A92-56078
A low speed wind tunnel investigation of the direct side force control of a joined-wing aircraft with overhanging fin p 1084 A92-56079
TAM, CHRISTOPHER K. W.
Broadband shock associated noise from supersonic jets measured by a ground observer p 1135 A92-54909
TAM, TIM C.
Flow characterization in the NASA Ames 16-inch Shock Tunnel
[AIAA PAPER 92-3810] p 1090 A92-54180
TAMAGNO, J.
Effects of oxygen dissociation on hypervelocity *combustion experiments*
[AIAA PAPER 92-3964] p 1098 A92-56791
TAMAKI, TEIICHI
Conceptual design of scramjet engine p 1065 A92-53490
TAMURA, HIROBUMI
Fabrication test and evaluation of graphite/PMR-15 polyimide for HOPE primary structure p 1105 A92-53516
TAMURA, T.
Measurements of turbulence in hypersonic flow p 1092 A92-56005
TAN, C. S.
Computational and experimental studies of flow in multi-lobed forced mixers
[AIAA PAPER 92-3568] p 1112 A92-54057
TAN, CARINA M.
First level release of 2GCHAS for comprehensive helicopter analysis p 1133 A92-56339
TANAHASHI, YOSHIHARU
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043
TANAKA, A.
Supersonic wind tunnel test of airintake/airframe integrated models p 1028 A92-56006
A conceptual study for future engine test facility
[AIAA PAPER 92-3992] p 1099 A92-56815
TANAKA, ATSUSHIGE
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
TANAKA, HIROYUKI
Analysis and wind tunnel test of low aspect wing gust load alleviation p 1053 A92-56020
TANAKA, KEIJI
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
Flight simulator test of cockpit advisory system p 1054 A92-56115
TANAKA, KOUHEI
A shock tunnel experiment on aerodynamic interference induced by RCS jet p 1029 A92-56042
TANAKA, TOSHIYUKI
A robust gain scheduler interpolated into multiple models by membership functions
[AIAA PAPER 92-4553] p 1131 A92-55265
TANAKA, YASUHIKO
Experimental investigation of the boundary layer in a corner formed by two circular arc airfoils p 1029 A92-56046
TANASE, SHOJI
Piloted simulation for the BK117 FBW demonstrator p 1053 A92-56077
TANATSUGU, NOBUHIRO
Development study on air turbo-ramjet engine for space plane p 1065 A92-53487
Tests results on Air Turbo Ramjet for a future space plane
[IAF PAPER 92-0657] p 1071 A92-57098
TANEDA, H.
Flutter analysis and wind tunnel test with respect to a low-aspect-ratio wing with free-rotational control surface p 1052 A92-56014
TANG, D. M.
Flutter and stall response of a helicopter blade with structural nonlinearity p 1055 A92-56178
TANG, SHOU
Stability and dynamic coupling of elastic vehicles with unsteady aerodynamic forces considered p 1102 A92-53545
TANI, KOUICHIRO
Flow measurements in scramjet inlets p 1102 A92-53565
TANIKAWA, EIJI
Present status of Al-Li alloys p 1106 A92-56105
TANIMOTO, MITSUMORI
Experimental study of convection effects around the phase charge interface p 1111 A92-53755
TARANNIKOVA, T. N.
Viscosity characteristics of synthetic aviation oils at low temperatures p 1105 A92-53875
TAUKE, G. J.
Flight management system of the F-117A p 1082 A92-55910
TAURA, S.
Optimization of composite material wing of fighter type aircrafts p 1053 A92-56018
TAYLOR, ARTHUR C., III
Methodology for calculating aerodynamic sensitivity derivatives p 1024 A92-54911
TEMPELMAN, W. G.
Performance benefits of adaptive in-flight propulsion system optimization
[AIAA PAPER 92-3749] p 1068 A92-54149
TENNING, CARL
Design of the Boeing 777 electric system p 1070 A92-55902
TERESHKIN, A. A.
An experimental study of organismic principles of the functioning of the crew-transport aircraft system p 1133 A92-57446
TERESHKIN, G. A.
Using the simulation modeling method to estimate the reliability of the crew-flight vehicle system p 1133 A92-57444
TERUI, YUSHI
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
TESHIMA, KOJI
Experimental and numerical investigation of a supersonic free jet impinging on a perpendicular surface p 1018 A92-53555
THIBODEAUX, J. J.
Control of large cryogenic tunnels
[AIAA PAPER 92-3930] p 1096 A92-56761

THOMAS, A. M.
Investigation of advancing front method for generating unstructured grid
[NASA-CR-190902] p 1128 N92-34043
THOMAS, CLAUDINE
The need for GPS standardization
p 1049 N92-33351
Precise GPS ephemerides from DMA and NGS tested by time transfer p 1049 N92-33355
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
THOMAS, D. R.
Active control of sound transmission through stiff lightweight composite fuselage constructions
p 1137 N92-32957
THOMPSON, DANNIELLA M.
Global/local methods research using the CSM testbed
p 1107 N92-32528
THOMPSON, SCOTT A.
Wind tunnel blockage effects on slender wings undergoing large amplitude motions
[AIAA PAPER 92-3926] p 1096 A92-56757
THOMSON, MICHAEL
Experience with Ada on the F-18 High Alpha Research *Vehicle Flight Test Program*
[NASA-TM-104259] p 1062 N92-34039
THYR, U.
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG
p 1050 N92-33356
TILLMAN, T. G.
Computational and experimental studies of flow in multi-lobed forced mixers
[AIAA PAPER 92-3568] p 1112 A92-54057
TIRRES, LIZET
A comparison of the calculated and experimental off-design performance of a radial flow turbine
[AIAA PAPER 92-3069] p 1020 A92-54004
Description of a pressure measurement technique for obtaining surface static pressures of a radial turbine
[AIAA PAPER 92-4006] p 1123 A92-56829
TISHCHENKO, A. A.
Pulsation characteristics of one-phase and two-phase steam flows in Laval nozzles under off-design conditions
p 1019 A92-53882
TIWARI, S. N.
Investigation of advancing front method for generating unstructured grid
[NASA-CR-190902] p 1128 N92-34043
TODA, N.
Flutter analysis and wind tunnel test with respect to a low-aspect-ratio wing with free-rotational control surface
p 1052 A92-56014
TODA, NOBUO
Propeller-nacelle whirl flutter analysis and wind tunnel test p 1052 A92-56016
TODD, J. R.
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
TOFUKUJI, NORIYASU
A consideration on air traffic control processing capability in terminal area p 1047 A92-56110
TOGAWA, MORITO
Key design considerations for scramjet powered space plane p 1066 A92-53491
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
TOH, K. H.
Flow induction by pressure forces
[AIAA PAPER 92-3571] p 1067 A92-54060
TOKARCIK, SUSAN
Numerical simulation of unsteady flow in a hypersonic *shock tunnel facility*
[AIAA PAPER 92-4029] p 1034 A92-56851
TOKUDA, EI
Flight control system design using H(infinity) optimal control p 1083 A92-56030
TOKUNAGA, TATSURU
Key design considerations for scramjet powered space plane p 1066 A92-53491
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
TOMIOKA, KENJI
Experimental study on three-dimensional shock wave-turbulent boundary layer interaction induced by protuberance p 1019 A92-53997
Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance
p 1029 A92-56009
TOMIOKA, Y.
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729
TOMITA, HIROSHI
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS
p 1047 A92-56118
TORII, KAHORU
Enhancement of laminar boundary layer heat transfer by a vortex generator p 1118 A92-55453
TORIUMI, MASAKI
Lateral control of spaceplane at hypersonic flight
p 1104 A92-56069
TRAXLER, BOB
Departments of Veterans Affairs and Housing and Urban Development, and independent agencies appropriations for 1993, part 6
[GAO-55-636-PT-6] p 1141 N92-32505
TRIPATHI, SATISH
Distributed systems: Interconnection and fault tolerance studies
[AD-A252869] p 1135 N92-33920
TSANGARIS, PARRY
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964
TSKHOVREBOV, M. M.
The study of experimental turboramjets
[AIAA PAPER 92-3720] p 1067 A92-54135
TSUBAKI, KENJI
Application of X-ray image radiography system for aircraft p 1118 A92-56084
TSUCHIYA, KEIICHI
Evaluation report of an experimental Satcom operation by a Japan Airline's B747 passenger plane
p 1046 A92-56092
TSUJIMOTO, TAKASHI
Roles of wind tunnel tests and CFD analyses in the design of energy-efficient SST
[AIAA PAPER 92-3923] p 1133 A92-56754
Study on international cooperative test facilities for future SST/HST
[AIAA PAPER 92-3945] p 1097 A92-56775
TSUJIO, SHOWZOW
A development of hypermedia type database system for instruction of aircraft conceptual design
p 1132 A92-56113
TSUKANO, YUKICHI
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
TSUMURA, T.
Measurement of position and attitude using laser and retro-reflectors p 1047 A92-56120
TU, EUGENE L.
Navier-Stokes simulation of a close-coupled canard-wing-body configuration p 1031 A92-56163
TUDA, S.
New 1.27-m leg of the National Aerospace Laboratory hypersonic wind tunnel p 1092 A92-56003
TUZZOLO, M. F.
Surface heat transfer and flow properties of vortex arrays induced artificially and from centrifugal instabilities
p 1121 A92-56371
TYSON, JOHN, II
Inspection of fabricated fuselage panels using electronic shearography
[DOT/FAA/CT-TN92/26] p 1127 N92-33627

U

UCHIDA, HIROYUKI
Fundamental studies on Marangoni convection related to Bridgman crystal growth p 1111 A92-53758
UCHIDA, TADAO
Synthesis of a MLS automatic landing control law for the NAL experimental research aircraft Do-228
p 1084 A92-56062
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
UCHIDA, TAKASHI
Wind tunnel test of M = 2.5 mixed compression inlet
p 1028 A92-56008
UDIN, SERGEI V.
Wing mass formula for twin fuselage aircraft
p 1054 A92-56171
UEMURA, NAKOTO
An autorotation-entry control for a helicopter with a fuzzy controller p 1083 A92-56032
UEMURA, TSUNEHARU
A note on thrust control for jetliner during approach
p 1053 A92-56061
UENO, TORU
A consideration on air traffic control processing capability in terminal area p 1047 A92-56110
ULBRICH, N.
Blockage correction in three-dimensional wind tunnel testing based on the wall signature method
[AIAA PAPER 92-3925] p 1095 A92-56756
UNGER, GEORGE
Research needs for a commercial passenger tiltrotor
p 1056 A92-56298

V

VAILLANCOURT, WALTER
Talons 95 GHz radar sensor for autonomous landing guidance p 1063 A92-55908
VALAREZO, WALTER O.
High-lift testing at high Reynolds numbers
[AIAA PAPER 92-3986] p 1033 A92-56810
VAN DER GEEST, P. J.
A simulator evaluation of various manual control concepts for fly-by-wire transport aircraft
[AIAA PAPER 92-4328] p 1073 A92-55172
VAN FOSSEN, G. J.
Increased heat transfer to elliptical leading edges due to spanwise variations in the freestream momentum - Numerical and experimental results
[AIAA PAPER 92-3070] p 1020 A92-54005
VANDERHOEK, M. W.
Calibration of GPS antennas
[ETN-92-92034] p 1051 N92-33693
VANSTEENWYK, BRETT
Control design of a UH-60 rotorcraft via CLTR and direct optimization
[AIAA PAPER 92-4470] p 1076 A92-55230
VATSA, VEER N.
Evaluation of a multigrid-based Navier-Stokes solver for aerothermodynamic computations
[AIAA PAPER 92-4563] p 1027 A92-55375
VEILLET, CHRISTIAN
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG
p 1050 N92-33356
VELOVICH, ALEXANDER
Mikoyan's market-buster p 1052 A92-54981
VENET, GERARD
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
VENKATESAN, C.
Coupled rotor-fuselage vibration reduction with multiple frequency blade pitch control p 1085 A92-56315
VENN, G.
The Eurofar program - An European overview on advanced VTOL civil transportation system
p 1016 A92-56299
VERDEBOUT, JEAN
Time Resolved Lidar Fluorosensor operating from helicopter p 1121 A92-56296
VERHOFF, VINCENT G.
Transonic turbine blade cascade testing facility
[AIAA PAPER 92-4034] p 1101 A92-56856
VERMEULEN, J. P.
Quantitative heat transfer measurements in hypersonic wind tunnels by means of infrared thermography
p 1115 A92-54321
VERMEULEN, P. J.
Acoustic control of combustor primary zone air-jet mixing
[AIAA PAPER 92-3651] p 1067 A92-54104
VICHI, FRANK
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480
VIEGAS, JOHN R.
Assessment of compressibility corrections to the k-epsilon model in high-speed shear layers
p 1024 A92-54905
VILLASENOR, R.
Interaction between chemical reaction and turbulence *in supersonic nonpremixed H2-air combustion*
p 1117 A92-54931
VINH, N. X.
A Lie Bracket solution of the optimal thrust magnitude on a singular arc in atmospheric flight
[AIAA PAPER 92-4345] p 1079 A92-55334
VISBAL, MIGUEL R.
Comparative numerical study of two turbulence models for airfoil static and dynamic stall
[AIAA PAPER 92-4649] p 1028 A92-55394
VITAGILANO, P. L.
New concepts for multi-block grid generation for flow domains around complex aerodynamic configurations
[NLR-TP-91046-U] p 1037 N92-32730
VIVIANI, A.
Stokes flows in superposed immiscible liquids with horizontal heating
[IAF PAPER 92-0909] p 1123 A92-57288
VOGT, ANN T.
Cost/benefit analysis of the AH-64 (Apache) helicopter Automated Test Equipment (ATE)
[AD-A252909] p 1101 N92-33398

VOGT, KONRAD
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951
VOLAKIS, JOHN L.
Development of 3D electromagnetic modeling tools for airborne vehicles
[NASA-CR-190810] p 1126 N92-33307
VON RETH, R. D.
Organization and technical status of the NH90 European helicopter programme p 1016 A92-56306
VORONKOV, A. Z.
Safety provision against 'ground resonance' free vibration of a coaxial helicopter p 1056 A92-56289

W

WAGGONER, LARRY P.
Cost/benefit analysis of the AH-64 (Apache) helicopter Automated Test Equipment (ATE)
[AD-A252909] p 1101 N92-33398
WAGNER, D. W.
Performance evaluation of a transonic wind tunnel compressor
[AIAA PAPER 92-3927] p 1096 A92-56758
WAGNER, S.
Development of a conceptual design method for rotary-wing aircraft using digital computers p 1058 A92-56340
Investigation of a plate-ramp-configuration by means of laser Doppler anemometry at Mach 2.95
[AIAA PAPER 92-3956] p 1097 A92-56784
The trisonic wind tunnel Muenchen and its involvement in the German SAeNGER-programme
[AIAA PAPER 92-4019] p 1100 A92-56841
WAKAHAR, H.
Analysis of the main wing lift distribution of the STOL research aircraft Asuka p 1053 A92-56051
WAKAI, HIROSHI
A shock tunnel experiment on aerodynamic interference induced by RCS jet p 1029 A92-56042
WAKAMATSU, YOSHIO
Conceptual design of scramjet engine p 1065 A92-53490
Scramjet engine and its flying test bed p 1066 A92-53492
Performance analysis of idealized scramjet p 1066 A92-53493
Flow measurements in scramjet inlets p 1102 A92-53565
WALCH, STEPHEN P.
H-N2 interaction energies, transport cross sections, and collision integrals p 1135 A92-54660
WALCHLI, LAWRENCE A.
High angle-of-attack control enhancement on a forward swept wing aircraft
[AIAA PAPER 92-4427] p 1080 A92-55351
WALKER, K. P.
Life prediction and constitutive models for engine hot section anisotropic materials program
[NASA-CR-189223] p 1072 N92-33479
WALLACE, F. B.
Regional airline and equipment review - Evolution, trends, and future prospects p 1015 A92-55102
WALTERS, KEVIN D.
Solutions to supportability concerns related to reduced-signature aircraft p 1055 A92-56220
WAN, T.
Aerodynamic calculation of an elliptic ring wing
[AIAA PAPER 91-0068] p 1035 A92-57035
WANG, H. M.
Fault diagnostics on jet engine starting p 1116 A92-54345
WANG, JAMES M.
Dynamics of helicopters with dissimilar blades in forward flight p 1056 A92-56288
WANG, JHY-HORNG
Experimental investigation of the stability of a clearance-excited rotor system with optimal parameters p 1114 A92-54223
WANG, LIXIA
Improved calculation of transonic potential flow past swept wings p 1031 A92-56179
WANG, SHIH H.
Quantitative Feedback Theory approach to AIAA Controls Design Challenge
[AIAA PAPER 92-4626] p 1077 A92-55303
WANKE, CRAIG R.
A data fusion algorithm for multi-sensor microburst hazard assessment
[AIAA PAPER 92-4339] p 1063 A92-55328
WARBURTON, F.
A simulation study of tiltrotor vertical takeoff procedures using conventional and variable diameter rotor systems p 1056 A92-56301
WARDWELL, DOUGLAS A.
On the anomalies in single-jet hover suckdown data
[NASA-TM-102261] p 1038 N92-33306
Dynamic response of induced pressures, suckdown, and temperatures for two tandem jet STOVL configurations
[NASA-TM-103934] p 1039 N92-33581
On the estimation of jet-induced fountain lift and additional suckdown in hover for two-jet configurations
[NASA-TM-102268] p 1040 N92-33618
WARE, GEORGE M.
Predicted aerodynamic characteristics for HL-20 lifting-body using the aerodynamic preliminary analysis system (APAS)
[AIAA PAPER 92-3941] p 1033 A92-56771
WARNAKA, GLENN E.
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964
WARNER, DAVID N., JR.
A workstation-based evaluation of a far-field route planner for helicopters
[NASA-TM-102882] p 1051 N92-33609
WARNER, M.
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
WARREN, DALE S.
Air transports in the 21st century p 1015 A92-55103
WASHBURN, ANTHONY E.
Effects of external influences in subsonic delta wing vortices
[AIAA PAPER 92-4033] p 1034 A92-56855
WASHIDA, T.
Numerical prediction of the flow characteristics in an arc wind tunnel
[AIAA PAPER 92-4016] p 1100 A92-56838
WATANABE, ATSUSHI
Flight simulator test of cockpit advisory system p 1054 A92-56115
WATANABE, SHIGEYA
Aerodynamic studies on space plane configuration at hypersonic speed p 1019 A92-53641
Optimal launch trajectory of a hypersonic research vehicle
[AIAA PAPER 92-4302] p 1103 A92-55310
WATANABE, Y.
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055
WATERMAN, ELLY H.
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
WEATHERILL, WARREN H.
Flutter in the transonic flight regime p 1089 N92-34167
Flutter analyses using high speed computers. Part 1: Flutter analyses for large aircraft p 1089 N92-34168
Flutter analyses using high speed computers. Part 2: Aerodynamic procedures p 1089 N92-34169
WEBER, M. E.
Airport Surveillance Radar (ASR-9) wind shear processor: 1991 test at Orlando, Florida
[AD-A252246] p 1124 N92-32686
WEBER, TIMOTHY LAVERN
Turbulence-induced loads on a teetered rotor p 1042 N92-34029
WEBSTER, LEE
The wind tunnel test 'system' of 1995 - Cost effective experimentation through a fusion of related technologies p 1091 A92-54342
WEI, YING-JYI P.
Intelligent control law tuning for AIAA Controls Design Challenge
[AIAA PAPER 92-4631] p 1132 A92-55306
WEINDORF, PAUL
The C-17 Multifunction Display - A building block for avionic systems p 1063 A92-55907
WEINSTEIN, LEONARD M.
Vaporizing particle velocimeter
[NASA-CASE-LAR-14685-1] p 1042 N92-34172
WEINSTEIN, LISA F.
The utility of analog vertical velocity information during instrument flight with a Head-Up Display (HUD)
[AD-A252863] p 1065 N92-33277
WEISEND, NORBERT A.
Low energy ice protection for helicopters p 1059 A92-56348
WELLBORN, S. R.
An experimental investigation of the flow in a diffusing S-duct
[AIAA PAPER 92-3622] p 1021 A92-54090
WELLBORN, STEVEN R.
Navier-Stokes analysis and experimental data comparison of compressible flow in a diffusing S-duct
[NASA-TM-105683] p 1072 N92-33746
WENDT, J. F.
Quantitative heat transfer measurements in hypersonic wind tunnels by means of infrared thermography p 1115 A92-54321
WHITE, J. A.
CAN-DO, CFD-based Aerodynamic Nozzle Design and Optimization program for supersonic/hypersonic wind tunnels
[AIAA PAPER 92-4009] p 1033 A92-56832
WHITEHEAD, ROBIN S.
Structural assessment of ultralightweight composites p 1107 N92-32525
Damage tolerance certification methodology for composite structures p 1108 N92-32579
WHITMORE, STEPHEN A.
High angle-of-attack flush airdata sensing system p 1064 A92-56172
WIGGENRAAD, J. F. M.
Global/local interlaminar stress analysis of a grid-stiffened composite panel
[NASA-CR-190822] p 1125 N92-33139
WILKINSON, S. P.
Supersonic and hypersonic quiet tunnel technology at NASA Langley
[AIAA PAPER 92-3908] p 1094 A92-56743
WILLIAMS, F. A.
Theories of turbulent combustion in high speed flows
[AD-A253032] p 1111 N92-33624
WILLIAMS, R. M.
PAYCOS, a multidisciplinary sizing code for hypersonic vehicles
[AIAA PAPER 92-4564] p 1132 A92-55376
WILLIAMS, STEVEN P.
Computational algorithms for increased control of depth-viewing volume for stereo three-dimensional graphic displays
[NASA-TM-4379] p 1065 N92-34109
WILLIAMS, T.
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
WILLSHIRE, WILLIAM L., JR.
Preliminary results from the White Sands Missile Range sonic boom propagation experiment p 1140 N92-33884
Advanced subsonic transport approach noise: The relative contribution of airframe noise
[NASA-TM-104112] p 1140 N92-34148
WILMOTH, RICHARD G.
Application of a parallel direct simulation Monte Carlo method to hypersonic rarefied flows p 1024 A92-54916
WILSON, F. T.
The achievement of aerodynamic goals on the EH101 project through the 'single site' concept p 1058 A92-56342
WILSON, JOSEPH J.
Engine bird ingestion experience of the Boeing 737 aircraft: Expanded data base
[DOT/FAA/CT-91/32] p 1045 N92-34151
WILSON, K.
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
V-22 propulsion system design p 1070 A92-56300
WINGROVE, R. C.
Severe turbulence and maneuvering from airline flight records
[AIAA PAPER 92-4341] p 1078 A92-55330
WINKLER, P.-J.
Examples of advanced near-net shape manufacturing techniques for aerospace
[MBB-Z-0399-91-PUB] p 1125 N92-32742
WISSINK, A. M.
Efficient iterative methods for the transonic small disturbance equation p 1025 A92-54933
WOERNDLE, RUDOLF
Influence of cross section variations on the structural behaviour of composite rotor blades p 1121 A92-56320
WOLF, JOHN D.
Air transports in the 21st century p 1015 A92-55103
WOLF, T.
Design of a variable contraction for a full-scale automotive wind tunnel
[AIAA PAPER 92-3929] p 1096 A92-56760
WOLF, THOMAS
Flight testing and simulation of an F-15 airplane using throttles for flight control
[NASA-TM-104255] p 1087 N92-32864
WONG, DOUGLAS T.
Evaluation of electrolytic tilt sensors for wind tunnel model angle-of-attack (AOA) measurements p 1116 A92-54344

WONG, TIN-CHEE
Computation of vortex wake flows and control of their effects on trailing wings
[AIAA PAPER 92-4429] p 1025 A92-55353
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations
p 1127 N92-33968
WOOD, E. R.
A time-dependent tip loss formula for rotor blade dynamic analysis p 1057 A92-56310
WOOD, RICHARD M.
Assessment of passive porosity with free and fixed separation on a tangent ogive forebody
[AIAA PAPER 92-4494] p 1081 A92-55363
WORTMAN, A.
Detonation duct gas generator demonstration program
[AIAA PAPER 92-3174] p 1066 A92-54011
WRIGHT, JAN R.
Elementary flutter analysis p 1088 N92-34162
Flight flutter testing p 1089 N92-34163
WRIGHT, P. I.
An improved compressor performance prediction model
[PNR-90873] p 1072 N92-33749
WRIGHT, ROBERT E., JR.
Problems and solutions for transition detection in cryogenic wind tunnels by infrared imaging
p 1090 A92-54319
WU, WENLIANG
Steady state risetimes of shock waves in the atmosphere p 1140 N92-33882

X

XIONG, XIAOFEI
Parameter identification of unsteady aerodynamic forces for elastic vehicles
[AIAA PAPER 92-4505] p 1027 A92-55372
XU, MIN
The research of reducing 3-D low supersonic shock wave reflection in a 2-D transonic flexible walls adaptive wind tunnel
[AIAA PAPER 92-3924] p 1095 A92-56755

Y

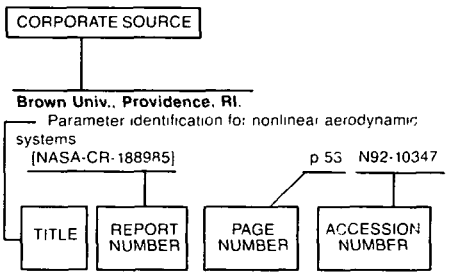
YAMADA, H.
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
YAMAGUCHI, YUTAKA
Preliminary airfoil testing experience in the NDA cryogenic wind tunnel p 1091 A92-54326
YAMAME, KOSABURO
Grooved runway surface texture before and after rubber removal p 1093 A92-56111
YAMAMOTO, H.
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
YAMAMOTO, KEIZOU
Design and testing of a composite hingeless hub for rotary-wing aircraft p 1053 A92-56075
YAMAMOTO, KIYOSHI
Spaceplane aerodynamic heating and thermal protection design method p 1102 A92-53578
YAMAMOTO, O.
Numerical calculations of propfan/swirl recovery vane flow field
[AIAA PAPER 92-3771] p 1022 A92-54160
YAMAMOTO, SHIRO
Effect of porosity in transpiration cooling system
p 1112 A92-53786
YAMAMOTO, YUKIMITSU
Spaceplane aerodynamic heating and thermal protection design method p 1102 A92-53578
YAMAMOTO, YUKIMITU
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043
YAMAMURA, T.
A model study on diffuser pressure recovery in NAL scramjet test facility with simulated hydrogen combustion
[AIAA PAPER 92-3979] p 1071 A92-56805
YAMANAKA, T.
Airbreathing engine selection criteria for SSTO propulsion system
[IAF PAPER 92-0658] p 1071 A92-57099
YAMANAKA, TATSUO
Key design considerations for scramjet powered space plane p 1066 A92-53491
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
YAMANASHI, AKIRA
Development of aircraft bonded structure and the NDI method p 1016 A92-56100
YAMAO, HIROYUKI
Experimental study on three-dimensional shock wave-turbulent boundary layer interaction induced by protuberance p 1019 A92-53997
Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance
p 1029 A92-56009
YAMAZAKI, TETSUO
Design and wind tunnel test of low-Reynolds-number airfoil p 1029 A92-56047
YAN, HENGYUAN
Stability and dynamic coupling of elastic vehicles with unsteady aerodynamic forces considered
p 1102 A92-53545
YANAGI, RYOJI
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
YANAGIHARA, JURANDIR I.
Enhancement of laminar boundary layer heat transfer by a vortex generator p 1118 A92-55453
YANAGIHARA, M.
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test
p 1093 A92-56114
YANAGIHARA, MASAAKI
Measurements of longitudinal static aerodynamic coefficients with cable mount system
p 1093 A92-56013
On the effect of canards on NAL spaceplane model (0 order) in low speed area p 1030 A92-56052
YANAGIZAWA, MITSUNORI
Calculations for aerodynamic characteristics of HOPE type vehicle in subsonic and hypersonic flow
p 1018 A92-53560
Calculations of aerodynamic forces on a wing with thrust using B.E.M p 1030 A92-56049
Generalized aerodynamics analysis by the boundary element method p 1030 A92-56050
YANAZAKI, TAKASHI
A shock tunnel experiment on aerodynamic interference induced by RCS jet p 1029 A92-56042
YANG, YONGSHENG
Free-radicals aided combustion with scramjet applications
[IAF PAPER 92-0659] p 1106 A92-57100
YANG, ZHILI
The flow field characteristics about a fighter configuration at high angles of attack
[AIAA PAPER 92-4358] p 1025 A92-55344
YANO, K.
A simple three component velocity measurement method using a rotated split-film sensor
p 1115 A92-54333
YANTA, WILLIAM J.
A fine-wire thermocouple probe for measurement of stagnation temperatures in real gas hypersonic flows of nitrogen p 1114 A92-54317
Boundary layer study on nozzle wall at hypersonic velocities
[AIAA PAPER 92-4013] p 1034 A92-56836
YAO, LIXIN
Steady state risetimes of shock waves in the atmosphere p 1140 N92-33882
YASUTOMI, ZENSABURO
Three-dimensional numerical analysis of impinging circular jet - Discrete vortex method
p 1029 A92-56040
YAZAWA, K.
Analysis of the main wing lift distribution of the STOL research aircraft Asuka p 1053 A92-56051
YEDAVALLI, R. K.
Aircraft ride quality controller design using new robust root clustering theory for linear uncertain systems
[AIAA PAPER 92-4399] p 1075 A92-55199
YEDAVLLI, R. K.
Applications of robust control theory - Educational implications
[AIAA PAPER 92-4559] p 1131 A92-55271
YEH, J. H.
Study on supersonic combustion in a hypersonic flight
[IAF PAPER 92-0661] p 1106 A92-57101
YEN, GUAN-WEI
Computing high-speed flows past an oscillating cylinder near a vertical wall
[AIAA PAPER 92-4653] p 1028 A92-55397
YILLIKCI, Y. K.
Trimming rotor blades with periodically deflecting trailing edge flaps p 1085 A92-56283
YINGER, COLLEEN H.
Evaluation of GPS/UTC steering performance
p 1049 N92-33353
YIP, LONG P.
Model flight tests of a spin-resistant trainer configuration p 1054 A92-56158
YOKOMIZO, T.
Reduction of the side force on pointed forebodies through add-on tip devices p 1024 A92-54918
YONEMOTO, KOICHI
Scramjet engine and its flying test bed
p 1066 A92-53492
Pre-flight physical simulation test of HIMES reentry test vehicle p 1103 A92-53640
YONEZAWA, SATOSHI
Optimization of aeroelastic system with active control
p 1083 A92-56022
YOROZU, MASAHIRO
Preliminary airfoil testing experience in the NDA cryogenic wind tunnel p 1091 A92-54326
YOSHIDA, K.
A conceptual study for future engine test facility
[AIAA PAPER 92-3992] p 1099 A92-56815
YOSHIZAWA, AKIRA
Aerodynamic heating characteristics of space planes tested by NAL hypersonic wind tunnel
p 1017 A92-53547
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043
YOUNG, CLARENCE P., JR.
Buffet test in the National Transonic Facility
[AIAA PAPER 92-4032] p 1100 A92-56854
YOUNT, LARRY J.
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
YOUSEFPOR, M.
An framework for robust flight control design using constrained optimization
[AIAA PAPER 92-4603] p 1131 A92-55282
YOUSSEF, H. M.
Identification and control of aircraft dynamics using radial basis function neural networks
[AIAA PAPER 92-4393] p 1074 A92-55194
YU, K.
Supersonic flow mixing and combustion using RAMP nozzle
[AIAA PAPER 92-3840] p 1113 A92-54198
YUHAS, ANDREW J.
Effects of bleed air extraction of thrust levels on the F404-GE-400 turbofan engine
[AIAA PAPER 92-3092] p 1066 A92-54009
YUKAWA, KIYOSHI
An experimental program concerning a satellite data link for oceanic ATC p 1046 A92-56093
YUMITE, YOSHIYUKI
Development of ITS90 small gas turbine engine
p 1070 A92-55500

Z

ZAB, RONALD JOSEPH
Thermal mechanical analysis of sprag clutches
[NASA-CR-190686] p 1128 N92-34207
ZACHO, LEON H.
An overview of the planned aerospace test facilities at Capua, Italy
[AIAA PAPER 92-3944] p 1097 A92-56773
ZAKRAJSEK, JAMES J.
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
ZAMBRANA, HORACIO A.
Flow characterization in the NASA Ames 16-inch Shock Tunnel
[AIAA PAPER 92-3810] p 1090 A92-54180
ZANOTTI, C.
Aluminium-lithium alloys - Application on helicopters
p 1106 A92-56326
ZAVARZINA, E. K.
High-temperature metal matrix composite
p 1105 A92-53878
ZEITLIN, ANDREW D.
Safety study of TCAS 2 for logic version 6.04
[DOT/FAA/RD-92/22] p 1047 N92-32537
ZELENAK, M.
Development and validation of a freejet technique for inlet-engine compatibility testing
[AIAA PAPER 92-3921] p 1033 A92-56752
ZELENKA, RICHARD E.
Integration of radar altimeter, precision navigation, and digital terrain data for low-altitude flight
[AIAA PAPER 92-4420] p 1063 A92-55212
ZHANG, B.
Rayleigh imaging and flow tagging in ground test facilities p 1115 A92-54330
ZHOU, MENG
An analysis of boundary layer for droplet aerodynamic stripped in high speed gas flow p 1116 A92-54563

ZHUANG, F. C.
An analysis of boundary layer for droplet aerodynamic stripped in high speed gas flow p 1116 A92-54563
ZINGG, D. W.
Grid studies for thin-layer Navier-Stokes computations of airfoil flowfields p 1025 A92-54935
ZOTTO, M.
Dynamic analysis of rotor blades with root retention design variations p 1054 A92-56156
ZUO, PEI C.
The research of reducing 3-D low supersonic shock wave reflection in a 2-D transonic flexible walls adaptive wind tunnel
[AIAA PAPER 92-3924] p 1095 A92-56755
ZUPPARDI, GENNARO
Detecting 3-D, turbulent separation regions using unsteady computerized thermographic technique
p 1023 A92-54308

Typical Corporate Source Index Listing



Listings in this index are arranged alphabetically by corporate source. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

A

Advanced Aviation Concepts, Jupiter, FL.
Workshop on Aeronautical Decision Making (ADM). Volume 1: Executive summary
[DOT/FAA/RD-92/14-VOL-1] p 1142 N92-33305

Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
The Utilization of Advanced Composites in Military Aircraft
[AGARD-R-785] p 1109 N92-33033

Aerospace Corp., El Segundo, CA.
Evaluation of GPS/UTC steering performance
p 1049 N92-33353

Air Force Inst. of Tech., Wright-Patterson AFB, OH.
A learning enhanced flight control system for high performance aircraft
[AD-A252520] p 1086 N92-32435

Air Force Systems Command, Wright-Patterson AFB, OH.
Lateral spread of sonic boom measurements from US Air Force boomfile flight tests p 1140 N92-33883

Alabama Univ., Huntsville.
High temperature aircraft research furnace facilities
[NASA-CR-184384] p 1101 N92-33826

Alenia, Foggia (Italy).
CFRP stiffened panels under compression
p 1109 N92-33044

Alenia Aeronautica, Naples (Italy).
Active vibrations and noise control for turboprop application research program activities
p 1138 N92-32962

Applied Acoustic Research, State College, PA.
A lightweight loudspeaker for aircraft communications and active noise control p 1125 N92-32964

Arizona Univ., Tucson.
Leading-edge receptivity for blunt-nose bodies
[NASA-CR-190563] p 1036 N92-32648

Army Aviation Systems Command, Hampton, VA.
Evaluation of composite components on the Bell 206L and Sikorsky S-76 helicopters p 1107 N92-32575

Army Cold Regions Research and Engineering Lab., Hanover, NH.
Effects of the abrasiveness of test and training site soils on parachute life
[AD-A252389] p 1038 N92-32900
Performance of insulated pavements at Newton Fields, Jackman, Maine
[CRREL-92-9] p 1101 N92-32903

Army Materiel Systems Analysis Activity, Aberdeen Proving Ground, MD.
Cost/benefit analysis of the AH-64 (Apache) helicopter Automated Test Equipment (ATE)
[AD-A252909] p 1101 N92-33398

B

Ballistic Research Labs., Aberdeen Proving Ground, MD.
Analysis of the flight performance of the 155 mm M864 base burn projectile
[BRL-TR-3083] p 1041 N92-33699

Battelle Columbus Labs., OH.
A review and discussion of flight management system incidents reported to the aviation safety reporting system
[AD-A252438] p 1043 N92-32941

Boeing Commercial Airplane Co., Seattle, WA.
Flutter in the transonic flight regime
p 1089 N92-34167
Flutter analyses using high speed computers. Part 1: Flutter analyses for large aircraft p 1089 N92-34168
Flutter analyses using high speed computers. Part 2: Aerodynamic procedures p 1089 N92-34169

Boeing Military Airplane Development, Wichita, KS.
Development of thermoplastic components for structural validation p 1107 N92-32522

Bombardier, Inc., Montreal (Quebec).
Further development of the CANAERO computer code to include propulsor modelling
[DREA-CR-90-425] p 1038 N92-32811

British Aerospace Aircraft Group, Warton (England).
Aspects of compression in aerospace composites: Future requirements p 1109 N92-33036

British Petroleum Co. Ltd., London (England).
Spray nozzle for fire control
[CA-PATENT-APPL-SN-2-011-94] p 1125 N92-32856

Bureau International des Poids et Mesures, Sevres (France).
The need for GPS standardization
p 1049 N92-33351
Precise GPS ephemerides from DMA and NGS tested by time transfer p 1049 N92-33355

C

California Polytechnic State Univ., San Luis Obispo.
Human factors issues in the use of artificial intelligence in air traffic control. October 1990 Workshop
[NASA-CR-190925] p 1051 N92-34203

California Univ., San Diego, La Jolla.
Theories of turbulent combustion in high speed flows
[AD-A253032] p 1111 N92-33624

Cambridge Collaborative, Inc., MA.
Use of SEA to predict structure-borne noise in aircraft
p 1137 N92-32955

Case Western Reserve Univ., Cleveland, OH.
Thermal mechanical analysis of sprag clutches
[NASA-CR-190686] p 1128 N92-34207

Centre d'Essais Aeronautique Toulouse (France).
Evaluation of the effects of the environment on the behavior of the primary structures of composite material aircraft in service: Historic and current situation
p 1110 N92-33048

Cincinnati Univ., OH.
The dynamics of flexible multibody systems: A finite segment approach p 1128 N92-34036

Clemson Univ., SC.
Real-time processing of radar return on a parallel computer
[NASA-CR-4456] p 1043 N92-32606

Coast Guard Academy, New London, CT.
Integrated Russian VLF/Omega receiver design
[PB92-193390] p 1051 N92-33809

Committee on Appropriations (U.S. House).
Departments of Veterans Affairs and Housing and Urban Development, and independent agencies appropriations for 1993, part 6
[GAO-55-636-PT-6] p 1141 N92-32505

Committee on Science, Space and Technology (U.S. House).
NASA authorization, 1993, volume 1
[GPO-55-260-VOL-1] p 1142 N92-33147

Congress of the United States, Washington, DC.
The 1991 Federal Aviation Administration plan for research, engineering and development
p 1142 N92-32453

Cranfield Inst. of Tech., Bedford (England).
Radial inflow turbine study
[AD-A252783] p 1127 N92-33538

D

Dayton Univ. Research Inst., OH.
Engine bird ingestion experience of the Boeing 737 aircraft: Expanded data base
[DOT/FAA/CT-91/32] p 1045 N92-34151

Defence Research Establishment Pacific, Victoria (British Columbia).
Detection of honeycomb damage using hexagonal grid discontinuities
[DREP-89-9] p 1109 N92-32846

Delaware Univ., Newark.
Continuation of tailored composite structures of ordered staple thermoplastic material
[NASA-CR-189671] p 1110 N92-33613

Department of Defense, Washington, DC.
DoD key technologies plan
[AD-A253692] p 1142 N92-33238

Department of the Navy, Washington, DC.
Improved articulated fin/wing control system statement of government interests
[AD-D015268] p 1088 N92-34131

Deutsche Insurance Germany (F.R.).
Pilot noise exposure during a Boeing 747-400 round trip: Judgement of noise and analysis in respect to hearing impairment of pilots p 1138 N92-32961

Deutsche Lufthansa A.G., Frankfurt am Main (Germany).
Pilots noise exposure during a Boeing 747-400 round trip: Ambient noise and acoustic-head recording and analysis of data p 1137 N92-32960

Dornier Luftfahrt G.m.b.H., Friedrichshafen (Germany).
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956

Douglas Aircraft Co., Inc., Long Beach, CA.
Fly-by-light technology development plan
[NASA-CR-181954] p 1086 N92-32778
MD-80 aft cabin noise control: A case history
p 1137 N92-32950

Dynamics Research Corp., Wilmington, MA.
Development of rating instruments and procedures for aviation mishap investigation
[AD-A253072] p 1044 N92-33288

E

EG and G Energy Measurements, Inc., Woburn, MA.
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596

ESDU International Ltd., London (England).
Aerodynamic centre of wing-body combinations
[ESDU-92024] p 1036 N92-32479
Contribution of tailplane-mounted twin fins to sideforce, yawing moment, and rolling moment derivatives due to sideslip
[ESDU-92007] p 1086 N92-32487

A background to the handling qualities of aircraft
[ESDU-92006] p 1087 N92-32780
Lift and rolling moment due to spoilers on wings with trailing-edge flaps deflected at subsonic speeds
[ESDU-92002-SUPPL] p 1037 N92-32782

F

Federal Aviation Administration, Atlantic City, NJ.
Bird ingestion into large turbofan engines
[DOT/FAA/CT-91/17] p 1043 N92-33005
ILS mathematical modeling study of an ILS localizer and glide slope proposed for runway 32R, Moffett Field Airport, California
[DOT/FAA/CT-TN92/28] p 1048 N92-33308
Federal Aviation Administration, Cambridge, MA.
Controller response to conflict resolution advisory prototype
[PB92-190032] p 1050 N92-33596
Federal Aviation Administration, Washington, DC.
The 1991 Federal Aviation Administration plan for research, engineering and development
p 1142 N92-32453
Exposures from headset interference tones
[AD-A247175] p 1136 N92-32697
Federal aviation regulations. Part 91: General operating and flight rules
[PB92-197334] p 1017 N92-33176
Accomplishments under the Airport Improvement Program, FY 1991
[AD-A253046] p 1101 N92-33434
Field Aviation Co., Inc., Mississauga (Ontario).
Fire bombing and fire bombers
[CA-PATENT-1-268-164] p 1061 N92-33582
Florida Atlantic Univ., Boca Raton.
Computational aspects of helicopter trim analysis and damping levels from Floquet theory
[NASA-CR-190736] p 1087 N92-33107
Fokker B.V., Schipol-Oost (Netherlands).
Active synchrophasing of propeller unbalance
p 1138 N92-32963

G

Galaxy Scientific Corp., Mays Landing, NJ.
Current nondestructive inspection methods for aging aircraft
[DOT/FAA/CT-91/5] p 1126 N92-33480
General Accounting Office, Washington, DC.
Air traffic control: FAA's advanced automation system contract
[GAO/IMTEC-91-25] p 1048 N92-32861
General Motors Corp., Indianapolis, IN.
Cooled high-temperature radial turbine program 2
[NASA-CR-189122] p 1073 N92-34236
Georgia Inst. of Tech., Atlanta.
Numerical investigation of the effects of icing on fixed and rotary wing aircraft
[NASA-CR-190542] p 1044 N92-34105
Grumman Aerospace Corp., Bethpage, NY.
Design, evaluation and experimental effort toward development of a high strain composite wing for Navy aircraft p 1107 N92-32514

H

Honeywell, Inc., Minneapolis, MN.
Study objectives: Will commercial avionics do the job? Improvements needed? p 1065 N92-33340

I

Illinois Inst. of Tech., Chicago.
Electro optical system to measure strains at high temperature
[NASA-CR-190450] p 1127 N92-33696
Institut de Mecanique de Grenoble (France).
Numerical simulation of turbulence at the back of the airplane
[ETN-92-91664] p 1037 N92-32769
Institute for Aerospace Research, Ottawa (Ontario).
Processing and environmental effects on mechanical properties of composite repairs
[NRC-LTR-ST-1826] p 1109 N92-32791
A Kalman filter integrated navigation design for the IAR Twin Otter Atmospheric Research Aircraft
[NRC-32148] p 1048 N92-32849

J

Johns Hopkins Univ., Baltimore, MD.
Aeroelasticity of bluff bodies p 1089 N92-34165

K

Krug Life Sciences, Inc., San Antonio, TX.
The utility of analog vertical velocity information during instrument flight with a Head-Up Display (HUD)
[AD-A252863] p 1065 N92-33277

L

Laser Technology, Inc., Norristown, PA
Inspection of fabricated fuselage panels using electronic shearography
[DOT/FAA/CT-TN92/26] p 1127 N92-33627
Leeds Univ. (England).
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
Lehigh Univ., Bethlehem, PA.
Unsteady response of the leading-edge vortices on a pitching delta wing p 1041 N92-33851
Lockheed Aeronautical Systems Co., Marietta, GA.
Acoustic loads prediction on jet aircraft
p 1136 N92-32949

M

Manchester Univ. (England).
Elementary flutter analysis p 1088 N92-34162
Flight flutter testing p 1089 N92-34163
Maryland Univ., College Park.
Distributed systems: Interconnection and fault tolerance studies
[AD-A252869] p 1135 N92-33920
Massachusetts Inst. of Tech., Cambridge.
Active contrc' of compressor surge and stall
[AD-A252771] p 1126 N92-33498
Impacts of technology on the capacity needs of the US national airspace system
[NASA-CR-4470] p 1045 N92-34192
Massachusetts Inst. of Tech., Lexington.
Airport Surveillance Radar (ASR-9) wind shear processor: 1991 test at Orlando, Florida
[AD-A252246] p 1124 N92-32686
MCAT Inst., San Jose, CA.
High speed transition prediction
[NASA-CR-190836] p 1039 N92-33424
McDonnell Aircraft Co., Saint Louis, MO.
Out of plane analysis for composite structures
p 1107 N92-32527
McMaster Univ., Hamilton (Ontario).
Radar clutter classification
[ISBN-0-315-57981-1] p 1126 N92-33440
Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany).
Stability failure of sandwich structures
[MBB-UD-0613-92-PUB] p 1111 N92-33994
Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany).
Examples of advanced near-net shape manufacturing techniques for aerospace
[MBB-Z-0399-91-PUB] p 1125 N92-32742
Michigan Univ., Ann Arbor.
Development of 3D electromagnetic modeling tools for airborne vehicles
[NASA-CR-190810] p 1126 N92-33307
Minnesota Univ., Minneapolis.
Design of helicopter flight control systems for hover and low speed using eigenstructure assignment
p 1061 N92-33952
Nonlinear dynamic-inversion flight control of supermaneuverable aircraft p 1062 N92-33953
Mississippi Univ., University.
Steady state risetimes of shock waves in the atmosphere p 1140 N92-33882
Mitre Corp., McLean, VA.
Safety study of TCAS 2 for logic version 6.04
[DOT/FAA/RD-92/22] p 1047 N92-32537
Simulation test and evaluation of TCAS 2 logic version 6.04
[DOT/FAA/RD-92/23] p 1048 N92-33098
Mitsubishi Space Software Corp. (Japan).
Analysis of spacecraft entry into Mars atmosphere
p 1105 N92-33763

N

National Aeronautical Establishment, Ottawa (Ontario).
The use of Kalman filtering techniques to improve the accuracy of flight test data
[NRC-32139] p 1064 N92-32850
National Aeronautics and Space Administration, Washington, DC.
An experimental examination of the effects of incoming boundary layer modifications on the dynamics of a turbulent compression corner interaction
[AIAA PAPER 92-3667] p 1022 A92-54111
Comparison between computational and experimental data for a hypersonic laser propelled vehicle
[AIAA PAPER 92-3808] p 1023 A92-54179
An assumed joint-Beta PDF approach for supersonic turbulent combustion
[AIAA PAPER 92-3844] p 1113 A92-54199
A fine-wire thermocouple probe for measurement of stagnation temperatures in real gas hypersonic flows of nitrogen p 1114 A92-54317
Measured and calculated optical property profiles in the mixed layer and free troposphere p 1129 A92-54630
Optimal recovery from microburst wind shear
[AIAA PAPER 92-4338] p 1078 A92-55327
A data fusion algorithm for multi-sensor microburst hazard assessment
[AIAA PAPER 92-4339] p 1063 A92-55328
Multidisciplinary optimization of aeroservoelastic systems using reduced-size models
p 1054 A92-56176
Research needs for a commercial passenger tiltrotor
p 1056 A92-56298
Effects of oxygen dissociation on hypervelocity combustion experiments
[AIAA PAPER 92-3964] p 1098 A92-56791
A code validation strategy and facility for nonequilibrium, reacting flows
[AIAA PAPER 92-3970] p 1098 A92-56796
Small engine components test facility compressor testing cell at NASA Lewis Research Center
[AIAA PAPER 92-3980] p 1098 A92-56806
Advanced nozzle and engine components test facility
[AIAA PAPER 92-3993] p 1099 A92-56816
Engine component instrumentation development facility at NASA Lewis Research Center
[AIAA PAPER 92-3995] p 1099 A92-56818
Description of a pressure measurement technique for *obtaining surface static pressures of a radial turbine*
[AIAA PAPER 92-4006] p 1123 A92-56829
Boundary layer study on nozzle wall at hypersonic velocities
[AIAA PAPER 92-4013] p 1034 A92-56836
A database of aerothermal measurements in hypersonic flow for CFD validation
[AIAA PAPER 92-4023] p 1034 A92-56845
Free-radicals aided combustion with scramjet applications
[IAF PAPER 92-0659] p 1106 A92-57100
Technologies for the National Aero-Space Plane
[IAF PAPER 92-0868] p 1105 A92-57259
An international aerospace information system: A cooperative opportunity
[NASA-TM-108171] p 1142 N92-33237
National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
Heat transfer measurements and CFD comparison of swept shock wave/boundary-layer interactions
[AIAA PAPER 92-3665] p 1021 A92-54110
Comparison of turbulence models for powered-lift flow fields
[AIAA PAPER 92-3674] p 1022 A92-54117
Flow characterization in the NASA Ames 16-inch Shock Tunnel
[AIAA PAPER 92-3810] p 1090 A92-54180
Improving designer productivity
[AIAA PAPER 92-1187] p 1130 A92-54285
H-N2 interaction energies, transport cross sections, and collision integrals p 1135 A92-54660
Assessment of compressibility corrections to the k-epsilon model in high-speed shear layers
p 1024 A92-54905
Flowfield of a lifting rotor in hover - A Navier-Stokes simulation p 1024 A92-54906
Analysis of the onset of dynamic stall
p 1024 A92-54919
Vortical flow computations on a flexible blended wing-body configuration p 1024 A92-54922
Vision-based stereo ranging as an optimal control problem
[AIAA PAPER 92-4418] p 1045 A92-55211
Integration of radar altimeter, precision navigation, and digital terrain data for low-altitude flight
[AIAA PAPER 92-4420] p 1063 A92-55212
Control design of a UH-60 rotorcraft via CLTR and direct optimization
[AIAA PAPER 92-4470] p 1076 A92-55230
Concepts for pilot interaction with an automated NOE obstacle-avoidance system
[AIAA PAPER 92-4472] p 1076 A92-55232

An framework for robust flight control design using constrained optimization
[AIAA PAPER 92-4603] p 1131 A92-55282
Severe turbulence and maneuvering from airline flight records
[AIAA PAPER 92-4341] p 1078 A92-55330
Flight simulator fidelity assessment in a rotorcraft lateral translation maneuver
[AIAA PAPER 92-4424] p 1092 A92-55348
Navier-Stokes prediction of large-amplitude delta-wing roll oscillations characterizing wing rock
[AIAA PAPER 92-4428] p 1080 A92-55352
Vortical flow control on a wing-body combination using tangential blowing
[AIAA PAPER 92-4430] p 1081 A92-55354
Navier-Stokes computations for oscillating control surfaces
[AIAA PAPER 92-4431] p 1026 A92-55355
A discrete vortex model for predicting wing rock of slender wings
[AIAA PAPER 92-4497] p 1026 A92-55365
Computations of the unsteady flow about a generic wing/pylon/finned-store configuration
[AIAA PAPER 92-4568] p 1027 A92-55377
Force production mechanisms of a tangential jet on bodies at high alpha
[AIAA PAPER 92-4648] p 1082 A92-55393
Analysis of image-based navigation system for rotorcraft low-altitude flight p 1046 A92-55968
Unsteady shock-vortex interaction on a flexible delta wing p 1030 A92-56157
Navier-Stokes simulation of a close-coupled canard-wing-body configuration p 1031 A92-56163
Euler/experiment correlation of a generic fighter p 1031 A92-56164
Two-fence concept for efficient trapping of vortices on airfoils p 1031 A92-56165
Application of computational fluid dynamics to sonic boom near- and mid-field prediction p 1031 A92-56173
Modular techniques for dynamic fault-tree analysis p 1120 A92-56241
The computation and validation of hovering rotor performance p 1055 A92-56285
Finite-element analysis and multibody dynamics issues in rotorcraft dynamic analysis p 1055 A92-56286
Coupled rotor-fuselage vibration reduction with multiple frequency blade pitch control p 1085 A92-56315
Research on measurement and control of helicopter rotor response using blade-mounted accelerometers 1990-91 p 1057 A92-56316
First level release of 2GCHAS for comprehensive helicopter analysis p 1133 A92-56339
Approximations for inclusion of rotor lag dynamics in helicopter flight dynamics models p 1060 A92-56354
Experimental results for a hypersonic nozzle/afterbody flow field
[AIAA PAPER 92-3915] p 1032 A92-56747
Blockage correction in three-dimensional wind tunnel testing based on the wall signature method
[AIAA PAPER 92-3925] p 1095 A92-56756
Development and integration of modern laboratories in aerospace education
[AIAA PAPER 92-4022] p 1141 A92-56844
CFD validation experiments for hypersonic flows
[AIAA PAPER 92-4024] p 1034 A92-56846
Laboratory simulation of aerothermodynamic phenomena - A review
[AIAA PAPER 92-4025] p 1104 A92-56847
Numerical simulation of unsteady flow in a hypersonic shock tunnel facility
[AIAA PAPER 92-4029] p 1034 A92-56851
Potential flow theory and operation guide for the panel code PMARC
[NASA-TM-102851] p 1036 N92-32422
Vision-based range estimation using helicopter flight data
[NASA-TM-103930] p 1047 N92-32424
Computations of unsteady multistage compressor flows in a workstation environment
[NASA-TM-103839] p 1071 N92-32452
Collaborative research on V/STOL control system/cockpit display tradeoffs under the NASA/MOD *joint aeronautical program*
[NASA-TM-103910] p 1087 N92-32788
Ski jump takeoff performance predictions for a mixed-flow, remote-lift STOVL aircraft
[NASA-TM-103866] p 1060 N92-32887
CTAS: Computer intelligence for air traffic control in the terminal area
[NASA-TM-103959] p 1044 N92-33080
Analysis of delay reducing and fuel saving sequencing and spacing algorithms for arrival traffic
[NASA-TM-103880] p 1044 N92-33194
On the anomalies in single-jet hover suckdown data
[NASA-TM-102261] p 1038 N92-33306
Design and evaluation of an advanced air-ground data-link system for air traffic control
[NASA-TM-103899] p 1050 N92-33407
Dynamic response of induced pressures, suckdown, and temperatures for two tandem jet STOVL configurations
[NASA-TM-103934] p 1039 N92-33581
A workstation-based evaluation of a far-field route planner for helicopters
[NASA-TM-102882] p 1051 N92-33609
On the estimation of jet-induced fountain lift and additional suckdown in hover for two-jet configurations
[NASA-TM-102268] p 1040 N92-33618
Research and technology, 1990
[NASA-TM-107967] p 1143 N92-33948

National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
Experience with Ada on the F-18 High Alpha Research Vehicle Flight Test Program
[NASA-TM-104259] p 1062 N92-34039

National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
Effects of bleed air extraction of thrust levels on the F404-GE-400 turbofan engine
[AIAA PAPER 92-3092] p 1066 A92-54009
Getting up to speed in hypersonic structures p 1117 A92-55127
Flight-determined stability analysis of multiple-input-multiple-output control systems
[AIAA PAPER 92-4396] p 1074 A92-55196
High angle-of-attack flush airdata sensing system p 1064 A92-56172
User's manual for AeroFcn: A FORTRAN program to compute aerodynamic parameters
[NASA-TM-104237] p 1133 N92-32507
Flight testing and simulation of an F-15 airplane using throttles for flight control
[NASA-TM-104255] p 1087 N92-32864
The development of an airborne information management system for flight test
[NASA-TM-104251] p 1065 N92-32866
Rapid development of the X-31 simulation to support flight-testing
[NASA-TM-104256] p 1060 N92-33149
The F-18 high alpha research vehicle: A *high-angle-of-attack testbed aircraft*
[NASA-TM-104253] p 1060 N92-33404
Thermal-structural test facilities at NASA Dryden
[NASA-TM-104249] p 1062 N92-34202

National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
Issues in developing control zones for international space operations p 1141 A92-56602
SATWG networked quality function deployment p 1134 N92-33339

National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
An assumed joint-Beta PDF approach for supersonic turbulent combustion
[AIAA PAPER 92-3844] p 1113 A92-54199
Comparison of frequency domain and time domain laser velocimeter signal processors p 1114 A92-54314
Problems and solutions for transition detection in cryogenic wind tunnels by infrared imaging p 1090 A92-54319
Signal processing schemes for Doppler global velocimetry p 1115 A92-54338
Evaluation of electrolytic tilt sensors for wind tunnel model angle-of-attack (AOA) measurements p 1116 A92-54344
A laser fluorescence anemometer system for the Langley 16- by 24-inch water tunnel p 1092 A92-54347
The use of silicon microsensors in smart skins for aerodynamic research p 1116 A92-54348
Broadband shock associated noise from supersonic jets measured by a ground observer p 1135 A92-54909
Methodology for calculating aerodynamic sensitivity derivatives p 1024 A92-54911
Application of a parallel direct simulation Monte Carlo method to hypersonic rarefied flows p 1024 A92-54916
Approximate Riemann solver for hypervelocity flows p 1117 A92-54934
Getting up to speed in hypersonic structures p 1117 A92-55127
DAMVIBS looks at rotorcraft vibration p 1052 A92-55128
New materials drive high-performance aircraft p 1105 A92-55134
Dynamics and control of hypersonic aeropropulsive/aeroelastic vehicles
[AIAA PAPER 92-4326] p 1073 A92-55170
Robust dynamic inversion control laws for aircraft control
[AIAA PAPER 92-4329] p 1073 A92-55173
Preliminary assessment of the robustness of dynamic inversion based flight control laws
[AIAA PAPER 92-4330] p 1074 A92-55174
Aircraft ride quality controller design using new robust root clustering theory for linear uncertain systems
[AIAA PAPER 92-4399] p 1075 A92-55199
New literal approximations for the longitudinal dynamic characteristics of flexible flight vehicles
[AIAA PAPER 92-4411] p 1075 A92-55205
Constrained control allocation
[AIAA PAPER 92-4550] p 1131 A92-55262
Applications of robust control theory - Educational implications
[AIAA PAPER 92-4559] p 1131 A92-55271
An integrated development of the equations of motion for elastic hypersonic flight vehicles
[AIAA PAPER 92-4605] p 1077 A92-55283
Aerodynamic parameters of the X-31 drop model estimated from flight-data at high angles of attack
[AIAA PAPER 92-4357] p 1080 A92-55343
Active control of asymmetric vortical flows around cones using injection and heating
[AIAA PAPER 92-4426] p 1025 A92-55350
Computation of vortex wake flows and control of their effects on trailing wings
[AIAA PAPER 92-4429] p 1025 A92-55353
Assessment of passive porosity with free and fixed separation on a tangent ogive forebody
[AIAA PAPER 92-4494] p 1081 A92-55363
Evaluation of a multigrid-based Navier-Stokes solver for aerothermodynamic computations
[AIAA PAPER 92-4563] p 1027 A92-55375
PAYCOS, a multidisciplinary sizing code for hypersonic vehicles
[AIAA PAPER 92-4564] p 1132 A92-55376
Computing high-speed flows past an oscillating cylinder near a vertical wall
[AIAA PAPER 92-4653] p 1028 A92-55397
Aeroelastic effects of spoiler surfaces on a low-aspect-ratio rectangular wing p 1030 A92-56154
Model flight tests of a spin-resistant trainer configuration p 1054 A92-56158
Application of advanced multidisciplinary analysis and optimization methods to vehicle design synthesis p 1054 A92-56160
HiRel - Reliability/availability integrated workstation tool p 1120 A92-56257
Detailed analysis and test correlation of a stiffened composite wing panel p 1121 A92-56324
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344
A quiet-flow Ludwieg tube for experimental study of high speed boundary layer transition
[AIAA PAPER 92-3885] p 1094 A92-56727
Supersonic and hypersonic quiet tunnel technology at NASA Langley
[AIAA PAPER 92-3908] p 1094 A92-56743
The ASU Transition Research Facility
[AIAA PAPER 92-3910] p 1094 A92-56744
A clean air continuous flow propulsion facility
[AIAA PAPER 92-3912] p 1094 A92-56745
Control of large cryogenic tunnels
[AIAA PAPER 92-3930] p 1096 A92-56761
Hypersonic aerodynamic/aerothermodynamic testing capabilities at Langley Research Center
[AIAA PAPER 92-3937] p 1096 A92-56767
The Langley 15-inch Mach 6 High Temperature Tunnel
[AIAA PAPER 92-3938] p 1096 A92-56768
Test description and preliminary pitot-pressure surveys for Langley Test Technique Demonstrator at Mach 6
[AIAA PAPER 92-3940] p 1096 A92-56770
Predicted aerodynamic characteristics for HL-20 lifting-body using the aerodynamic preliminary analysis system (APAS)
[AIAA PAPER 92-3941] p 1033 A92-56771
Performance data of the new free-piston shock tunnel at GALCIT
[AIAA PAPER 92-3943] p 1033 A92-56776
Effects of oxygen dissociation on hypervelocity combustion experiments
[AIAA PAPER 92-3964] p 1098 A92-56791
An approach for increasing aeroelastic divergence dynamic pressure of wind-tunnel models
[AIAA PAPER 92-4002] p 1099 A92-56825
CAN-DO, CFD-based Aerodynamic Nozzle Design and Optimization program for supersonic/hypersonic wind tunnels
[AIAA PAPER 92-4009] p 1033 A92-56832
Computational and numerical analysis of hypersonic nozzle flows with comparisons to wind tunnel calibration data
[AIAA PAPER 92-4011] p 1033 A92-56834
Buffet test in the National Transonic Facility
[AIAA PAPER 92-4032] p 1100 A92-56854

Effects of external influences in subsonic delta wing vortices
[AIAA PAPER 92-4033] p 1034 A92-56855
Numerical modeling of transonic juncture flow
[AIAA PAPER 92-4036] p 1035 A92-56858
An integrated analytical aeropropulsive/aeroelastic model for the dynamic analysis of hypersonic vehicles
[AIAA PAPER 92-4567] p 1035 A92-57034
A method for designing blended wing-body configurations for low wave drag
[NASA-TP-3261] p 1036 N92-32480
Eighth DOD/NASA/FAA Conference on Fibrous Composites in Structural Design, part 1
[NASA-CP-3087-PT-1] p 1106 N92-32513
A Protection And Detection Surface (PADS) for damage tolerance p 1107 N92-32523
Global/local methods research using the CSM testbed p 1107 N92-32528
The multiple-function multi-input/multi-output digital controller system for the AFW wind-tunnel model
[NASA-TM-107600] p 1060 N92-32536
Residual strength of repaired graphite/epoxy laminates after 5 years of outdoor exposure p 1108 N92-32577
Analysis of data from a DO-178A software development process p 1134 N92-32880
Fourth Aircraft Interior Noise Workshop
[NASA-CP-10103] p 1136 N92-32948
Active control of interior noise in a large scale cylinder using piezoelectric actuators p 1137 N92-32958
Flight service environmental effects on composite materials and structures p 1110 N92-33054
Computational methods for global/local analysis
[NASA-TM-107591] p 1125 N92-33104
Building vibrations induced by noise from rotorcraft and propeller aircraft flyovers
[NASA-TM-104170] p 1138 N92-33160
Isothermal aging of IM7/8320 and IM7/5260
[NASA-TM-107666] p 1110 N92-33423
Advanced techniques in reliability model representation and solution
[NASA-TP-3242] p 1134 N92-33483
Applications of a direct/iterative design method to complex transonic configurations
[NASA-TP-3234] p 1039 N92-33484
Simulation model of a twin-tail, high performance airplane
[NASA-TM-107601] p 1088 N92-33537
A nozzle internal performance prediction method
[NASA-TP-3221] p 1040 N92-33625
Experimental study of a generic high-speed civil transport
[NASA-TM-4382] p 1040 N92-33631
Survey and analysis of research on supersonic drag-due-to-lift minimization with recommendations for wing design
[NASA-TP-3202] p 1040 N92-33656
Effect of afterbody geometry on aerodynamic characteristics of isolated nonaxisymmetric afterbodies at transonic Mach numbers
[NASA-TP-3236] p 1041 N92-33706
Application of magnitude estimation scaling to the assessment of subjective loudness response to simulated sonic booms
[NASA-TM-107657] p 1138 N92-33719
High-Speed Research: Sonic Boom, volume 1
[NASA-CP-3172] p 1061 N92-33874
Preliminary results from the White Sands Missile Range sonic boom propagation experiment p 1140 N92-33884
Subjective loudness response to simulated sonic booms p 1140 N92-33885
Finite difference time domain grid generation from AMC helicopter models
[NASA-TM-107679] p 1128 N92-34017
Computational algorithms for increased control of depth-viewing volume for stereo three-dimensional graphic displays
[NASA-TM-4379] p 1065 N92-34109
Pressure measurements on a rectangular wing with a NACA0012 airfoil during conventional flutter
[NASA-TM-104211] p 1042 N92-34147
Advanced subsonic transport approach noise: The relative contribution of airframe noise
[NASA-TM-104112] p 1140 N92-34148
Vaporizing particle velocimeter
[NASA-CASE-LAR-14685-1] p 1042 N92-34172
Effects of constraint on crack growth under aircraft spectrum loading
[NASA-TM-107677] p 1128 N92-34178
Parametric investigation of single-expansion-ramp nozzles at Mach numbers from 0.60 to 1.20
[NASA-TP-3240] p 1042 N92-34193
Pilot-pressure probe for measuring pressure in a hypersonic wind tunnel
[NASA-CASE-LAR-14232-1] p 1102 N92-34213

National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
Three-dimensional Navier-Stokes heat transfer predictions for turbine blade rows
[AIAA PAPER 92-3068] p 1020 A92-54003
A comparison of the calculated and experimental off-design performance of a radial flow turbine
[AIAA PAPER 92-3069] p 1020 A92-54004
Increased heat transfer to elliptical leading edges due to spanwise variations in the freestream momentum - Numerical and experimental results
[AIAA PAPER 92-3070] p 1020 A92-54005
FREPS - A forced response prediction system for turbomachinery blade rows
[AIAA PAPER 92-3072] p 1130 A92-54006
Detonation duct gas generator demonstration program
[AIAA PAPER 92-3174] p 1066 A92-54011
Full Navier-Stokes calculations on the installed F/A-18 inlet at a high angle of attack
[AIAA PAPER 92-3175] p 1020 A92-54012
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[AIAA PAPER 92-3177] p 1020 A92-54013
Navier-Stokes analysis of three-dimensional unsteady flows inside turbine stages
[AIAA PAPER 92-3211] p 1021 A92-54016
Preliminary dynamic tests of a flight-type ejector
[AIAA PAPER 92-3261] p 1066 A92-54020
Applied analytical combustion/emissions research at the NASA Lewis Research Center - A progress report
[AIAA PAPER 92-3338] p 1067 A92-54025
Summary highlights of the Advanced Rotorcraft Transmission (ART) program
[AIAA PAPER 92-3362] p 1051 A92-54026
The VRT gas turbine combustor - Phase II
[AIAA PAPER 92-3471] p 1067 A92-54035
Modal simulation of gearbox vibration with experimental correlation
[AIAA PAPER 92-3494] p 1112 A92-54036
Experimental investigation of an ejector-powered free-jet facility
[AIAA PAPER 92-3569] p 1090 A92-54058
Full Navier-Stokes analysis of a two-dimensional mixer/ejector nozzle for noise suppression
[AIAA PAPER 92-3570] p 1067 A92-54059
Flow induction by pressure forces
[AIAA PAPER 92-3571] p 1067 A92-54060
An experimental investigation of the flow in a diffusing S-duct
[AIAA PAPER 92-3622] p 1021 A92-54090
A finite-volume numerical method to calculate fluid forces and rotordynamic coefficients in seals
[AIAA PAPER 92-3712] p 1113 A92-54132
Wind tunnel performance results of swirl recovery vanes as tested with an advanced high speed propeller
[AIAA PAPER 92-3770] p 1068 A92-54159
Unsteady blade pressures on a propfan - Predicted and measured compressibility effects
[AIAA PAPER 92-3774] p 1023 A92-54161
Experimental performance of three design factors for ventral nozzles for SSTOVL aircraft
[AIAA PAPER 92-3789] p 1069 A92-54168
Internal reversing flow in a tailpipe offtake configuration for SSTOVL aircraft
[AIAA PAPER 92-3790] p 1069 A92-54169
Use of an approximate similarity principle for the thermal scaling of a full-scale thrust augmenting ejector
[AIAA PAPER 92-3792] p 1069 A92-54171
Aeroelastic modal characteristics of mistuned blade assemblies - Mode localization and loss of eigenstructure p 1117 A92-54921
Turning up the heat on aircraft structures p 1052 A92-55131
Propulsion system performance resulting from an integrated Flight/Propulsion Control design
[AIAA PAPER 92-4602] p 1069 A92-55281
Analysis of airframe/engine interactions for a STOVL aircraft with integrated flight/propulsion control
[AIAA PAPER 92-4623] p 1052 A92-55300
Surface heat transfer and flow properties of vortex arrays induced artificially and from centrifugal instabilities p 1121 A92-56371
Flow quality studies of the NASA Lewis Research Center 8- by 6-foot supersonic/9- by 15-foot Low Speed Wind Tunnel
[AIAA PAPER 92-3916] p 1095 A92-56748
Laser-driven hypersonic air-breathing propulsion simulator
[AIAA PAPER 92-3922] p 1095 A92-56753
Small engine components test facility compressor testing cell at NASA Lewis Research Center
[AIAA PAPER 92-3980] p 1098 A92-56806
Advanced nozzle and engine components test facility
[AIAA PAPER 92-3993] p 1099 A92-56816
Engine component instrumentation development facility at NASA Lewis Research Center
[AIAA PAPER 92-3995] p 1099 A92-56818
Calibration of hemispherical-head flow angularity probes
[AIAA PAPER 92-4005] p 1122 A92-56828
Description of a pressure measurement technique for obtaining surface static pressures of a radial turbine
[AIAA PAPER 92-4006] p 1123 A92-56829
Transonic turbine blade cascade testing facility
[AIAA PAPER 92-4034] p 1101 A92-56856
Experimental unsteady pressures on an oscillating cascade with supersonic leading edge locus
[AIAA PAPER 92-4035] p 1035 A92-56857
Effect of a simulated glaze ice shape on the aerodynamic performance of a rectangular wing
[AIAA PAPER 92-4042] p 1035 A92-56861
A critical evaluation of a three-dimensional Navier-Stokes CFD as a tool to design supersonic turbine stages p 1124 N92-32268
Liquid lubricants for advanced aircraft engines
[NASA-TM-104531] p 1109 N92-32863
Navier-Stokes analysis and experimental data comparison of compressible flow in a diffusing S-duct
[NASA-TM-105683] p 1072 N92-33746
A graphical user-interface for propulsion system analysis
[NASA-TM-105696] p 1134 N92-33894
Piloted evaluation of an integrated propulsion and flight control simulator
[NASA-TM-105797] p 1088 N92-34107
Application of computational fluid dynamics to the study of vortex flow control for the management of inlet distortion
[NASA-TM-105672] p 1128 N92-34112
Analysis of iced wings
[NASA-TM-105773] p 1042 N92-34144
Method of reducing drag in aerodynamic systems
[NASA-CASE-LEW-14791-1] p 1043 N92-34243

National Aerospace Lab., Amsterdam (Netherlands).
Modeling and numerical simulation of vortex flow in aerodynamics
[NLR-TP-91154-U] p 1037 N92-32673
New concepts for multi-block grid generation for flow domains around complex aerodynamic configurations
[NLR-TP-91046-U] p 1037 N92-32730
An experimental study of the flow over a sharp-edged delta wing at subsonic and transonic speeds
[NLR-TP-91117-U] p 1037 N92-32732
Integration of wall interference assessment and wall adaptation
[NLR-TP-91119-U] p 1101 N92-32734
Development of new flight procedures for the Microwave Landing System (MLS)
[NLR-TP-91156-U] p 1047 N92-32830
Global/local interlaminar stress analysis of a grid-stiffened composite panel
[NASA-CR-190822] p 1125 N92-33139
Activities report of the National Aerospace Laboratory
[ETN-92-92053] p 1143 N92-33694

National Inst. for Fusion Science, Nagoya (Japan).
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743

National Inst. of Standards and Technology, Gaithersburg, MD.
Preliminary screening procedures and criteria for replacements for Halons 1211 and 1301
[AD-A252912] p 1126 N92-33501

National Oceanic and Atmospheric Administration, Rockville, MD.
GPS orbit determination at the National Geodetic Survey p 1049 N92-33354

National Research Council of Canada, Ottawa (Ontario).
The design and development of a portable, DSP micro-processor based, high-accuracy data acquisition system
[NRC-32146] p 1134 N92-32851

National Transportation Safety Board, Washington, DC.
Aircraft accident report: L'Express Airlines, Inc., Flight 508, Beech C99, N7217L weather encounter and crash near Birmingham, Alabama, July 10, 1991
[PB92-910401] p 1043 N92-32455
Aircraft accident/incident summary report: Controlled flight into terrain Bruno's Inc., Beechjet, N25BR, Rome, Georgia, 11 December 1991
[PB92-910404] p 1044 N92-34081

Naval Air Propulsion Test Center, Trenton, NJ.
Statistics on aircraft gas turbine engine rotor failures that occurred in US commercial aviation during 1988
[DOT/FAA/CT-91/28] p 1071 N92-33105

Naval Air Warfare Center, Warminster, PA.
An investigation of switched reluctance rotor position estimation using neural networks
[AD-A252846] p 1061 N92-33414
Naval Observatory, Washington, DC.
LORAN-C data reduction at the US Naval Observatory
p 1050 N92-33358
Naval Ocean Systems Center, San Diego, CA.
Feasibility of measuring transverse electric noise at VLF and LF on an ice cap
[AD-A252280] p 1129 N92-33220
Naval Postgraduate School, Monterey, CA.
Investigation of the flight control requirements of a half-scale ducted fan unmanned aerial vehicle
[AD-A252730] p 1087 N92-32988
Implementation of a personal computer based parameter estimation program
[AD-A252914] p 1061 N92-33502
Static and dynamic flow visualization studies of two double-delta wing models at high angles of attack
[AD-A252878] p 1040 N92-33678
Naval Research Lab., Washington, DC.
Lightning strike tests of composite connectors
[AD-A252281] p 1044 N92-33249
North Carolina State Univ., Raleigh.
An approximate viscous shock layer technique for calculating chemically reacting hypersonic flows about blunt-nosed bodies p 1041 N92-33837
Northrop Corp., Hawthorne, CA.
Structural assessment of ultralightweight composites
p 1107 N92-32525
Supportability evaluation of thermoplastic and thermoset composites p 1108 N92-32576
Damage tolerance certification methodology for composite structures p 1108 N92-32579

O

Oak Ridge National Lab., TN.
Proof of concept of a magnetically coupled Stirling engine-driven heat pump
[DE92-017129] p 1129 N92-33271
Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
Research on some centered implicit methods for calculating transonic flows by solving Navier-Stokes equations
[ONERA-RSF-24/1408-AY-150A] p 1037 N92-32773
Strong coupling between inviscid fluid and boundary layer of sharp leading edges: Two-dimensional stationary and turbulent cases for isolated profiles and guard vanes
[ONERA-RT-44/1621-RY-016-R] p 1125 N92-32776
Flutter models: Their design, manufacture, and ground testing p 1089 N92-34164
Unsteady wind tunnel tests p 1089 N92-34166
Ohio State Univ., Columbus.
Computation and stability analysis of laminar flow over a blunt cone in hypersonic flow p 1041 N92-33839
Old Dominion Univ., Norfolk, VA.
Prediction and control of asymmetric vortical flows around slender bodies using Navier-Stokes equations
p 1127 N92-33968
Investigation of advancing front method for generating unstructured grid
[NASA-CR-190902] p 1128 N92-34043
Dynamics and control of a five degree-of-freedom magnetic suspension system
[NASA-CR-191259] p 1102 N92-34222
Omega Navigation System Center, Alexandria, VA.
US Coast Guard GPS Information Center (GPSIC) and its function within the Civil GPS Service (CGS)
p 1049 N92-33352
Oregon State Univ., Corvallis.
Turbulence-induced loads on a teetered rotor
p 1042 N92-34029

P

Patras Univ. (Greece).
Jet fuel absorption and dynamic mechanical analysis of carbon fibre composites p 1110 N92-33050
Pennsylvania State Univ., University Park.
Numerical simulation of turbomachinery flows with advanced turbulence models p 1124 N92-32270
Swept shock/boundary layer interaction experiments in support of CFD code validation
[NASA-CR-190583] p 1036 N92-32494
Wave equations and computational models for sonic boom propagation through a turbulent atmosphere
p 1139 N92-33877
Simulations of sonic boom ray tube area fluctuations for propagation through atmospheric turbulence including caustics via a Monte Carlo method
p 1139 N92-33878
Analysis of sonic boom data to quantify distortions of shock profiles p 1139 N92-33879
Pneumo Corp., Boston, MA.
Landing gear mechanism including runway-roughness restrictor assembly
[CA-PATENT-1-257-618] p 1061 N92-33585
Power Reactor and Nuclear Fuel Development Corp., Oarai (Japan).
Study of potassium turbine electric generator system
p 1129 N92-33794
Pratt and Whitney Aircraft Group, East Hartford, CT.
Life prediction and constitutive models for engine hot section anisotropic materials program
[NASA-CR-189223] p 1072 N92-33479
Princeton Univ., NJ.
On the calculation of the response of helicopters to control inputs
[NASA-CR-190812] p 1088 N92-33536

R

RAND Corp., Santa Monica, CA.
Developing robust support structures for high-technology subsystems: The AH-64 Apache helicopter
[AD-A252773] p 1017 N92-33499
Advanced airframe structural materials: A primer and cost estimating methodology
[AD-A253371] p 1062 N92-34182
Research and Development Labs., Culver City, CA.
United States Air Force summer research program 1991. Volume 1: Program management report
[AD-A248763] p 1142 N92-32338
Research Inst. for Computing and Information Systems, Houston, TX.
Advanced software development workstation: Effectiveness of constraint-checking
[NASA-CR-190712] p 1134 N92-32865
Resource International, Inc., Westerville, OH.
Criteria for use of seal coats on airport pavements
[DOT/FAA/RD-92/18] p 1102 N92-34247
Rolls-Royce Ltd., Bristol (England).
Joint study on the computerisation of in-field aero engines vibration diagnosis
[PNR-90799] p 1072 N92-33815
Rolls-Royce Ltd., Derby (England).
Re-engining for real stage 3 compliance
[PNR-90872] p 1072 N92-33748
An improved compressor performance prediction model
[PNR-90873] p 1072 N92-33749
The Rolls-Royce Trent
[PNR-90875] p 1061 N92-33750
The impact of air transport on the environment
[PNR-90876] p 1129 N92-33751
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-34019
Ruhr Univ., Bochum (Germany).
Influence of the swirl producing construction in the flow and reaction field of turbulent diffusion flames
[ETN-92-92103] p 1127 N92-33916

S

Saab Aircraft Co., Linkoping (Sweden).
Vibro-acoustic FE analyses of the Saab 2000 aircraft
p 1137 N92-32952
South Carolina Research Authority, Charleston.
PDES application protocol suite for composites (PAS-C). Functional needs report for the PAS-C program
[AD-A247886] p 1108 N92-32629
Southampton Univ. (England).
Active control of sound transmission through stiff lightweight composite fuselage constructions
p 1137 N92-32957

T

Technische Univ., Brunswick (Germany).
A multivariable control concept for a gas turbine engine
[ETN-92-92104] p 1072 N92-33645
Technische Univ., Delft (Netherlands).
Calibration of GPS antennas
[ETN-92-92034] p 1051 N92-33693
Technische Univ., Graz (Austria).
Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG
p 1050 N92-33356
Tennessee Univ. Space Inst., Tullahoma.
Dynamic interactions between hypersonic vehicle aerodynamics and propulsion system performance
[NASA-CR-190638] p 1038 N92-33304
Texas A&M Univ., College Station.
Further wind tunnel investigation of the SM701 airfoil with aileron and turbulators
[NASA-CR-190702] p 1038 N92-33063
Experimental study of performance degradation of a *rotating system in the NASA Lewis RC icing tunnel*
[NASA-CR-190684] p 1102 N92-34141
Texas Univ., Austin.
A numerical model for sonic boom propagation through an inhomogeneous, windy atmosphere
p 1138 N92-33876
Model experiment to study the effect of turbulence on risetime and waveform of N waves
p 1139 N92-33881
Toronto Univ. (Ontario).
An evaluation of decelerating IFR approaches utilizing a helicopter flight simulator
[CTN-92-60348] p 1048 N92-32845
Ideal efficiency of propellers based on Theodorsen's theory: A review and computer study, with extended plus simplified charts
[UTIAS-TN-271] p 1071 N92-33102

U

United Technologies Research Center, East Hartford, CT.
Turbine disk cavity aerodynamics and heat transfer
p 1124 N92-32265
Universiteit Twente, Enschede (Netherlands).
On the origin and acoustical behaviour of cloud cavitation
[ISBN-90-9004317-9] p 1125 N92-33066
University of Southern California, Los Angeles.
Perspectives on hypersonic viscous and nonequilibrium flow research
[NASA-CR-190817] p 1039 N92-33413

V

Virginia Polytechnic Inst. and State Univ., Blacksburg.
Effects of curvature and rotation on turbulence in the NASA low-speed centrifugal compressor impeller
p 1124 N92-32292
Initial postbuckling response of an unsymmetrically laminated rectangular plate p 1108 N92-32586
Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
Introduction to Flutter of Winged Aircraft, volume 2
[VKI-LS-1992-01-VOL-2] p 1088 N92-34161

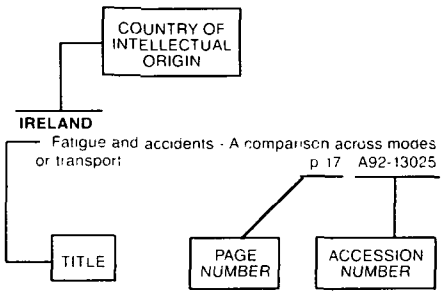
W

Washington Univ., Seattle.
Formation and sustainment of a very low aspect ratio tokamak using coaxial helicity injection: Helicity Injected Torus (HIT) experiment
[DE92-014311] p 1136 N92-32595
Wright Lab., Wright-Patterson AFB, OH.
An examination of several high resolution schemes applied to complex problems in high speed flows
[AD-A250814] p 1124 N92-32632
Vortex flow visualization using colored and fluorescent dyes on flat plate delta wing with leading edge extension
[AD-A251139] p 1036 N92-32651
Fluid effects: Thermoset and thermoplastic matrix composites p 1110 N92-33049
Wyle Labs., Inc., Arlington, VA.
The effect of turbulence on the loudness of minimized sonic boom signatures p 1139 N92-33880

Z

Zeiss (Carl), Oberkochen (Germany).
Airborne experimental FLIR program
p 1064 N92-32447

Typical Foreign Technology Index Listing



Listings in this index are arranged alphabetically by *country of intellectual origin*. The *title* of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the citation in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

A

AUSTRALIA

Unsteady shock propagation in a steady flow nozzle expansion p 1023 A92-54489

Effects of oxygen dissociation on hypervelocity combustion experiments [AIAA PAPER 92-3964] p 1098 A92-56791

AUSTRIA

Comparison of two-way satellite time transfer and GPS common-view time transfer between OCA and TUG p 1050 N92-33356

B

BELGIUM

Quantitative heat transfer measurements in hypersonic wind tunnels by means of infrared thermography p 1115 A92-54321

Introduction to Flutter of Winged Aircraft, volume 2 [VKI-LS-1992-01-VOL-2] p 1088 N92-34161

BRAZIL

Some thermodynamical aspects in the optimization of supersonic combustors p 1065 A92-53486

The behaviour of the pressure temperature and density in an inviscid unsteady transonic axisymmetric flow with shock waves p 1018 A92-53553

Enhancement of laminar boundary layer heat transfer by a vortex generator p 1118 A92-55453

C

CANADA

Acoustic control of combustor primary zone air-jet mixing [AIAA PAPER 92-3651] p 1067 A92-54104

Reduction of the side force on pointed forebodies through add-on tip devices p 1024 A92-54918

Grid studies for thin-layer Navier-Stokes computations of airfoil flowfields p 1025 A92-54935

Processing and environmental effects on mechanical properties of composite repairs [NRC-LTR-ST-1826] p 1109 N92-32791

Further development of the CANAERO computer code to include propulsor modelling [DREA-CR-90-425] p 1038 N92-32811

An evaluation of decelerating IFR approaches utilizing a helicopter flight simulator [CTN-92-60348] p 1048 N92-32845

Detection of honeycomb damage using hexagonal grid discontinuities [DREP-89-9] p 1109 N92-32846

A Kalman filter integrated navigation design for the IAR Twin Otter Atmospheric Research Aircraft [NRC-32148] p 1048 N92-32849

The use of Kalman filtering techniques to improve the accuracy of flight test data [NRC-32139] p 1064 N92-32850

The design and development of a portable, DSP micro-processor based, high-accuracy data acquisition system [NRC-32146] p 1134 N92-32851

Ideal efficiency of propellers based on Theodorsen's theory: A review and computer study, with extended plus simplified charts [UTIAS-TN-271] p 1071 N92-33102

Radar clutter classification [ISBN-0-315-57981-1] p 1126 N92-33440

Fire bombing and fire bombers [CA-PATENT-1-268-164] p 1061 N92-33582

CHINA

Stability and dynamic coupling of elastic vehicles with unsteady aerodynamic forces considered p 1102 A92-53545

Fault diagnostics on jet engine starting p 1116 A92-54345

An analysis of boundary layer for droplet aerodynamic stripped in high speed gas flow p 1116 A92-54563

The flow field characteristics about a fighter configuration at high angles of attack [AIAA PAPER 92-4358] p 1025 A92-55344

Parameter identification of unsteady aerodynamic forces for elastic vehicles [AIAA PAPER 92-4505] p 1027 A92-55372

The research of reducing 3-D low supersonic shock wave reflection in a 2-D transonic flexible walls adaptive wind tunnel [AIAA PAPER 92-3924] p 1095 A92-56755

F

FRANCE

Turbulent combustion modelling in a side dump ramjet combustor [AIAA PAPER 92-3599] p 1112 A92-54075

Experimental investigation of the reflection of a shock wave on a heated surface in presence of a turbulent boundary layer p 1023 A92-54569

Efficient methods for inviscid non-equilibrium hypersonic flow fields p 1024 A92-54571

Mechanisms of high-current pulses in lightning and long-spark stepped leaders p 1116 A92-54678

Physics of vortical flows p 1031 A92-56166

Experimental study of noise generation and propagation in a turbofan model p 1136 A92-56169

The computation and validation of hovering rotor performance p 1055 A92-56285

The Eurofar program - An European overview on advanced VTOL civil transportation system p 1016 A92-56299

Organization and technical status of the NH90 European helicopter programme p 1016 A92-56306

A finite element method for shear stresses calculation in composite blade models p 1121 A92-56322

The advantages of digital engine control as compared with traditional systems (hydraulic or pneumatic) p 1070 A92-56338

AS 332 MKII - Development and certification p 1059 A92-56343

The SR3 low density wind tunnel - Facility capabilities and research development [AIAA PAPER 92-3972] p 1098 A92-56798

Numerical simulation of turbulence at the back of the airplane [ETN-92-91664] p 1037 N92-32769

Research on some centered implicit methods for calculating transonic flows by solving Navier-Stokes equations [ONERA-RSF-24/1408-AY-150A] p 1037 N92-32773

Strong coupling between inviscid fluid and boundary layer of sharp leading edges: Two-dimensional stationary and turbulent cases for isolated profiles and guard vanes [ONERA-RT-44/1621-RY-016-R] p 1125 N92-32776

The Utilization of Advanced Composites in Military Aircraft [AGARD-R-785] p 1109 N92-33033

Evaluation of the effects of the environment on the behavior of the primary structures of composite material aircraft in service: Historic and current situation p 1110 N92-33048

The need for GPS standardization p 1049 N92-33351

Precise GPS ephemerides from DMA and NGS tested by time transfer p 1049 N92-33355

Flutter models: Their design, manufacture, and ground testing p 1089 N92-34164

Unsteady wind tunnel tests p 1089 N92-34166

G

GERMANY

Aerodynamic assessment of an optical pressure measurement system (OPMS) by comparison with conventional pressure measurements in a high speed wind tunnel p 1114 A92-54304

Conception of a UHB engine simulator for the essential characteristics of a true-scale engine p 1090 A92-54322

Some important factors in turbulence in flight measurement p 1063 A92-54324

Shock detection on airfoils by means of piezo foil- and hot film arrays p 1115 A92-54334

Application of a wall pressure method in a wind tunnel test section with adjustable longitudinal slots p 1091 A92-54336

Automatic control of test parameters for intake measurements in a low-speed wind tunnel p 1091 A92-54341

A general approach to optimal real-time guidance of dynamic systems based on nonlinear programming [AIAA PAPER 92-4378] p 1131 A92-55182

ATTAS flight test and simulation results of the advanced gust management system LARS [AIAA PAPER 92-4343] p 1079 A92-55332

Computed tomography (CT) as a nondestructive test method used for composite helicopter components p 1121 A92-56276

Repair procedures for advanced composites for helicopters p 1016 A92-56277

Design and development of test rigs for main rotor and main rotor transmission of a helicopter in the 6-ton-class p 1093 A92-56280

'A new proposal for an old problem' - The right engine for the right helicopter p 1070 A92-56281

Test and integration concept for complex helicopter avionic systems p 1064 A92-56292

Laser-radar based obstacle avoidance system for helicopters p 1064 A92-56295

Short takeoff optimization for the XV-15 tiltrotor aircraft p 1056 A92-56302

Modern helicopter technologies at MBB and the application in future programmes p 1016 A92-56304

Blade instability of horizontally stoppable rotors p 1085 A92-56308

HEPO mission simulator - Development and usage for NH90 helicopter p 1094 A92-56313

Influence of cross section variations on the structural behaviour of composite rotor blades p 1121 A92-56320

FOREIGN

A small light-weight rotor platform for ground observation and pollution control p 1057 A92-56329
Analysis of helicopter rotor-fuselage interference with time averaged pressure distribution p 1032 A92-56331
Current European rotorcraft research activities on development of advanced CFD methods for the design of rotor blades (BRITE/EURAM 'DACRO' project) p 1032 A92-56332
Development of a conceptual design method for rotary-wing aircraft using digital computers p 1058 A92-56340
BVI impulsive noise reduction by higher harmonic pitch control - Results of a scaled model rotor experiment in the DNW p 1136 A92-56344
Sound produced by vortex-airfoil interaction p 1136 A92-56345
Mission oriented investigation of handling qualities through simulation p 1059 A92-56353
Design of a variable contraction for a full-scale automotive wind tunnel
[AIAA PAPER 92-3929] p 1096 A92-56760
The high enthalpy shock tunnel in Goettingen
[AIAA PAPER 92-3942] p 1104 A92-56772
Investigation of a plate-ramp-configuration by means of laser Doppler anemometry at Mach 2.95
[AIAA PAPER 92-3956] p 1097 A92-56784
The cryogenic balance design and balance calibration methods
[AIAA PAPER 92-4001] p 1122 A92-56824
The trisonic wind tunnel Muenchen and its involvement in the German SAeNGER-programme
[AIAA PAPER 92-4019] p 1100 A92-56841
Optimization of two stage reusable space transportation systems with rocket and airbreathing propulsion concepts
[IAF PAPER 92-0863] p 1104 A92-57254
The German Hypersonics Technology Programme - Status report 1992
[IAF PAPER 92-0867] p 1105 A92-57258
Airborne experimental FLIR program p 1064 N92-32447
Examples of advanced near-net shape manufacturing techniques for aerospace
[MBB-Z-0399-91-PUB] p 1125 N92-32742
The Dornier 328 Acoustic Test Cell (ATC) for interior noise tests and selected test results
[AIAA PAPER 92-2164] p 1137 N92-32951
Advanced Study for Active Noise Control in Aircraft (ASANCA)
[AIAA PAPER 92-2092] p 1137 N92-32956
Pilots noise exposure during a Boeing 747-400 round trip: Ambient noise and acoustic-head recording and analysis of data p 1137 N92-32960
Pilot noise exposure during a Boeing 747-400 round trip: Judgement of noise and analysis in respect to hearing impairment of pilots p 1138 N92-32961
A multivariable control concept for a gas turbine engine
[ETN-92-92104] p 1072 N92-33645
Influence of the swirl producing construction in the flow and reaction field of turbulent diffusion flames
[ETN-92-92103] p 1127 N92-33916
Stability failure of sandwich structures
[MBB-UD-0613-92-PUB] p 1111 N92-33994

GREECE

Jet fuel absorption and dynamic mechanical analysis of carbon fibre composites p 1110 N92-33050

I

INDIA

Parameter estimation of an augmented airplane with unsteady aerodynamics modelling p 1073 A92-53546
Computer aided evaluation of aircraft handling qualities and flight control system robustness
[AIAA PAPER 92-4423] p 1080 A92-55347

ISRAEL

Optimal trajectories for an unmanned air-vehicle in the horizontal plane
[AIAA PAPER 92-4344] p 1079 A92-55333
Effects of the roll angle on cruciform wing-body configurations at high incidences
[AIAA PAPER 92-4356] p 1079 A92-55342
Pulsating spanwise blowing on a fighter aircraft
[AIAA PAPER 92-4359] p 1025 A92-55345
The effect of gyro nonorthogonality error on gyrocompassing p 1045 A92-55955
Multidisciplinary optimization of aeroservoelastic systems using reduced-size models p 1054 A92-56176
Response of helicopter blades to a sharp collective increase p 1084 A92-56282
A generic harmonic rotor model for helicopter flight simulation p 1086 A92-56333

ITALY

Detecting 3-D, turbulent separation regions using unsteady computerized thermographic technique p 1023 A92-54308
Skin friction measurements in 3-D boundary layers p 1092 A92-54351
Monitoring fatigue cracks in gears p 1116 A92-54496
A module-level testing environment for safety-critical software systems p 1132 A92-56293
Time Resolved Lidar Fluorosensor operating from helicopter p 1121 A92-56296
Aluminium-lithium alloys - Application on helicopters p 1106 A92-56326
Structural design and testing results of composite landing gear components p 1057 A92-56328
Current European research activities in helicopter interactional aerodynamics p 1058 A92-56330
The achievement of aerodynamic goals on the EH101 project through the 'single site' concept p 1058 A92-56342
Correlation of flight, tunnel and prediction data on a helicopter main rotor p 1059 A92-56350
Numerical simulation of unsteady rotor wakes p 1032 A92-56352
An overview of the planned aerospace test facilities at Capua, Italy
[AIAA PAPER 92-3944] p 1097 A92-56773
Stokes flows in superposed immiscible liquids with horizontal heating
[IAF PAPER 92-0909] p 1123 A92-57288
Effects of spectrum variations on fatigue crack growth p 1123 A92-57399
Active vibrations and noise control for turboprop application research program activities p 1138 N92-32962
CFRP stiffened panels under compression p 1109 N92-33044

J

JAPAN

Japan pushes high speed research p 1015 A92-53434
Development study on air turbo-ramjet engine for space plane p 1065 A92-53487
Conceptual design of scramjet engine p 1065 A92-53490
Key design considerations for scramjet powered space plane p 1066 A92-53491
Scramjet engine and its flying test bed p 1066 A92-53492
Performance analysis of idealized scramjet p 1066 A92-53493
Fabrication test and evaluation of graphite/PMR-15 polyimide for HOPE primary structure p 1105 A92-53516
Aerodynamic heating characteristics of space planes tested by NAL hypersonic wind tunnel p 1017 A92-53547
Hypersonic flows with air chemistry over a reentry vehicle at high altitudes p 1017 A92-53549
Detailed numerical analysis of standing oblique detonation p 1111 A92-53550
Rarefied gas numerical wind tunnel p 1017 A92-53552
Experimental and numerical investigation of a supersonic free jet impinging on a perpendicular surface p 1018 A92-53555
Numerical study on the secondary jet into a supersonic flow p 1018 A92-53556
Experimental investigation on turbulent phenomena in three-dimensional shock wave/turbulent boundary layer interaction induced by blunt fin p 1018 A92-53557
Numerical simulations of shock reflections by a TVD scheme p 1018 A92-53558
Navier-Stokes simulation for the winged space vehicle 'HOPE' at subsonic, transonic, and supersonic regimes p 1018 A92-53559
Calculations for aerodynamic characteristics of HOPE type vehicle in subsonic and hypersonic flow p 1018 A92-53560
A preliminary study of a supersonic wind tunnel for a ram jet test facility p 1089 A92-53564
Flow measurements in scramjet inlets p 1102 A92-53565
Spaceplane aerodynamic heating and thermal protection design method p 1102 A92-53578
Radiative heat transfer from nonequilibrium shock layer to a hypersonic reentry body p 1019 A92-53579
Thermally and chemically nonequilibrium hypersonic flow in three-dimensional geometry p 1019 A92-53580
Integrated system to support computer analysis in conceptual aerospace design p 1130 A92-53596
Space plane navigation simulation p 1103 A92-53603
Concepts of flight experiments for HOPE development p 1103 A92-53635
Aerodynamic study of H-II Orbiting Plane, HOPE p 1103 A92-53639
Pre-flight physical simulation test of HIMES reentry test vehicle p 1103 A92-53640
Aerodynamic studies on space plane configuration at hypersonic speed p 1019 A92-53641
Experimental study of convection effects around the phase charge interface p 1111 A92-53755
Fundamental studies on Marangoni convection related to Bridgman crystal growth p 1111 A92-53758
Improvement of atmospheric flight performance of a space vehicle through H infinity-control theory p 1130 A92-53785
Effect of porosity in transpiration cooling system p 1112 A92-53786
Experimental study on three-dimensional shock wave-turbulent boundary layer interaction induced by protuberance p 1019 A92-53997
Mach 3 wind tunnel test of mixed compression supersonic inlet
[AIAA PAPER 92-3625] p 1021 A92-54092
An advanced scramjet propulsion concept for a 350 MG SSTO space plane - External nozzle performance
[AIAA PAPER 92-3719] p 1067 A92-54134
Preliminary airfoil testing experience in the NDA cryogenic wind tunnel p 1091 A92-54326
Three-dimensional calculation of radiative field in hypersonic air shock layers p 1023 A92-54498
Effect of streamwise pressure gradient on the supersonic mixing layer p 1025 A92-54936
Double piston shock-wave valve p 1117 A92-54938
HOPE re-entry experimental vehicle p 1103 A92-55098
Optimal control of helicopters following power failure
[AIAA PAPER 92-4471] p 1076 A92-55231
A robust gain scheduler interpolated into multiple models by membership functions
[AIAA PAPER 92-4553] p 1131 A92-55265
Multiple delay model approach applied to the AIAA 1922 Controls Design Challenge
[AIAA PAPER 92-4630] p 1078 A92-55305
Optimal launch trajectory of a hypersonic research vehicle
[AIAA PAPER 92-4302] p 1103 A92-55310
An identification procedure for a system with a choice of feedback structures p 1132 A92-55426
Development of ITS90 small gas turbine engine p 1070 A92-55500
Aircraft Symposium, 29th, Gifu, Japan, Oct. 7-9, 1991, Proceedings p 1015 A92-56001
Current status of R&D on materials for super/hypersonic transports p 1106 A92-56002
New 1.27-m leg of the National Aerospace Laboratory hypersonic wind tunnel p 1092 A92-56003
Measurements of turbulence in hypersonic flow p 1092 A92-56005
Supersonic wind tunnel test of airintake/airframe integrated models p 1028 A92-56006
A hypersonic wind tunnel test of a mixed-compression air inlet model p 1028 A92-56007
Wind tunnel test of M = 2.5 mixed compression inlet p 1028 A92-56008
Three-dimensional shock wave-turbulent boundary layer interaction induced by blunt body and protuberance p 1029 A92-56009
On the structure of unsteady shock induced separation of the transonic airfoil in the NAL two-dimensional wind tunnel p 1029 A92-56010
Evaluation of sidewall interference in the NAL *two-dimensional transonic wind tunnel* p 1092 A92-56011
On improvements of three-dimensional position measuring system for dynamic wind tunnel testing p 1093 A92-56012
Measurements of longitudinal static aerodynamic *coefficients with cable mount system* p 1093 A92-56013
Flutter analysis and wind tunnel test with respect to a low-aspect-ratio wing with free-rotational control surface p 1052 A92-56014
An example of whirl flutter analysis p 1052 A92-56015
Propeller-nacelle whirl flutter analysis and wind tunnel test p 1052 A92-56016
Whirl flutter analysis and application to aircraft design p 1053 A92-56017
Optimization of composite material wing of fighter type aircrafts p 1053 A92-56018
Research on aeroelastic tailoring at NAL p 1053 A92-56019
Analysis and wind tunnel test of low aspect wing gust load alleviation p 1053 A92-56020

Synthesis of gust load alleviation with flutter margin augmentation p 1082 A92-56021
Optimization of aeroelastic system with active control p 1083 A92-56022
Measurements of blade flapping motion on a wind tunnel model p 1093 A92-56023
Structural optimization of a cantilevered beam subject to combined static loadings p 1118 A92-56024
Optimization approach for helicopter maneuverability with a point mass model p 1083 A92-56025
An investigation of the automation of emergency landings for helicopters p 1083 A92-56026
Multiaxis control in longitudinal mode of aircraft p 1083 A92-56027
A320 flight control from the pilot's point of view p 1083 A92-56028
Robust control system design with multiple model approach p 1083 A92-56029
Flight control system design using H(infinity) optimal control p 1083 A92-56030
An autorotation-entry control for a helicopter with a fuzzy controller p 1083 A92-56032
Application of fuzzy control to aircraft guidance p 1083 A92-56033
Gust response and cross wind performance of a hovercraft with vertical wings p 1118 A92-56034
On the maneuvering tests of an ACV model p 1118 A92-56035
Configuration of flexible-skirts for an ACV and its CAD p 1118 A92-56036
Planning method of skirt systems for small ACVs p 1118 A92-56038
A potential flow theory of two-dimensional bifurcated curtain jets. II p 1118 A92-56039
Three-dimensional numerical analysis of impinging circular jet - Discrete vortex method p 1029 A92-56040
A shock tunnel experiment on aerodynamic interference induced by RCS jet p 1029 A92-56042
Aerothermodynamic test of spaceplane by thin-skin method p 1093 A92-56043
BGK1 airfoil oilflow tests in the NAL two-dimensional wind tunnel. II p 1029 A92-56044
High subsonic wind tunnel test of a two-dimensional hybrid-laminar-flow-control airfoil with slotted surface p 1029 A92-56045
Experimental investigation of the boundary layer in a corner formed by two circular arc airfoils p 1029 A92-56046
Design and wind tunnel test of low-Reynolds-number airfoil p 1029 A92-56047
Numerical simulation of supersonic unsteady flow using a panel method p 1030 A92-56048
Calculations of aerodynamic forces on a wing with thrust using B.E.M p 1030 A92-56049
Generalized aerodynamics analysis by the boundary element method p 1030 A92-56050
Analysis of the main wing lift distribution of the STOL research aircraft Asuka p 1053 A92-56051
On the effect of canards on NAL spaceplane model (0 order) in low speed area p 1030 A92-56052
Motion analysis of 2-dimensional flat plate in ground effect p 1030 A92-56053
Low-speed wind tunnel testing for the high-speed propeller at high shaft angle of attack p 1030 A92-56054
Noise test of high-speed counterrotation propeller in low-speed wind tunnel p 1135 A92-56055
Estimation of aircraft inertial characteristics using *maximum likelihood estimation* p 1084 A92-56057
A physical approach to the estimation of aerodynamic characteristics from flight data p 1030 A92-56058
Flight test of a flight reference display for powered-lift STOL aircraft p 1064 A92-56059
A note on thrust control for jetliner during approach p 1053 A92-56061
Synthesis of a MLS automatic landing control law for the NAL experimental research aircraft Do-228 p 1084 A92-56062
MIMO state-feedback control system considering phase stability by -90 deg phase-locus method p 1084 A92-56066
Design of a flight control system using a feedback-error-learning-type neural network p 1132 A92-56067
Application of restructurable flight control system using nonlinear control to an airliner p 1084 A92-56068
Lateral control of spaceplane at hypersonic flight p 1104 A92-56069
Selection of sampling rate for nonlinear flight trajectory controller of aircraft p 1084 A92-56070
Efficiency and accuracy in helicopter hovering performance calculation p 1053 A92-56072
Sensitivity analysis for structural optimization of helicopter rotor blades p 1053 A92-56073
A calculation method to predict helicopter noise and its verification p 1135 A92-56074
Design and testing of a composite hingeless hub for rotary-wing aircraft p 1053 A92-56075
Helicopter rotor testing using scaled model p 1093 A92-56076
Piloted simulation for the BK117 FBW demonstrator p 1053 A92-56077
A low speed wind tunnel investigation of a joined-wing aircraft with an overhanging fin p 1030 A92-56078
A low speed wind tunnel investigation of the direct side force control of a joined-wing aircraft with overhanging fin p 1084 A92-56079
Working together in the development of the B777 p 1015 A92-56080
Height keeping performance requirements for reducing vertical separation minima used for air traffic control p 1046 A92-56081
Engine condition monitoring system for B747-400 p 1064 A92-56082
Automatic function testing in the aircraft production p 1015 A92-56083
Application of X-ray image radiography system for aircraft p 1118 A92-56084
Current repair technologies for jet engine components p 1016 A92-56085
Change and reliability of the DC-9-81 digital flight guidance system p 1084 A92-56086
The operational status of automated aircraft washing system p 1016 A92-56087
History of aeronautical satellite communications p 1046 A92-56088
Aeronautical satellite communications system p 1046 A92-56089
A data processing system for oceanic air traffic control p 1046 A92-56090
Aircraft satellite communication systems p 1046 A92-56091
Evaluation report of an experimental Satcom operation by a Japan Airline's B747 passenger plane p 1046 A92-56092
An experimental program concerning a satellite data link for oceanic ATC p 1046 A92-56093
Fatigue cracking threshold prediction of transport airplanes p 1118 A92-56094
Development of aircraft bonded structure and the NDI method p 1016 A92-56100
Mechanical properties of laminate aluminum matrix composites p 1106 A92-56102
Titanium alloy casting for aerospace p 1106 A92-56103
Present status of Al-Li alloys p 1106 A92-56105
Development of an automatic drilling system. II p 1118 A92-56107
Application of automation for structural-composites production p 1119 A92-56109
A consideration on air traffic control processing capability in terminal area p 1047 A92-56110
Grooved runway surface texture before and after rubber removal p 1093 A92-56111
Optimal design of wing shape by use of neural-network p 1054 A92-56112
A development of hypermedia type database system for instruction of aircraft conceptual design p 1132 A92-56113
Aerodynamic model identification of a spaceplane model from a cable-mount dynamic wind-tunnel test p 1093 A92-56114
Flight simulator test of cockpit advisory system p 1054 A92-56115
Flight evaluation of navigation systems including MLS using NAL Do228 - Outline p 1047 A92-56116
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of MLS p 1047 A92-56117
Flight evaluation of navigation systems including MLS using NAL Do228 - Results of GPS p 1047 A92-56118
An experimental study on variable pressure hydraulic flight control system p 1084 A92-56119
Measurement of position and attitude using laser and retro-reflectors p 1047 A92-56120
Evaluation of a IMU with optical fiber gyros in dynamic windtunnel tests p 1104 A92-56121
Optimal control of tiltrotor aircraft following power failure p 1085 A92-56303
High enthalpy wind tunnel for erosion testing of advanced materials
[AIAA PAPER 92-3888] p 1094 A92-56729
Tohoku University low-turbulence wind tunnel
[AIAA PAPER 92-3913] p 1095 A92-56746
Roles of wind tunnel tests and CFD analyses in the design of energy-efficient SST
[AIAA PAPER 92-3923] p 1133 A92-56754
Study on international cooperative test facilities for future SST/HST
[AIAA PAPER 92-3945] p 1097 A92-56775
A model study on diffuser pressure recovery in NAL scramjet test facility with simulated hydrogen combustion
[AIAA PAPER 92-3979] p 1071 A92-56805
A conceptual study for future engine test facility
[AIAA PAPER 92-3992] p 1099 A92-56815
Numerical prediction of the flow characteristics in an arc wind tunnel
[AIAA PAPER 92-4016] p 1100 A92-56838
Tests results on Air Turbo Ramjet for a future space plane
[IAF PAPER 92-0657] p 1071 A92-57098
Airbreathing engine selection criteria for SSTO propulsion system
[IAF PAPER 92-0658] p 1071 A92-57099
Shafranov shift in low-aspect-ratio heliotron/torsatron CHS
[NIFS-110] p 1138 N92-33743
Analysis of spacecraft entry into Mars atmosphere p 1105 N92-33763
Study of potassium turbine electric generator system p 1129 N92-33794

JORDAN

Small two-dimensional surface excrescences on aircraft wings approaching separation p 1031 A92-56170

K

KOREA, REPUBLIC OF

Application of recursive partially unknown system identification to aerodynamic coefficients estimation
[AIAA PAPER 92-4504] p 1081 A92-55371

N

NETHERLANDS

A simulator evaluation of various manual control concepts for fly-by-wire transport aircraft
[AIAA PAPER 92-4328] p 1073 A92-55172
Understanding and development of a prediction method of transonic limit cycle oscillation characteristics of fighter aircraft
[AIAA PAPER 92-4501] p 1026 A92-55369
Real-time helicopter simulation using the blade element method p 1132 A92-56278
Application of electronically scanned pressure measurement system for engine simulation tests in the German-Dutch Wind Tunnel
[AIAA PAPER 92-4003] p 1122 A92-56826
Modeling and numerical simulation of vortex flow in aerodynamics
[NLR-TP-91154-U] p 1037 N92-32673
New concepts for multi-block grid generation for flow domains around complex aerodynamic configurations
[NLR-TP-91046-U] p 1037 N92-32730
An experimental study of the flow over a sharp-edged delta wing at subsonic and transonic speeds
[NLR-TP-91117-U] p 1037 N92-32732
Integration of wall interference assessment and wall adaptation
[NLR-TP-91119-U] p 1101 N92-32734
Development of new flight procedures for the Microwave Landing System (MLS)
[NLR-TP-91156-U] p 1047 N92-32830
Active synchrophasing of propeller unbalance p 1138 N92-32963
On the origin and acoustical behaviour of cloud cavitation
[ISBN-90-9004317-9] p 1125 N92-33066
Global/local interlaminar stress analysis of a grid-stiffened composite panel
[NASA-CR-190822] p 1125 N92-33139
Calibration of GPS antennas
[ETN-92-92034] p 1051 N92-33693
Activities report of the National Aerospace Laboratory
[ETN-92-92053] p 1143 N92-33694

P

POLAND

Simulation of helicopter see-saw rotor motion p 1055 A92-56287

R

RUSSIA

Interaction between a body flying at a supersonic velocity and a point explosion p 1019 A92-53867
Viscosity characteristics of synthetic aviation oils at low temperatures p 1105 A92-53875

High-temperature metal matrix composite
p 1105 A92-53878
Pulsation characteristics of one-phase and two-phase steam flows in Laval nozzles under off-design conditions
p 1019 A92-53882
Aerodynamic airfoils design by quasi-solutions method of inverse boundary-value problems
p 1020 A92-53998
The enhancement of the mixing and combustion processes in supersonic flow applied to scramjet engine
[AIAA PAPER 92-3428] p 1112 A92-54029
The study of experimental turboramjets
[AIAA PAPER 92-3720] p 1067 A92-54135
Stochastic self-induced roll oscillations of slender delta wing at high angles of attack
[AIAA PAPER 92-4498] p 1081 A92-55366
State-space representation of aerodynamic characteristics of an aircraft at high angels of attack
[AIAA PAPER 92-4651] p 1028 A92-55395
The solution of the helicopter flight dynamics tasks by the methods of optimal control theory
p 1085 A92-56284
Safety provision against 'ground resonance' free vibration of a coaxial helicopter p 1056 A92-56289
Helicopter tail rotor stall flutter p 1056 A92-56290
Aeroelasticity of a coaxial helicopter rotor
p 1057 A92-56309
Oscillations of an anisotropic rotor on an elastic anisotropic support p 1057 A92-56311
Composite blades for helicopter main and tail rotors developed by Mil Design Bureau p 1057 A92-56325
Design method of a helicopter cockpit
p 1058 A92-56337
Aerodynamic features of a coaxial rotor helicopter
p 1032 A92-56349
TSNIIMASH capabilities for aerogasdynamical and thermal testing of hypersonic vehicles
[AIAA PAPER 92-3962] p 1097 A92-56789
Increasing the accuracy of the Godunov scheme for calculating steady-state supersonic gas flows by solving the generalized Riemann problem p 1035 A92-57499

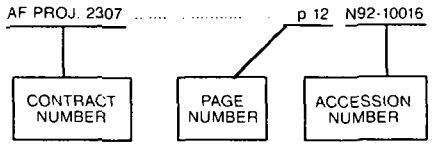
S

SAUDI ARABIA
Effect of atmospheric disturbances on airplane response
[AIAA PAPER 92-4340] p 1078 A92-55329
SINGAPORE
Robustness of a helicopter flight control system designed using eigenstructure assignment
[AIAA PAPER 92-4469] p 1076 A92-55229
SWEDEN
Vibro-acoustic FE analyses of the Saab 2000 aircraft
p 1137 N92-32952

U

UNITED KINGDOM
Recent developments in data acquisition and control systems at the Aircraft Research Association Limited
p 1091 A92-54323
Particle image velocimetry measurements of the aerodynamics of a wind turbine p 1115 A92-54337
The interaction between a high-frequency gust and a blade row p 1135 A92-54484
CIS engines - The range revealed. II
p 1069 A92-54546
Joining a Ni-based creep-resistant (ODS) alloy by brazing p 1116 A92-54867
Diffusion bonding a creep-resistant Fe-ODS alloy
p 1117 A92-54868
Mikoyan's market-buster p 1052 A92-54981
The application of math-dynamic models to characterise a range of helicopter rotor system faults
p 1056 A92-56297
Lynx - A 50 year product? p 1056 A92-56307
Creation of a living specification for an experimental helicopter active flight control system through incremental simulation p 1057 A92-56312
Experimental investigation of helicopter coupled rotor/body control p 1086 A92-56318
Technology exploitation for in-service support of future rotorcraft p 1016 A92-56327
A study of helicopter rotor/fuselage response in low-speed manoeuvres - Comparison of theory with flight p 1086 A92-56334
The identification of coupled flapping/inflow models for hovering flight p 1058 A92-56335
The compound helicopter - A concept revisited
p 1058 A92-56341
Path identification in structural acoustics
p 1059 A92-56346
A high speed edgewise rotor using circulation control only in the reversed flow area p 1059 A92-56347
Measurements of the dynamic stall vortex convection speed p 1032 A92-56351
Comparison of recent results from different wind tunnel facilities along with comparisons of measured flight results and wind tunnel based predictions
[AIAA PAPER 92-3985] p 1060 A92-56809
A dynamic stiffness technique for the vibration analysis of stiffened shell structures p 1123 A92-56866
Aerodynamic centre of wing-body combinations
[ESDU-92024] p 1036 N92-32479
Contribution of tailplane-mounted twin fins to sideforce, yawing moment, and rolling moment derivatives due to sideslip
[ESDU-92007] p 1086 N92-32487
A background to the handling qualities of aircraft
[ESDU-92006] p 1087 N92-32780
Lift and rolling moment due to spoilers on wings with trailing-edge flaps deflected at subsonic speeds
[ESDU-92002-SUPPL] p 1037 N92-32782
Spray nozzle for fire control
[CA-PATENT-APPL-SN-2-011-94] p 1125 N92-32856
Active control of sound transmission through stiff lightweight composite fuselage constructions
p 1137 N92-32957
Aspects of compression in aerospace composites: Future requirements p 1109 N92-33036
Comparison of GLONASS and GPS time transfers between two west European time laboratories and VNIIFTRI p 1050 N92-33381
Radial inflow turbine study
[AD-A252783] p 1127 N92-33538
Re-engining for real stage 3 compliance
[PNR-90872] p 1072 N92-33748
An improved compressor performance prediction model
[PNR-90873] p 1072 N92-33749
The Rolls-Royce Trent
[PNR-90875] p 1061 N92-33750
The impact of air transport on the environment
[PNR-90876] p 1129 N92-33751
Joint study on the computerisation of in-field aero engines vibration diagnosis
[PNR-90799] p 1072 N92-33815
Fatigue crack growth of small corner defects from blunt notches in an aeroengine alloy
[PNR-90860] p 1111 N92-34019
Elementary flutter analysis p 1088 N92-34162
Flight flutter testing p 1089 N92-34163

Typical Contract Number Index Listing

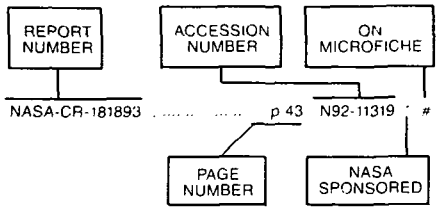


Listings in this index are arranged alphanumerically by contract number. Under each contract number, the accession numbers denoting documents that have been produced as a result of research done under the contract are shown. The accession number denotes the number by which the citation is identified in the abstract section. Preceding the accession number is the page number on which the citation may be found.

AF PROJ. 2307 ..... p 1124 N92-32632
AF-AFOSR-0104-91 ..... p 1039 N92-33413
AF-AFOSR-0310-89 ..... p 1111 N92-33624
AF-AFOSR-85-0288 ..... p 1112 A92-54057
AF-AFOSR-86-0266 ..... p 1022 A92-54113
AF-AFOSR-88-0163 ..... p 1024 A92-54919
AF-AFOSR-89-0010 ..... p 1082 A92-55911
AF-AFOSR-89-0315 ..... p 1022 A92-54113
AF-AFOSR-89-0397 ..... p 1032 A92-56351
AF-AFOSR-89-0502 ..... p 1026 A92-55367
AF-AFOSR-90-0032 ..... p 1082 A92-55396
AF-AFOSR-90-0234 ..... p 1094 A92-56744
AF-AFOSR-90-0321 ..... p 1096 A92-56757
BMVG-T/RF41/I0008/I1407 ..... p 1058 A92-56340
DA PROJ. 1L1-62618-AH-80 ..... p 1041 N92-33699
DAAJ09-90-G-0022 ..... p 1055 A92-56279
DAAL03-86-K-0056 ..... p 1076 A92-55229
DAAL03-87-K-0023 ..... p 1055 A92-56178
DAAL03-88-C-0003 ..... p 1085 A92-56314
DAAL03-88-C-0006 ..... p 1024 A92-54906
DAAL03-88-C-004 ..... p 1054 A92-56156
DAAL03-90-C-0013 ..... p 1024 A92-54906
DAAL03-91-G-0023 ..... p 1022 A92-54111
DAHC35-89-D-0030 ..... p 1044 N92-33288
DAJA45-89-C-0006 ..... p 1127 N92-33538
DASG60-87-C-0066 ..... p 1135 N92-33920
DE-AC04-76DP-00789 ..... p 1104 A92-55311
p 1122 A92-56828
DE-AC05-84OR-21400 ..... p 1129 N92-33271
DE-FG06-90ER-54095 ..... p 1136 N92-32595
DFG-SFB-255 ..... p 1097 A92-56784
DFG-SFB-259 ..... p 1104 A92-57254
DOD/FA7INA-AP ..... p 1071 N92-33105
DREA-W7707-8-1140-01-SC ..... p 1038 N92-32811
DRET-89-1433-DS-SR ..... p 1055 A92-56285
DRET-89-204 ..... p 1037 N92-32769
DRET-89-34-001 ..... p 1037 N92-32773
p 1125 N92-32776
DTFA01-89-C-00001 ..... p 1047 N92-32537
p 1048 N92-33098
DTFA01-89-Z-02030 ..... p 1124 N92-32686
DTFA01-89-Z-02050 ..... p 1101 N92-32903
DTFA01-90-C-00029 ..... p 1102 N92-34247
DTFA01-90-C-00042 ..... p 1142 N92-33305
DTFA03-88-C-00024 ..... p 1045 N92-34151
DTFA03-89-C-00043 ..... p 1126 N92-33480
DTRS57-90-P-80922 ..... p 1127 N92-33627
EEC-AERO-0028-C ..... p 1137 N92-32956
FAA-T0603-S ..... p 1048 N92-33308
F19628-90-C-0002 ..... p 1063 A92-55328
F29601-85-C-0038 ..... p 1026 A92-55364
F33615-88-C-5447 ..... p 1107 N92-32525
F33615-89-C-0603 ..... p 1065 N92-33277
F33615-91-C-5713 ..... p 1108 N92-32629
F49620-86-C-0133 ..... p 1117 A92-54932
F49620-88-C-0053 ..... p 1075 A92-55200
F49620-88-C-0076 ..... p 1024 A92-54910
F49620-90-C-0076 ..... p 1142 N92-32338
F49620-91-C-0003 ..... p 1062 N92-34182
MDA903-91-C-0006 ..... p 1017 N92-33499
NAC2-478 ..... p 1120 A92-56241
NAGW-1061 ..... p 1039 N92-33413
NAGW-1072 ..... p 1114 A92-54317
p 1034 A92-56836
NAGW-1331 ..... p 1113 A92-54199
NAGW-1708 ..... p 1054 A92-56176
NAGW-674 ..... p 1098 A92-56791
NAGW-964 ..... p 1022 A92-54111
NAG1-1032 ..... p 1094 A92-56744
NAG1-1056 ..... p 1102 N92-34222
NAG1-1111 ..... p 1094 A92-56744
NAG1-1133 ..... p 1094 A92-56727
NAG1-1135 ..... p 1036 N92-32648
NAG1-1149 ..... p 1045 N92-34192
NAG1-1150 ..... p 1028 A92-55397
NAG1-1164 ..... p 1075 A92-55199
p 1131 A92-55271
NAG1-1201 ..... p 1094 A92-56727
NAG1-1205 ..... p 1038 N92-33304
NAG1-1209 ..... p 1033 A92-56776
NAG1-1260 ..... p 1038 N92-33063
NAG1-1265 ..... p 1024 A92-54911
NAG1-1341 ..... p 1073 A92-55170
p 1075 A92-55205
p 1077 A92-55283
p 1132 A92-55376
p 1035 A92-57034
NAG1-1380 ..... p 1073 A92-55173
NAG1-168 ..... p 1108 N92-32586
NAG1-244 ..... p 1113 A92-54199
NAG1-421 ..... p 1135 A92-54909
NAG1-537 ..... p 1108 N92-32586
NAG1-795 ..... p 1094 A92-56745
NAG1-821 ..... p 1073 A92-55173
p 1074 A92-55174
NAG1-937 ..... p 1094 A92-56744
NAG1-947 ..... p 1139 N92-33877
p 1139 N92-33878
p 1139 N92-33879
NAG1-994 ..... p 1025 A92-55350
p 1025 A92-55353
NAG2-477 ..... p 1085 A92-56315
NAG2-482 ..... p 1092 A92-55348
NAG2-541 ..... p 1126 N92-33307
NAG2-547 ..... p 1127 N92-33696
NAG2-561 ..... p 1060 A92-56354
p 1088 N92-33536
NAG2-592 ..... p 1021 A92-54110
p 1036 N92-32494
NAG2-654 ..... p 1131 A92-55282
NAG2-669 ..... p 1051 N92-34203
NAG2-691 ..... p 1076 A92-55230
NAG2-727 ..... p 1087 N92-33107
NAG2-733 ..... p 1095 A92-56756
NAG3-1163 ..... p 1117 A92-54921
NAG3-1275 ..... p 1021 A92-54090
NAG3-653 ..... p 1128 N92-34207
NAG3-768 ..... p 1044 N92-34105
NAG3-860 ..... p 1067 A92-54060
NAG3-998 ..... p 1052 A92-55300
NASA ORDER C-22955-P ..... p 1122 A92-56828
NASA ORDER C-30030-P ..... p 1121 A92-56371
NAS1-17925 ..... p 1125 N92-33139
NAS1-18028 ..... p 1086 N92-32778
NAS1-18458 ..... p 1094 A92-56743
NAS1-18584 ..... p 1090 A92-54319
NAS1-18585 ..... p 1034 A92-56855
p 1088 N92-33537
NAS1-18667 ..... p 1092 A92-54347
NAS1-18758 ..... p 1110 N92-33613
NAS1-19125 ..... p 1096 A92-56761
NAS2-13357 ..... p 1022 A92-54117
NAS3-23939 ..... p 1072 N92-33479
NAS3-24230 ..... p 1073 N92-34236
NAS3-25266 ..... p 1020 A92-54004
p 1020 A92-54012
p 1023 A92-54161
p 1072 N92-33746
NAS3-25453 ..... p 1066 A92-54011
NAS3-25644 ..... p 1113 A92-54132
NAS3-26146 ..... p 1095 A92-56753
NAS8-36955 ..... p 1101 N92-33826
NAS8-37462 ..... p 1124 N92-32265
NCA2-406 ..... p 1026 A92-55365
NCC1-141 ..... p 1100 A92-56854
NCC1-158 ..... p 1131 A92-55262
NCC1-29 ..... p 1080 A92-55343
NCC1-68 ..... p 1128 N92-34043
NCC1-98 ..... p 1035 A92-56858
NCC2-366 ..... p 1057 A92-56316
NCC2-387 ..... p 1135 A92-54660
NCC2-478 ..... p 1135 A92-54660
NCC2-553 ..... p 1032 A92-56747
NCC2-55 ..... p 1081 A92-55354
p 1082 A92-55393
NCC2-575 ..... p 1045 A92-55211
NCC2-605 ..... p 1026 A92-55355
NCC2-692 ..... p 1027 A92-55377
NCC2-704 ..... p 1039 N92-33424
NCC3-132 ..... p 1102 N92-34141
NCC9-16 ..... p 1134 N92-32865
NGL-22-009-640 ..... p 1063 A92-55328
NGL-31-001-252 ..... p 1078 A92-55327
NGT-50414 ..... p 1043 N92-32606
NIVR-01604-N ..... p 1037 N92-32730
NR PROJ. RR0-3308 ..... p 1129 N92-33220
NSCRC-77-0401-E007-17 ..... p 1114 A92-54223
NSCRC-79-0210-D006-03 ..... p 1136 A92-56162
NSCRC-80-0210-D006-04 ..... p 1106 A92-57101
NSERC-A-2181 ..... p 1024 A92-54918
NSERC-A-7801 ..... p 1067 A92-54104
NSF CTS-86-57130 ..... p 1113 A92-54108
p 1117 A92-54931
NSF CTS-90-10594 ..... p 1112 A92-54044
NSF DMC-86-57917 ..... p 1024 A92-54911
NSF INT-90-16501 ..... p 1131 A92-55271
N00014-85-K-0527 ..... p 1094 A92-56744
N00014-89-J-1783 ..... p 1094 A92-56726
N00014-90-J-1305 ..... p 1033 A92-56776
N00019-88-C-0029 ..... p 1112 A92-54057
N00039-88-C-0043 ..... p 1138 N92-33876
N00039-91-C-0082 ..... p 1138 N92-33876
N62269-87-C-0226 ..... p 1107 N92-32527
N62269-87-C-0259 ..... p 1108 N92-32579
RICIS PROJ. SR-02 ..... p 1134 N92-32865
RTOP 505-59-10-03 ..... p 1039 N92-33484
p 1040 N92-33631
RTOP 505-59-30 ..... p 1060 N92-32887
RTOP 505-59-53-01 ..... p 1036 N92-32480
RTOP 505-60-00 ..... p 1071 N92-32452
RTOP 505-61-71 ..... p 1036 N92-32422
p 1038 N92-33306
p 1040 N92-33618
RTOP 505-62-OK ..... p 1073 N92-34236
RTOP 505-62-30-01 ..... p 1040 N92-33625
p 1041 N92-33706
p 1042 N92-34193
RTOP 505-62-40 ..... p 1062 N92-34202
RTOP 505-62-50 ..... p 1088 N92-34107
RTOP 505-62-52 ..... p 1072 N92-33746
p 1128 N92-34112
RTOP 505-62-84 ..... p 1098 A92-56806
p 1099 A92-56816
p 1099 A92-56818
RTOP 505-63-01-09 ..... p 1106 N92-32513
RTOP 505-63-5A ..... p 1109 N92-32863
RTOP 505-63-50-04 ..... p 1110 N92-33423
RTOP 505-63-50-15 ..... p 1060 N92-32536
RTOP 505-63-50 ..... p 1042 N92-34147
RTOP 505-63-53-01 ..... p 1125 N92-33104
RTOP 505-64-10-07 ..... p 1134 N92-33483
RTOP 505-64-12-02 ..... p 1043 N92-32606
RTOP 505-64-13 ..... p 1044 N92-33080
p 1044 N92-33194
p 1050 N92-33407
RTOP 505-64-30-01 ..... p 1088 N92-33537
RTOP 505-64-30 ..... p 1060 N92-33149

RTOP 505-64-36 ..... p 1047 N92-32424
RTOP 505-64-70-01 ..... p 1128 N92-34017
RTOP 505-66-11 ..... p 1051 N92-33609
RTOP 505-67-01-04 ..... p 1065 N92-34109
RTOP 505-68-10 ..... p 1042 N92-34144
p 1073 N92-34236
RTOP 505-68-32 ..... p 1039 N92-33581
RTOP 505-68-50 ..... p 1065 N92-32866
RTOP 505-68-70-02 ..... p 1040 N92-33656
RTOP 505-69-20-01 ..... p 1045 N92-34192
RTOP 505-69-50 ..... p 1134 N92-33894
RTOP 506-46-21-05 ..... p 1086 N92-32778
RTOP 510-02-12-01 ..... p 1110 N92-33613
RTOP 533-02-35 ..... p 1060 N92-33404
p 1062 N92-34039
RTOP 533-02-36 ..... p 1133 N92-32507
p 1087 N92-32864
RTOP 533-02-37 ..... p 1087 N92-32788
RTOP 535-03-11-03 ..... p 1136 N92-32948
p 1138 N92-33160
RTOP 535-05-10 ..... p 1123 A92-56829
RTOP 537-03-21-01 ..... p 1061 N92-33874
RTOP 537-03-21-03 ..... p 1138 N92-33719
RTOP 537-03-21-04 ..... p 1140 N92-34148
RTOP 538-02-10-01 ..... p 1128 N92-34178
RTOP 590-21-11 ..... p 1072 N92-33479
TEES PROJ. 30540-AE ..... p 1038 N92-33063
TTN77-1038 ..... p 1125 N92-33066
W2207-7-AF69/01-SS ..... p 1048 N92-32845

Typical Report Number Index Listing



Listings in this index are arranged alphanumerically by report number. The page number indicates *the page on which the citation is located. The accession number denotes the number by which the citation is identified.* An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

A-90021 ..... p 1038 N92-33306 * #
A-90040 ..... p 1040 N92-33618 * #
A-90244 ..... p 1036 N92-32422 * #
A-90290 ..... p 1039 N92-33581 * #
A-91011 ..... p 1051 N92-33609 * #
A-91054 ..... p 1143 N92-33948 * #
A-91074 ..... p 1071 N92-32452 * #
A-91156 ..... p 1060 N92-32887 * #
A-91203 ..... p 1044 N92-33194 * #
A-92003 ..... p 1050 N92-33407 * #
A-92039 ..... p 1087 N92-32788 * #
A-92085 ..... p 1047 N92-32424 * #
A-92156 ..... p 1044 N92-33080 * #

AD-A247175 ..... p 1136 N92-32697 #
AD-A247886 ..... p 1108 N92-32629 #
AD-A248763 ..... p 1142 N92-32338 #
AD-A250814 ..... p 1124 N92-32632 #
AD-A251139 ..... p 1036 N92-32651 #
AD-A252246 ..... p 1124 N92-32686 #
AD-A252280 ..... p 1129 N92-33220 #
AD-A252281 ..... p 1044 N92-33249 #
AD-A252389 ..... p 1038 N92-32900 #
AD-A252438 ..... p 1043 N92-32941 #
AD-A252520 ..... p 1086 N92-32435 #
AD-A252730 ..... p 1087 N92-32988 #
AD-A252771 ..... p 1126 N92-33498 #
AD-A252773 ..... p 1017 N92-33499 #
AD-A252783 ..... p 1127 N92-33538 #
AD-A252846 ..... p 1061 N92-33414 #
AD-A252863 ..... p 1065 N92-33277 #
AD-A252869 ..... p 1135 N92-33920 #
AD-A252878 ..... p 1040 N92-33678 #
AD-A252909 ..... p 1101 N92-33398 #
AD-A252912 ..... p 1126 N92-33501 #
AD-A252914 ..... p 1061 N92-33502 #
AD-A252922 ..... p 1050 N92-33596 #
AD-A253004 ..... p 1109 N92-33033 #
AD-A253032 ..... p 1111 N92-33624 #
AD-A253046 ..... p 1101 N92-33434 #
AD-A253072 ..... p 1044 N92-33288 #
AD-A253371 ..... p 1062 N92-34182 #
AD-A253692 ..... p 1142 N92-33238 #

AD-D015268 ..... p 1088 N92-34131 #

AFIT/CI/CIA-92-039 ..... p 1086 N92-32435 #

AFOSR-92-0167TR-VOL-1 ..... p 1142 N92-32338 #
AFOSR-92-0673TR ..... p 1111 N92-33624 #

AGARD-R-785 ..... p 1109 N92-33033 #

AIAA PAPER 91-0068 ..... p 1035 A92-57035 #
AIAA PAPER 92-1187 ..... p 1130 A92-54285 * #
AIAA PAPER 92-2092 ..... p 1137 N92-32956 * #
AIAA PAPER 92-2164 ..... p 1137 N92-32951 * #
AIAA PAPER 92-2699 ..... p 1072 N92-33746 * #
AIAA PAPER 92-3068 ..... p 1020 A92-54003 * #
AIAA PAPER 92-3069 ..... p 1020 A92-54004 * #
AIAA PAPER 92-3070 ..... p 1020 A92-54005 * #
AIAA PAPER 92-3072 ..... p 1130 A92-54006 * #
AIAA PAPER 92-3092 ..... p 1066 A92-54009 * #
AIAA PAPER 92-3174 ..... p 1066 A92-54011 * #
AIAA PAPER 92-3175 ..... p 1020 A92-54012 * #
AIAA PAPER 92-3177 ..... p 1020 A92-54013 * #
AIAA PAPER 92-3177 ..... p 1128 N92-34112 * #
AIAA PAPER 92-3211 ..... p 1021 A92-54016 * #
AIAA PAPER 92-3245 ..... p 1103 A92-54019 #
AIAA PAPER 92-3261 ..... p 1066 A92-54020 * #
AIAA PAPER 92-3338 ..... p 1067 A92-54025 * #
AIAA PAPER 92-3362 ..... p 1051 A92-54026 * #
AIAA PAPER 92-3428 ..... p 1112 A92-54029 #
AIAA PAPER 92-3471 ..... p 1067 A92-54035 * #
AIAA PAPER 92-3494 ..... p 1112 A92-54036 * #
AIAA PAPER 92-3545 ..... p 1112 A92-54044 #
AIAA PAPER 92-3568 ..... p 1112 A92-54057 #
AIAA PAPER 92-3569 ..... p 1090 A92-54058 * #
AIAA PAPER 92-3570 ..... p 1067 A92-54059 * #
AIAA PAPER 92-3571 ..... p 1067 A92-54060 * #
AIAA PAPER 92-3599 ..... p 1112 A92-54075 #
AIAA PAPER 92-3622 ..... p 1021 A92-54090 * #
AIAA PAPER 92-3624 ..... p 1021 A92-54091 #
AIAA PAPER 92-3625 ..... p 1021 A92-54092 #
AIAA PAPER 92-3626 ..... p 1113 A92-54093 #
AIAA PAPER 92-3651 ..... p 1067 A92-54104 #
AIAA PAPER 92-3652 ..... p 1113 A92-54105 #
AIAA PAPER 92-3658 ..... p 1113 A92-54108 #
AIAA PAPER 92-3665 ..... p 1021 A92-54110 * #
AIAA PAPER 92-3667 ..... p 1022 A92-54111 * #
AIAA PAPER 92-3670 ..... p 1022 A92-54113 #
AIAA PAPER 92-3673 ..... p 1022 A92-54116 #
AIAA PAPER 92-3674 ..... p 1022 A92-54117 * #
AIAA PAPER 92-3675 ..... p 1022 A92-54118 #
AIAA PAPER 92-3712 ..... p 1113 A92-54132 * #
AIAA PAPER 92-3719 ..... p 1067 A92-54134 #
AIAA PAPER 92-3720 ..... p 1067 A92-54135 #
AIAA PAPER 92-3744 ..... p 1068 A92-54146 #
AIAA PAPER 92-3746 ..... p 1068 A92-54147 #
AIAA PAPER 92-3748 ..... p 1068 A92-54148 #
AIAA PAPER 92-3749 ..... p 1068 A92-54149 #
AIAA PAPER 92-3753 ..... p 1068 A92-54151 #
AIAA PAPER 92-3758 ..... p 1141 A92-54152 #
AIAA PAPER 92-3770 ..... p 1068 A92-54159 * #
AIAA PAPER 92-3771 ..... p 1022 A92-54160 #
AIAA PAPER 92-3774 ..... p 1023 A92-54161 * #
AIAA PAPER 92-3789 ..... p 1069 A92-54168 * #
AIAA PAPER 92-3790 ..... p 1069 A92-54169 * #
AIAA PAPER 92-3792 ..... p 1069 A92-54171 * #
AIAA PAPER 92-3805 ..... p 1069 A92-54177 #
AIAA PAPER 92-3806 ..... p 1069 A92-54178 #
AIAA PAPER 92-3808 ..... p 1023 A92-54179 * #
AIAA PAPER 92-3810 ..... p 1090 A92-54180 * #
AIAA PAPER 92-3840 ..... p 1113 A92-54198 #
AIAA PAPER 92-3844 ..... p 1113 A92-54199 #
AIAA PAPER 92-3883 ..... p 1094 A92-56726 #
AIAA PAPER 92-3885 ..... p 1094 A92-56727 * #
AIAA PAPER 92-3888 ..... p 1094 A92-56729 #
AIAA PAPER 92-3899 ..... p 1122 A92-56735 #
AIAA PAPER 92-3901 ..... p 1017 A92-56736 #
AIAA PAPER 92-3903 ..... p 1094 A92-56738 #
AIAA PAPER 92-3908 ..... p 1094 A92-56743 * #
AIAA PAPER 92-3910 ..... p 1094 A92-56744 * #
AIAA PAPER 92-3912 ..... p 1094 A92-56745 * #
AIAA PAPER 92-3913 ..... p 1095 A92-56746 #
AIAA PAPER 92-3915 ..... p 1032 A92-56747 * #
AIAA PAPER 92-3916 ..... p 1095 A92-56748 * #
AIAA PAPER 92-3917 ..... p 1095 A92-56749 #
AIAA PAPER 92-3918 ..... p 1032 A92-56750 #
AIAA PAPER 92-3921 ..... p 1033 A92-56752 #
AIAA PAPER 92-3922 ..... p 1095 A92-56753 * #
AIAA PAPER 92-3923 ..... p 1133 A92-56754 #
AIAA PAPER 92-3924 ..... p 1095 A92-56755 #
AIAA PAPER 92-3925 ..... p 1095 A92-56756 * #
AIAA PAPER 92-3926 ..... p 1096 A92-56757 #
AIAA PAPER 92-3927 ..... p 1096 A92-56758 #
AIAA PAPER 92-3928 ..... p 1070 A92-56759 #
AIAA PAPER 92-3929 ..... p 1096 A92-56760 #
AIAA PAPER 92-3930 ..... p 1096 A92-56761 * #
AIAA PAPER 92-3935 ..... p 1122 A92-56765 #
AIAA PAPER 92-3937 ..... p 1096 A92-56767 * #
AIAA PAPER 92-3938 ..... p 1096 A92-56768 * #
AIAA PAPER 92-3940 ..... p 1096 A92-56770 * #
AIAA PAPER 92-3941 ..... p 1033 A92-56771 * #
AIAA PAPER 92-3942 ..... p 1104 A92-56772 #
AIAA PAPER 92-3943 ..... p 1033 A92-56776 * #
AIAA PAPER 92-3944 ..... p 1097 A92-56773 #
AIAA PAPER 92-3945 ..... p 1097 A92-56775 #
AIAA PAPER 92-3946 ..... p 1097 A92-56774 #
AIAA PAPER 92-3953 ..... p 1133 A92-56781 #
AIAA PAPER 92-3956 ..... p 1097 A92-56784 #
AIAA PAPER 92-3960 ..... p 1122 A92-56788 #
AIAA PAPER 92-3962 ..... p 1097 A92-56789 #
AIAA PAPER 92-3963 ..... p 1097 A92-56790 #
AIAA PAPER 92-3964 ..... p 1098 A92-56791 #
AIAA PAPER 92-3969 ..... p 1098 A92-56795 #
AIAA PAPER 92-3970 ..... p 1098 A92-56796 * #
AIAA PAPER 92-3971 ..... p 1098 A92-56797 #
AIAA PAPER 92-3972 ..... p 1098 A92-56798 #
AIAA PAPER 92-3976 ..... p 1098 A92-56802 #
AIAA PAPER 92-3977 ..... p 1071 A92-56803 #
AIAA PAPER 92-3979 ..... p 1071 A92-56805 #
AIAA PAPER 92-3980 ..... p 1098 A92-56806 #
AIAA PAPER 92-3982 ..... p 1099 A92-56807 #
AIAA PAPER 92-3985 ..... p 1060 A92-56809 #
AIAA PAPER 92-3986 ..... p 1033 A92-56810 #
AIAA PAPER 92-3992 ..... p 1099 A92-56815 #
AIAA PAPER 92-3993 ..... p 1099 A92-56816 #
AIAA PAPER 92-3995 ..... p 1099 A92-56818 #
AIAA PAPER 92-4001 ..... p 1122 A92-56824 #
AIAA PAPER 92-4002 ..... p 1099 A92-56825 * #
AIAA PAPER 92-4003 ..... p 1122 A92-56826 #
AIAA PAPER 92-4005 ..... p 1122 A92-56828 * #
AIAA PAPER 92-4006 ..... p 1123 A92-56829 #
AIAA PAPER 92-4008 ..... p 1099 A92-56831 #
AIAA PAPER 92-4009 ..... p 1033 A92-56832 * #
AIAA PAPER 92-4011 ..... p 1033 A92-56834 * #
AIAA PAPER 92-4012 ..... p 1033 A92-56835 #
AIAA PAPER 92-4013 ..... p 1034 A92-56836 * #
AIAA PAPER 92-4016 ..... p 1100 A92-56838 #
AIAA PAPER 92-4017 ..... p 1100 A92-56839 #
AIAA PAPER 92-4018 ..... p 1100 A92-56840 #
AIAA PAPER 92-4019 ..... p 1100 A92-56841 #
AIAA PAPER 92-4020 ..... p 1141 A92-56842 #
AIAA PAPER 92-4021 ..... p 1100 A92-56843 #
AIAA PAPER 92-4022 ..... p 1141 A92-56844 * #
AIAA PAPER 92-4023 ..... p 1034 A92-56845 * #
AIAA PAPER 92-4024 ..... p 1034 A92-56846 * #
AIAA PAPER 92-4025 ..... p 1104 A92-56847 * #
AIAA PAPER 92-4028 ..... p 1100 A92-56850 #
AIAA PAPER 92-4029 ..... p 1034 A92-56851 * #
AIAA PAPER 92-4032 ..... p 1100 A92-56854 * #
AIAA PAPER 92-4033 ..... p 1034 A92-56855 * #
AIAA PAPER 92-4034 ..... p 1101 A92-56856 * #
AIAA PAPER 92-4035 ..... p 1035 A92-56857 * #
AIAA PAPER 92-4036 ..... p 1035 A92-56858 * #
AIAA PAPER 92-4041 ..... p 1123 A92-56860 #
AIAA PAPER 92-4042 ..... p 1035 A92-56861 * #
AIAA PAPER 92-4043 ..... p 1035 A92-56862 #
AIAA PAPER 92-4058 ..... p 1119 A92-56141 #
AIAA PAPER 92-4060 ..... p 1119 A92-56143 #
AIAA PAPER 92-4109 ..... p 1087 N92-32864 * #
AIAA PAPER 92-4113 ..... p 1065 N92-32866 * #
AIAA PAPER 92-4121 ..... p 1060 N92-33404 * #
AIAA PAPER 92-4176 ..... p 1060 N92-33149 * #
AIAA PAPER 92-4302 ..... p 1103 A92-55310 #
AIAA PAPER 92-4303 ..... p 1104 A92-55311 #
AIAA PAPER 92-4326 ..... p 1073 A92-55170 * #
AIAA PAPER 92-4327 ..... p 1073 A92-55171 #
AIAA PAPER 92-4328 ..... p 1073 A92-55172 #
AIAA PAPER 92-4329 ..... p 1073 A92-55173 * #
AIAA PAPER 92-4330 ..... p 1074 A92-55174 * #
AIAA PAPER 92-4338 ..... p 1078 A92-55327 * #
AIAA PAPER 92-4339 ..... p 1063 A92-55328 * #
AIAA PAPER 92-4340 ..... p 1078 A92-55329 #
AIAA PAPER 92-4341 ..... p 1078 A92-55330 * #
AIAA PAPER 92-4342 ..... p 1079 A92-55331 #
AIAA PAPER 92-4343 ..... p 1079 A92-55332 #
AIAA PAPER 92-4344 ..... p 1079 A92-55333 #
AIAA PAPER 92-4345 ..... p 1079 A92-55334 #
AIAA PAPER 92-4354 ..... p 1079 A92-55340 #

AIAA PAPER 92-4355 ..... p 1079 A92-55341 #
AIAA PAPER 92-4356 ..... p 1079 A92-55342 #
AIAA PAPER 92-4357 ..... p 1080 A92-55343 * #
AIAA PAPER 92-4358 ..... p 1025 A92-55344 #
AIAA PAPER 92-4359 ..... p 1025 A92-55345 #
AIAA PAPER 92-4378 ..... p 1131 A92-55182 #
AIAA PAPER 92-4390 ..... p 1074 A92-55191 #
AIAA PAPER 92-4391 ..... p 1074 A92-55192 #
AIAA PAPER 92-4392 ..... p 1074 A92-55193 #
AIAA PAPER 92-4393 ..... p 1074 A92-55194 #
AIAA PAPER 92-4396 ..... p 1074 A92-55196 * #
AIAA PAPER 92-4399 ..... p 1075 A92-55199 * #
AIAA PAPER 92-4400 ..... p 1075 A92-55200 #
AIAA PAPER 92-4409 ..... p 1075 A92-55203 #
AIAA PAPER 92-4410 ..... p 1075 A92-55204 #
AIAA PAPER 92-4411 ..... p 1075 A92-55205 * #
AIAA PAPER 92-4412 ..... p 1076 A92-55206 #
AIAA PAPER 92-4418 ..... p 1045 A92-55211 * #
AIAA PAPER 92-4420 ..... p 1063 A92-55212 * #
AIAA PAPER 92-4422 ..... p 1080 A92-55346 #
AIAA PAPER 92-4423 ..... p 1080 A92-55347 #
AIAA PAPER 92-4424 ..... p 1092 A92-55348 * #
AIAA PAPER 92-4425 ..... p 1080 A92-55349 #
AIAA PAPER 92-4426 ..... p 1025 A92-55350 * #
AIAA PAPER 92-4427 ..... p 1080 A92-55351 #
AIAA PAPER 92-4428 ..... p 1080 A92-55352 * #
AIAA PAPER 92-4429 ..... p 1025 A92-55353 * #
AIAA PAPER 92-4430 ..... p 1081 A92-55354 * #
AIAA PAPER 92-4431 ..... p 1026 A92-55355 * #
AIAA PAPER 92-4469 ..... p 1076 A92-55229 #
AIAA PAPER 92-4470 ..... p 1076 A92-55230 * #
AIAA PAPER 92-4471 ..... p 1076 A92-55231 #
AIAA PAPER 92-4472 ..... p 1076 A92-55232 * #
AIAA PAPER 92-4473 ..... p 1076 A92-55233 #
AIAA PAPER 92-4478 ..... p 1131 A92-55237 #
AIAA PAPER 92-4494 ..... p 1081 A92-55363 * #
AIAA PAPER 92-4496 ..... p 1026 A92-55364 #
AIAA PAPER 92-4497 ..... p 1026 A92-55365 * #
AIAA PAPER 92-4498 ..... p 1081 A92-55366 #
AIAA PAPER 92-4499 ..... p 1026 A92-55367 #
AIAA PAPER 92-4500 ..... p 1026 A92-55368 #
AIAA PAPER 92-4501 ..... p 1026 A92-55369 #
AIAA PAPER 92-4503 ..... p 1081 A92-55370 #
AIAA PAPER 92-4504 ..... p 1081 A92-55371 #
AIAA PAPER 92-4505 ..... p 1027 A92-55372 #
AIAA PAPER 92-4506 ..... p 1027 A92-55373 #
AIAA PAPER 92-4528 ..... p 1077 A92-55246 #
AIAA PAPER 92-4550 ..... p 1131 A92-55262 * #
AIAA PAPER 92-4553 ..... p 1131 A92-55265 #
AIAA PAPER 92-4555 ..... p 1131 A92-55267 #
AIAA PAPER 92-4559 ..... p 1131 A92-55271 * #
AIAA PAPER 92-4560 ..... p 1141 A92-55272 #
AIAA PAPER 92-4563 ..... p 1027 A92-55375 * #
AIAA PAPER 92-4564 ..... p 1132 A92-55376 * #
AIAA PAPER 92-4567 ..... p 1035 A92-57034 * #
AIAA PAPER 92-4568 ..... p 1027 A92-55377 * #
AIAA PAPER 92-4601 ..... p 1077 A92-55280 #
AIAA PAPER 92-4602 ..... p 1069 A92-55281 * #
AIAA PAPER 92-4603 ..... p 1131 A92-55282 * #
AIAA PAPER 92-4605 ..... p 1077 A92-55283 * #
AIAA PAPER 92-4606 ..... p 1077 A92-55284 #
AIAA PAPER 92-4619 ..... p 1077 A92-55296 #
AIAA PAPER 92-4623 ..... p 1052 A92-55300 * #
AIAA PAPER 92-4625 ..... p 1077 A92-55302 #
AIAA PAPER 92-4626 ..... p 1077 A92-55303 #
AIAA PAPER 92-4629 ..... p 1078 A92-55304 #
AIAA PAPER 92-4630 ..... p 1078 A92-55305 #
AIAA PAPER 92-4631 ..... p 1132 A92-55306 #
AIAA PAPER 92-4633 ..... p 1081 A92-55380 #
AIAA PAPER 92-4635 ..... p 1027 A92-55382 #
AIAA PAPER 92-4640 ..... p 1027 A92-55387 #
AIAA PAPER 92-4648 ..... p 1082 A92-55393 * #
AIAA PAPER 92-4649 ..... p 1028 A92-55394 #
AIAA PAPER 92-4651 ..... p 1028 A92-55395 #
AIAA PAPER 92-4652 ..... p 1082 A92-55396 #
AIAA PAPER 92-4653 ..... p 1028 A92-55397 * #

AL-TP-1992-0021 ..... p 1065 N92-33277 #

AMSAA-TR-519 ..... p 1101 N92-33398 #

ARI-RN-92-47 ..... p 1044 N92-33288 #

ATC-189 ..... p 1124 N92-32686 #

AVSCOM-TR-92-C-028 ..... p 1088 N92-34107 * #
AVSCOM-TR-92-E-002 ..... p 1065 N92-34109 * #

B-242745 ..... p 1048 N92-32861 #

BRL-TR-3083 ..... p 1041 N92-33699 #

CA-PATENT-APPL-SN-2-011-945 p 1125 N92-32856

CA-PATENT-1-257-618 ..... p 1061 N92-33585
CA-PATENT-1-268-164 ..... p 1061 N92-33582

CONF-920801-15 ..... p 1129 N92-33271 #

CRREL-SR-92-11 ..... p 1038 N92-32900 #

CRREL-92-9 ..... p 1101 N92-32903 #

CTN-91-60132 ..... p 1061 N92-33582
CTN-91-60166 ..... p 1061 N92-33585
CTN-92-60348 ..... p 1048 N92-32845 #
CTN-92-60350 ..... p 1109 N92-32846 #
CTN-92-60357 ..... p 1038 N92-32811 #
CTN-92-60369 ..... p 1048 N92-32849 #
CTN-92-60370 ..... p 1109 N92-32791 #
CTN-92-60371 ..... p 1064 N92-32850 #
CTN-92-60372 ..... p 1134 N92-32851 #
CTN-92-60378 ..... p 1071 N92-33102 #
CTN-92-60391 ..... p 1125 N92-32856
CTN-92-60565 ..... p 1126 N92-33440

CU-TR-14 ..... p 1043 N92-32606 * #

DE92-014311 ..... p 1136 N92-32595 #
DE92-017129 ..... p 1129 N92-33271 #

DOE/ER-54095/2 ..... p 1136 N92-32595 #

DOT-VNTSC-FAA-92-1 ..... p 1050 N92-33596 #
DOT-VNTSC-FAA-92-2 ..... p 1043 N92-32941 #

DOT/FAA/AM-92-03 ..... p 1050 N92-33596 #
DOT/FAA/AM-92/4 ..... p 1136 N92-32697 #

DOT/FAA/CT-TN92/26 ..... p 1127 N92-33627 #
DOT/FAA/CT-TN92/28 ..... p 1048 N92-33308 #

DOT/FAA/CT-91/17 ..... p 1043 N92-33005 #
DOT/FAA/CT-91/28 ..... p 1071 N92-33105 #
DOT/FAA/CT-91/32 ..... p 1045 N92-34151 #
DOT/FAA/CT-91/5 ..... p 1126 N92-33480 #

DOT/FAA/NR-92/7 ..... p 1124 N92-32686 #

DOT/FAA/RD-92/14-VOL-1 ..... p 1142 N92-33305 #
DOT/FAA/RD-92/18 ..... p 1102 N92-34247 #
DOT/FAA/RD-92/20 ..... p 1043 N92-32606 * #
DOT/FAA/RD-92/22 ..... p 1047 N92-32537 #
DOT/FAA/RD-92/23 ..... p 1048 N92-33098 #
DOT/FAA/RD-92/2 ..... p 1043 N92-32941 #
DOT/FAA/RD-92/8 ..... p 1101 N92-32903 #

DOT/FAA/RP-92/3 ..... p 1101 N92-33434 #

DREA-CR-90-425 ..... p 1038 N92-32811 #

DREP-89-9 ..... p 1109 N92-32846 #

E-6407 ..... p 1109 N92-32863 * #
E-7039 ..... p 1128 N92-34112 * #
E-7062 ..... p 1072 N92-33746 * #
E-7158 ..... p 1134 N92-33894 * #
E-7201 ..... p 1042 N92-34144 * #
E-7227 ..... p 1088 N92-34107 * #

EDR-15982 ..... p 1073 N92-34236 * #

ESDU-AERO-C.01.01.02 ..... p 1086 N92-32487

ESDU-90030 ..... p 1037 N92-32782
ESDU-92002-SUPPL ..... p 1037 N92-32782
ESDU-92006 ..... p 1087 N92-32780
ESDU-92007 ..... p 1086 N92-32487
ESDU-92024 ..... p 1036 N92-32479

ESL-TR-90-24 ..... p 1126 N92-33501 #

ETN-92-91664 ..... p 1037 N92-32769 #
ETN-92-91671 ..... p 1037 N92-32773 #
ETN-92-91675 ..... p 1125 N92-32776 #
ETN-92-91994 ..... p 1037 N92-32730 #
ETN-92-91996 ..... p 1125 N92-33139 * #
ETN-92-91997 ..... p 1037 N92-32732 #
ETN-92-91998 ..... p 1101 N92-32734 #
ETN-92-92000 ..... p 1037 N92-32673 #
ETN-92-92001 ..... p 1047 N92-32830 #
ETN-92-92034 ..... p 1051 N92-33693 #
ETN-92-92041 ..... p 1125 N92-33066 #
ETN-92-92053 ..... p 1143 N92-33694 #
ETN-92-92103 ..... p 1127 N92-33916 #
ETN-92-92104 ..... p 1072 N92-33645 #
ETN-92-92108 ..... p 1111 N92-33994 #
ETN-92-92118 ..... p 1125 N92-32742 #
ETN-92-92163 ..... p 1088 N92-34161 #
ETN-92-92177 ..... p 1072 N92-33815 #
ETN-92-92181 ..... p 1111 N92-34019 #
ETN-92-92183 ..... p 1072 N92-33748 #
ETN-92-92184 ..... p 1072 N92-33749 #
ETN-92-92185 ..... p 1061 N92-33750 #
ETN-92-92186 ..... p 1129 N92-33751 #

FTL-R-91-7 ..... p 1045 N92-34192 * #

GAO-55-636-PT-6 ..... p 1141 N92-32505 #

GAO/IMTEC-91-25 ..... p 1048 N92-32861 #

GPO-55-260-VOL-1 ..... p 1142 N92-33147 #

H-1675 ..... p 1133 N92-32507 * #
H-1818 ..... p 1062 N92-34202 * #
H-1826 ..... p 1087 N92-32864 * #
H-1839 ..... p 1065 N92-32866 * #
H-1846 ..... p 1060 N92-33404 * #
H-1857 ..... p 1060 N92-33149 * #
H-1860 ..... p 1062 N92-34039 * #

IAF PAPER 92-0657 ..... p 1071 A92-57098
IAF PAPER 92-0658 ..... p 1071 A92-57099
IAF PAPER 92-0659 ..... p 1106 A92-57100 *
IAF PAPER 92-0661 ..... p 1106 A92-57101
IAF PAPER 92-0663 ..... p 1104 A92-57102
IAF PAPER 92-0863 ..... p 1104 A92-57254
IAF PAPER 92-0867 ..... p 1105 A92-57258
IAF PAPER 92-0868 ..... p 1105 A92-57259 *
IAF PAPER 92-0909 ..... p 1123 A92-57288

IAR-AN-72 ..... p 1048 N92-32849 #

INT-PATENT-CLASS-B05B-1/00 . p 1125 N92-32856
INT-PATENT-CLASS-B64C-25/60 p 1061 N92-33585
INT-PATENT-CLASS-B64D-1/16 . p 1061 N92-33582

INT-PATENT-CLASS-G01P-3/36 . p 1042 N92-34172 *

ISBN 0-0783-0123-4 ..... p 1114 A92-54301
ISBN 0-7803-0521-3 ..... p 1119 A92-56201
ISBN 1-56347-031-4 ..... p 1052 A92-54550

ISBN-0-16-038597-0 ..... p 1141 N92-32505 #
ISBN-0-16-038832-5 ..... p 1142 N92-33147 #
ISBN-0-315-57981-1 ..... p 1126 N92-33440
ISBN-0-85679-807-X ..... p 1037 N92-32782
ISBN-0-85679-811-8 ..... p 1087 N92-32780
ISBN-0-85679-812-6 ..... p 1086 N92-32487
ISBN-0-85679-829-0 ..... p 1036 N92-32479
ISBN-90-9004317-9 ..... p 1125 N92-33066 #
ISBN-92-835-0666-9 ..... p 1109 N92-33033 #

L-16829 ..... p 1065 N92-34109 * #
L-16832-PT-1 ..... p 1106 N92-32513 * #
L-16962 ..... p 1039 N92-33484 * #
L-16963 ..... p 1040 N92-33656 * #
L-16965 ..... p 1040 N92-33625 * #
L-17034 ..... p 1041 N92-33706 * #
L-17046 ..... p 1040 N92-33631 * #
L-17048 ..... p 1134 N92-33483 * #
L-17067 ..... p 1042 N92-34193 * #
L-17095 ..... p 1036 N92-32480 * #
L-17145-VOL-1 ..... p 1061 N92-33874 * #

MBB-UD-0613-92-PUB ..... p 1111 N92-33994 #

MBB-Z-0399-91-PUB ..... p 1125 N92-32742 #

MCAT-92-017 ..... p 1039 N92-33424 * #

NAS 1.15:102261 ..... p 1038 N92-33306 * #
NAS 1.15:102268 ..... p 1040 N92-33618 * #
NAS 1.15:102851 ..... p 1036 N92-32422 * #
NAS 1.15:102882 ..... p 1051 N92-33609 * #
NAS 1.15:103839 ..... p 1071 N92-32452 * #
NAS 1.15:103866 ..... p 1060 N92-32887 * #
NAS 1.15:103880 ..... p 1044 N92-33194 * #
NAS 1.15:103899 ..... p 1050 N92-33407 * #
NAS 1.15:103910 ..... p 1087 N92-32788 * #
NAS 1.15:103930 ..... p 1047 N92-32424 * #
NAS 1.15:103934 ..... p 1039 N92-33581 * #
NAS 1.15:103959 ..... p 1044 N92-33080 * #
NAS 1.15:104112 ..... p 1140 N92-34148 * #
NAS 1.15:104170 ..... p 1138 N92-33160 * #
NAS 1.15:104211 ..... p 1042 N92-34147 * #
NAS 1.15:104237 ..... p 1133 N92-32507 * #
NAS 1.15:104249 ..... p 1062 N92-34202 * #
NAS 1.15:104251 ..... p 1065 N92-32866 * #
NAS 1.15:104253 ..... p 1060 N92-33404 * #
NAS 1.15:104255 ..... p 1087 N92-32864 * #
NAS 1.15:104256 ..... p 1060 N92-33149 * #
NAS 1.15:104259 ..... p 1062 N92-34039 * #
NAS 1.15:104531 ..... p 1109 N92-32863 * #
NAS 1.15:105672 ..... p 1128 N92-34112 * #
NAS 1.15:105683 ..... p 1072 N92-33746 * #
NAS 1.15:105696 ..... p 1134 N92-33894 * #
NAS 1.15:105773 ..... p 1042 N92-34144 * #

NAS 1.15:105797 ..... p 1088 N92-34107 * #
NAS 1.15:107591 ..... p 1125 N92-33104 * #
NAS 1.15:107600 ..... p 1060 N92-32536 * #
NAS 1.15:107601 ..... p 1088 N92-33537 * #
NAS 1.15:107657 ..... p 1138 N92-33719 * #
NAS 1.15:107666 ..... p 1110 N92-33423 * #
NAS 1.15:107677 ..... p 1128 N92-34178 * #
NAS 1.15:107679 ..... p 1128 N92-34017 * #
NAS 1.15:107967 ..... p 1143 N92-33948 * #
NAS 1.15:108171 ..... p 1142 N92-33237 * #
NAS 1.15:4379 ..... p 1065 N92-34109 * #
NAS 1.15:4382 ..... p 1040 N92-33631 * #
NAS 1.26:181954 ..... p 1086 N92-32778 * #
NAS 1.26:184384 ..... p 1101 N92-33826 * #
NAS 1.26:189122 ..... p 1073 N92-34236 * #
NAS 1.26:189223 ..... p 1072 N92-33479 * #
NAS 1.26:189671 ..... p 1110 N92-33613 * #
NAS 1.26:190450 ..... p 1127 N92-33696 * #
NAS 1.26:190542 ..... p 1044 N92-34105 * #
NAS 1.26:190563 ..... p 1036 N92-32648 * #
NAS 1.26:190583 ..... p 1036 N92-32494 * #
NAS 1.26:190638 ..... p 1038 N92-33304 * #
NAS 1.26:190684 ..... p 1102 N92-34141 * #
NAS 1.26:190686 ..... p 1128 N92-34207 * #
NAS 1.26:190702 ..... p 1038 N92-33063 * #
NAS 1.26:190712 ..... p 1134 N92-32865 * #
NAS 1.26:190736 ..... p 1087 N92-33107 * #
NAS 1.26:190810 ..... p 1126 N92-33307 * #
NAS 1.26:190812 ..... p 1088 N92-33536 * #
NAS 1.26:190817 ..... p 1039 N92-33413 * #
NAS 1.26:190822 ..... p 1125 N92-33139 * #
NAS 1.26:190836 ..... p 1039 N92-33424 * #
NAS 1.26:190902 ..... p 1128 N92-34043 * #
NAS 1.26:190925 ..... p 1051 N92-34203 * #
NAS 1.26:191259 ..... p 1102 N92-34222 * #
NAS 1.26:4456 ..... p 1043 N92-32606 * #
NAS 1.26:4470 ..... p 1045 N92-34192 * #
NAS 1.55:10103 ..... p 1136 N92-32948 * #
NAS 1.55:3087-PT-1 ..... p 1106 N92-32513 * #
NAS 1.55:3172 ..... p 1061 N92-33874 * #
NAS 1.60:3202 ..... p 1040 N92-33656 * #
NAS 1.60:3221 ..... p 1040 N92-33625 * #
NAS 1.60:3234 ..... p 1039 N92-33484 * #
NAS 1.60:3236 ..... p 1041 N92-33706 * #
NAS 1.60:3240 ..... p 1042 N92-34193 * #
NAS 1.60:3242 ..... p 1134 N92-33483 * #
NAS 1.60:3261 ..... p 1036 N92-32480 * #
NAS 1.71:LAR-14232-1 ..... p 1102 N92-34213 * #
NAS 1.71:LEW-14791-1 ..... p 1043 N92-34243 * #

NASA-CASE-LAR-14232-1 ..... p 1102 N92-34213 * #
NASA-CASE-LAR-14685-1 ..... p 1042 N92-34172 *

NASA-CASE-LEW-14791-1 ..... p 1043 N92-34243 * #

NASA-CP-10103 ..... p 1136 N92-32948 * #
NASA-CP-3087-PT-1 ..... p 1106 N92-32513 * #
NASA-CP-3172 ..... p 1061 N92-33874 * #

NASA-CR-181954 ..... p 1086 N92-32778 * #
NASA-CR-184384 ..... p 1101 N92-33826 * #
NASA-CR-189122 ..... p 1073 N92-34236 * #
NASA-CR-189223 ..... p 1072 N92-33479 * #
NASA-CR-189671 ..... p 1110 N92-33613 * #
NASA-CR-190450 ..... p 1127 N92-33696 * #
NASA-CR-190542 ..... p 1044 N92-34105 * #
NASA-CR-190563 ..... p 1036 N92-32648 * #
NASA-CR-190583 ..... p 1036 N92-32494 * #
NASA-CR-190638 ..... p 1038 N92-33304 * #
NASA-CR-190684 ..... p 1102 N92-34141 * #
NASA-CR-190686 ..... p 1128 N92-34207 * #
NASA-CR-190702 ..... p 1038 N92-33063 * #
NASA-CR-190712 ..... p 1134 N92-32865 * #
NASA-CR-190736 ..... p 1087 N92-33107 * #
NASA-CR-190810 ..... p 1126 N92-33307 * #
NASA-CR-190812 ..... p 1088 N92-33536 * #
NASA-CR-190817 ..... p 1039 N92-33413 * #
NASA-CR-190822 ..... p 1125 N92-33139 * #
NASA-CR-190836 ..... p 1039 N92-33424 * #
NASA-CR-190902 ..... p 1128 N92-34043 * #
NASA-CR-190925 ..... p 1051 N92-34203 * #
NASA-CR-191259 ..... p 1102 N92-34222 * #
NASA-CR-4456 ..... p 1043 N92-32606 * #
NASA-CR-4470 ..... p 1045 N92-34192 * #

NASA-TM-102261 ..... p 1038 N92-33306 * #
NASA-TM-102268 ..... p 1040 N92-33618 * #
NASA-TM-102851 ..... p 1036 N92-32422 * #
NASA-TM-102882 ..... p 1051 N92-33609 * #
NASA-TM-103839 ..... p 1071 N92-32452 * #
NASA-TM-103866 ..... p 1060 N92-32887 * #
NASA-TM-103880 ..... p 1044 N92-33194 * #
NASA-TM-103899 ..... p 1050 N92-33407 * #
NASA-TM-103910 ..... p 1087 N92-32788 * #
NASA-TM-103930 ..... p 1047 N92-32424 * #
NASA-TM-103934 ..... p 1039 N92-33581 * #
NASA-TM-103959 ..... p 1044 N92-33080 * #
NASA-TM-104112 ..... p 1140 N92-34148 * #
NASA-TM-104170 ..... p 1138 N92-33160 * #
NASA-TM-104211 ..... p 1042 N92-34147 * #
NASA-TM-104237 ..... p 1133 N92-32507 * #
NASA-TM-104249 ..... p 1062 N92-34202 * #
NASA-TM-104251 ..... p 1065 N92-32866 * #
NASA-TM-104253 ..... p 1060 N92-33404 * #
NASA-TM-104255 ..... p 1087 N92-32864 * #
NASA-TM-104256 ..... p 1060 N92-33149 * #
NASA-TM-104259 ..... p 1062 N92-34039 * #
NASA-TM-104531 ..... p 1109 N92-32863 * #
NASA-TM-105672 ..... p 1128 N92-34112 * #
NASA-TM-105683 ..... p 1072 N92-33746 * #
NASA-TM-105696 ..... p 1134 N92-33894 * #
NASA-TM-105773 ..... p 1042 N92-34144 * #
NASA-TM-105797 ..... p 1088 N92-34107 * #
NASA-TM-107591 ..... p 1125 N92-33104 * #
NASA-TM-107600 ..... p 1060 N92-32536 * #
NASA-TM-107601 ..... p 1088 N92-33537 * #
NASA-TM-107657 ..... p 1138 N92-33719 * #
NASA-TM-107666 ..... p 1110 N92-33423 * #
NASA-TM-107677 ..... p 1128 N92-34178 * #
NASA-TM-107679 ..... p 1128 N92-34017 * #
NASA-TM-107967 ..... p 1143 N92-33948 * #
NASA-TM-108171 ..... p 1142 N92-33237 * #
NASA-TM-4379 ..... p 1065 N92-34109 * #
NASA-TM-4382 ..... p 1040 N92-33631 * #

NASA-TP-3202 ..... p 1040 N92-33656 * #
NASA-TP-3221 ..... p 1040 N92-33625 * #
NASA-TP-3234 ..... p 1039 N92-33484 * #
NASA-TP-3236 ..... p 1041 N92-33706 * #
NASA-TP-3240 ..... p 1042 N92-34193 * #
NASA-TP-3242 ..... p 1134 N92-33483 * #
NASA-TP-3261 ..... p 1036 N92-32480 * #

NAVY-CASE-73152 ..... p 1088 N92-34131 #

NAWCADWAR-92022-60 ..... p 1061 N92-33414 #

NIFS-110 ..... p 1138 N92-33743 #

NIST-TN-1278 ..... p 1126 N92-33501 #

NLR-TP-91046-U ..... p 1037 N92-32730 #
NLR-TP-91052-U ..... p 1125 N92-33139 * #
NLR-TP-91117-U ..... p 1037 N92-32732 #
NLR-TP-91119-U ..... p 1101 N92-32734 #
NLR-TP-91154-U ..... p 1037 N92-32673 #
NLR-TP-91156-U ..... p 1047 N92-32830 #

NOSC/TR-1492 ..... p 1129 N92-33220 #

NRC-LTR-ST-1826 ..... p 1109 N92-32791 #

NRC-32139 ..... p 1064 N92-32850 #
NRC-32146 ..... p 1134 N92-32851 #
NRC-32148 ..... p 1048 N92-32849 #

NRL/MR/4654-92-6986 ..... p 1044 N92-33249 #

NTSB/AAR-92/01/SUM ..... p 1044 N92-34081 #
NTSB/AAR-92/01 ..... p 1043 N92-32455 #

ONERA-RSF-24/1408-AY-150A .. p 1037 N92-32773 #

ONERA-RT-44/1621-RY-016-R ... p 1125 N92-32776 #

PAPER-F07 ..... p 1088 N92-33536 * #

PASC002-01-00 ..... p 1108 N92-32629 #

PB92-190032 ..... p 1050 N92-33596 #
PB92-193390 ..... p 1051 N92-33809 #
PB92-197334 ..... p 1017 N92-33176 #
PB92-200963 ..... p 1043 N92-32941 #
PB92-910401 ..... p 1043 N92-32455 #
PB92-910404 ..... p 1044 N92-34081 #

PNR-90799 ..... p 1072 N92-33815 #
PNR-90860 ..... p 1111 N92-34019 #
PNR-90872 ..... p 1072 N92-33748 #
PNR-90873 ..... p 1072 N92-33749 #
PNR-90875 ..... p 1061 N92-33750 #
PNR-90876 ..... p 1129 N92-33751 #

PWA-5968-102 ..... p 1072 N92-33479 * #

R/D-5824-AN-01 ..... p 1127 N92-33538 #

RAND/R-3768-A ..... p 1017 N92-33499 #
RAND/R-4016-AF ..... p 1062 N92-34182 #

TR-91-7 ..... p 1051 N92-34203 * #

UDR-TR-91-125 ..... p 1045 N92-34151 #

UMICH-025921-32-T ..... p 1126 N92-33307 * #

US-PATENT-APPL-SN-718313 ..... p 1042 N92-34172 *
US-PATENT-APPL-SN-790607 ..... p 1088 N92-34131 #
US-PATENT-APPL-SN-914905 ..... p 1102 N92-34213 * #
US-PATENT-APPL-SN-943659 ..... p 1043 N92-34243 * #

US-PATENT-CLASS-356-28 ..... p 1042 N92-34172 *
US-PATENT-CLASS-356-318 ..... p 1042 N92-34172 *
US-PATENT-CLASS-73-861.05 .... p 1042 N92-34172 *

US-PATENT-5,153,665 ..... p 1042 N92-34172 *

USAAVSCOM-TR-92-C-010 ..... p 1073 N92-34236 * #

USCAE-151 ..... p 1039 N92-33413 * #

USCGA-TR-1-92 ..... p 1051 N92-33809 #

UTIAS-TN-271 ..... p 1071 N92-33102 #

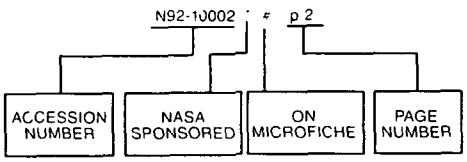
UWAERP-35 ..... p 1136 N92-32595 #

VKI-LS-1992-01-VOL-2 ..... p 1088 N92-34161 #

WL-TM-92-323 ..... p 1036 N92-32651 #

WL-TR-91-3089 ..... p 1124 N92-32632 #
WL-TR-92-8017 ..... p 1108 N92-32629 #

Typical Accession Number Index Listing



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A92-53434 p 1015
A92-53486 p 1065
A92-53487 p 1065
A92-53490 p 1065
A92-53491 p 1066
A92-53492 p 1066
A92-53493 p 1066
A92-53516 p 1105
A92-53545 p 1102
A92-53546 p 1073
A92-53547 p 1017
A92-53549 p 1017
A92-53550 p 1111
A92-53552 p 1017
A92-53553 p 1018
A92-53555 p 1018
A92-53556 p 1018
A92-53557 p 1018
A92-53558 p 1018
A92-53559 p 1018
A92-53560 p 1018
A92-53561 p 1019
A92-53564 p 1089
A92-53565 p 1102
A92-53578 p 1102
A92-53579 p 1019
A92-53580 p 1019
A92-53596 p 1130
A92-53603 p 1103
A92-53635 p 1103
A92-53639 p 1103
A92-53640 p 1103
A92-53641 p 1019
A92-53755 p 1111
A92-53758 p 1111
A92-53785 p 1130
A92-53786 p 1112
A92-53867 p 1019
A92-53875 p 1105
A92-53878 p 1105
A92-53882 p 1019
A92-53997 p 1019
A92-53998 p 1020
A92-54003 *# p 1020
A92-54004 *# p 1020
A92-54005 *# p 1020
A92-54006 *# p 1130
A92-54009 *# p 1066
A92-54011 *# p 1066
A92-54012 *# p 1020
A92-54013 *# p 1020
A92-54016 *# p 1021
A92-54019 # p 1103
A92-54020 *# p 1066
A92-54025 *# p 1067
A92-54026 *# p 1051
A92-54029 # p 1112
A92-54035 *# p 1067
A92-54036 *# p 1112
A92-54044 # p 1112
A92-54057 # p 1112
A92-54058 *# p 1090
A92-54059 *# p 1067
A92-54060 *# p 1067
A92-54075 # p 1112
A92-54090 *# p 1021
A92-54091 # p 1021
A92-54092 # p 1021
A92-54093 # p 1113
A92-54104 # p 1067
A92-54105 # p 1113
A92-54108 # p 1113
A92-54110 *# p 1021
A92-54111 *# p 1022
A92-54113 # p 1022
A92-54116 # p 1022
A92-54117 *# p 1022
A92-54118 # p 1022
A92-54132 *# p 1113
A92-54134 # p 1067
A92-54135 # p 1067
A92-54146 # p 1068
A92-54147 # p 1068
A92-54148 # p 1068
A92-54149 # p 1068
A92-54151 # p 1068
A92-54152 # p 1141
A92-54159 *# p 1068
A92-54160 # p 1022
A92-54161 *# p 1023
A92-54168 *# p 1069
A92-54169 *# p 1069
A92-54171 *# p 1069
A92-54177 # p 1069
A92-54178 # p 1069
A92-54179 *# p 1023
A92-54180 *# p 1090
A92-54198 # p 1113
A92-54199 # p 1113
A92-54223 p 1114
A92-54285 *# p 1130
A92-54301 p 1114
A92-54304 p 1114
A92-54307 p 1090
A92-54308 p 1023
A92-54311 p 1090
A92-54314 * p 1114
A92-54315 p 1090
A92-54317 * p 1114
A92-54319 * p 1090
A92-54321 p 1115
A92-54322 p 1090
A92-54323 p 1091
A92-54324 p 1063
A92-54325 p 1091
A92-54326 p 1091
A92-54330 p 1115
A92-54333 p 1115
A92-54334 p 1115
A92-54336 p 1091
A92-54337 p 1115
A92-54338 * p 1115
A92-54341 p 1091
A92-54342 p 1091
A92-54343 p 1092
A92-54344 * p 1116
A92-54345 p 1116
A92-54347 * p 1092
A92-54348 * p 1116
A92-54351 p 1092
A92-54484 p 1135
A92-54489 p 1023
A92-54496 p 1116
A92-54498 p 1023
A92-54546 p 1069
A92-54550 p 1052
A92-54563 p 1116
A92-54569 p 1023
A92-54571 p 1024
A92-54630 * p 1129
A92-54650 p 1116
A92-54660 * p 1135
A92-54678 p 1116
A92-54754 p 1045
A92-54867 p 1116
A92-54868 p 1117
A92-54902 p 1045
A92-54905 * p 1024
A92-54906 * p 1024
A92-54908 p 1135
A92-54909 * p 1135
A92-54910 p 1024
A92-54911 * p 1024
A92-54914 p 1024
A92-54916 * p 1024
A92-54918 p 1024
A92-54919 * p 1024
A92-54921 * p 1117
A92-54922 * p 1024
A92-54931 p 1117
A92-54932 p 1117
A92-54933 p 1025
A92-54934 * p 1117
A92-54935 p 1025
A92-54936 p 1025
A92-54938 p 1117
A92-54981 p 1052
A92-55098 p 1103
A92-55099 p 1015
A92-55100 p 1092
A92-55102 p 1015
A92-55103 p 1015
A92-55104 p 1052
A92-55127 p 1117
A92-55128 * p 1052
A92-55131 * p 1052
A92-55134 * p 1105
A92-55151 p 1130
A92-55170 *# p 1073
A92-55171 # p 1073
A92-55172 # p 1073
A92-55173 *# p 1073
A92-55174 *# p 1074
A92-55182 # p 1131
A92-55191 # p 1074
A92-55192 # p 1074
A92-55193 # p 1074
A92-55194 # p 1074
A92-55196 *# p 1074
A92-55199 *# p 1075
A92-55200 # p 1075
A92-55203 # p 1075
A92-55204 # p 1075
A92-55205 *# p 1075
A92-55206 # p 1076
A92-55211 *# p 1045
A92-55212 *# p 1063
A92-55229 # p 1076
A92-55230 *# p 1076
A92-55231 # p 1076
A92-55232 *# p 1076
A92-55233 # p 1076
A92-55237 # p 1131
A92-55246 # p 1077
A92-55262 *# p 1131
A92-55265 # p 1131
A92-55267 # p 1131
A92-55271 *# p 1131
A92-55272 # p 1141
A92-55280 # p 1077
A92-55281 *# p 1069
A92-55282 *# p 1131
A92-55283 *# p 1077
A92-55284 # p 1077
A92-55296 # p 1077
A92-55300 *# p 1052
A92-55302 # p 1077
A92-55303 # p 1077
A92-55304 # p 1078
A92-55305 # p 1078
A92-55306 # p 1132
A92-55310 # p 1103
A92-55311 # p 1104
A92-55326 p 1078
A92-55327 *# p 1078
A92-55328 *# p 1063
A92-55329 # p 1078
A92-55330 *# p 1078
A92-55331 # p 1079
A92-55332 # p 1079
A92-55333 # p 1079
A92-55334 # p 1079
A92-55340 # p 1079
A92-55341 # p 1079
A92-55342 # p 1079
A92-55343 *# p 1080
A92-55344 # p 1025
A92-55345 # p 1025
A92-55346 # p 1080
A92-55347 # p 1080
A92-55348 *# p 1092
A92-55349 # p 1080
A92-55350 *# p 1025
A92-55351 # p 1080
A92-55352 *# p 1080
A92-55353 *# p 1025
A92-55354 *# p 1081
A92-55355 *# p 1026
A92-55363 *# p 1081
A92-55364 # p 1026
A92-55365 *# p 1026
A92-55366 # p 1081
A92-55367 # p 1026
A92-55368 # p 1026
A92-55369 # p 1026
A92-55370 # p 1081
A92-55371 # p 1081
A92-55372 # p 1027
A92-55373 # p 1027
A92-55375 *# p 1027
A92-55376 *# p 1132
A92-55377 *# p 1027
A92-55380 # p 1081
A92-55382 # p 1027
A92-55387 # p 1027
A92-55393 *# p 1082
A92-55394 # p 1028
A92-55395 # p 1028
A92-55396 # p 1082
A92-55397 *# p 1028
A92-55426 p 1132
A92-55453 p 1118
A92-55500 p 1070
A92-55902 p 1070
A92-55906 p 1082
A92-55907 p 1063
A92-55908 p 1063
A92-55910 p 1082
A92-55911 p 1082
A92-55955 p 1045
A92-55968 * p 1046
A92-55973 p 1046
A92-56001 p 1015
A92-56002 p 1106
A92-56003 p 1092
A92-56005 p 1092
A92-56006 p 1028
A92-56007 p 1028
A92-56008 p 1028
A92-56009 p 1029
A92-56010 p 1029
A92-56011 p 1092
A92-56012 p 1093
A92-56013 p 1093
A92-56014 p 1052
A92-56015 p 1052
A92-56016 p 1052
A92-56017 p 1053
A92-56018 p 1053
A92-56019 p 1053
A92-56020 p 1053
A92-56021 p 1082
A92-56022 p 1083
A92-56023 p 1093
A92-56024 p 1118
A92-56025 p 1083
A92-56026 p 1083
A92-56027 p 1083
A92-56028 p 1083
A92-56029 p 1083
A92-56030 p 1083
A92-56032 p 1083
A92-56033 p 1083
A92-56034 p 1118
A92-56035 p 1118
A92-56036 p 1118
A92-56038 p 1118
A92-56039 p 1118
A92-56040 p 1029
A92-56042 p 1029
A92-56043 p 1093
A92-56044 p 1029
A92-56045 p 1029
A92-56046 p 1029
A92-56047 p 1029
A92-56048 p 1030
A92-56049 p 1030
A92-56050 p 1030
A92-56051 p 1053
A92-56052 p 1030
A92-56053 p 1030
A92-56054 p 1030
A92-56055 p 1135
A92-56057 p 1084
A92-56058 p 1030
A92-56059 p 1064
A92-56061 p 1053
A92-56062 p 1084
A92-56066 p 1084
A92-56067 p 1132
A92-56068 p 1084
A92-56069 p 1104
A92-56070 p 1084
A92-56072 p 1053
A92-56073 p 1053
A92-56074 p 1135
A92-56075 p 1053
A92-56076 p 1093
A92-56077 p 1053
A92-56078 p 1030
A92-56079 p 1084
A92-56080 p 1015
A92-56081 p 1046
A92-56082 p 1064
A92-56083 p 1015
A92-56084 p 1118
A92-56085 p 1016
A92-56086 p 1084
A92-56087 p 1016

A92-56088 p 1046
A92-56089 p 1046
A92-56090 p 1046
A92-56091 p 1046
A92-56092 p 1046
A92-56093 p 1046
A92-56094 p 1118
A92-56100 p 1016
A92-56102 p 1106
A92-56103 p 1106
A92-56105 p 1106
A92-56107 p 1118
A92-56109 p 1119
A92-56110 p 1047
A92-56111 p 1093
A92-56112 p 1054
A92-56113 p 1132
A92-56114 p 1093
A92-56115 p 1054
A92-56116 p 1047
A92-56117 p 1047
A92-56118 p 1047
A92-56119 p 1084
A92-56120 p 1047
A92-56121 p 1104
A92-56122 p 1070
A92-56141 # p 1119
A92-56143 # p 1119
A92-56151 p 1084
A92-56154 * p 1030
A92-56156 p 1054
A92-56157 * p 1030
A92-56158 * p 1054
A92-56159 p 1030
A92-56160 * p 1054
A92-56161 p 1031
A92-56162 p 1136
A92-56163 * p 1031
A92-56164 * p 1031
A92-56165 * p 1031
A92-56166 p 1031
A92-56169 p 1136
A92-56170 p 1031
A92-56171 p 1054
A92-56172 * p 1064
A92-56173 * p 1031
A92-56174 p 1054
A92-56176 * p 1054
A92-56178 p 1055
A92-56179 p 1031
A92-56180 p 1043
A92-56181 p 1119
A92-56201 p 1119
A92-56202 p 1119
A92-56209 p 1119
A92-56212 p 1141
A92-56215 p 1119
A92-56220 p 1055
A92-56221 p 1016
A92-56222 p 1120
A92-56225 p 1120
A92-56241 * p 1120
A92-56252 p 1120
A92-56254 p 1120
A92-56257 * p 1120
A92-56276 p 1121
A92-56277 p 1016
A92-56278 p 1132
A92-56279 p 1055
A92-56280 p 1093
A92-56281 p 1070
A92-56282 p 1084
A92-56283 p 1085
A92-56284 p 1085
A92-56285 * p 1055
A92-56286 * p 1055
A92-56287 p 1055
A92-56288 p 1056
A92-56289 p 1056
A92-56290 p 1056
A92-56292 p 1064
A92-56293 p 1132
A92-56295 p 1064
A92-56296 p 1121
A92-56297 p 1056
A92-56298 * p 1056
A92-56299 p 1016
A92-56300 p 1070
A92-56301 p 1056
A92-56302 p 1056
A92-56303 p 1085
A92-56304 p 1016
A92-56306 p 1016
A92-56307 p 1056
A92-56308 p 1085
A92-56309 p 1057
A92-56310 p 1057
A92-56311 p 1057
A92-56312 p 1057
A92-56313 p 1094
A92-56314 p 1085
A92-56315 * p 1085
A92-56316 * p 1057
A92-56317 p 1085
A92-56318 p 1086
A92-56320 p 1121
A92-56322 p 1121
A92-56324 * p 1121
A92-56325 p 1057
A92-56326 p 1106
A92-56327 p 1016
A92-56328 p 1057
A92-56329 p 1057
A92-56330 p 1058
A92-56331 p 1032
A92-56332 p 1032
A92-56333 p 1086
A92-56334 p 1086
A92-56335 p 1058
A92-56336 p 1058
A92-56337 p 1058
A92-56338 p 1070
A92-56339 * p 1133
A92-56340 p 1058
A92-56341 p 1058
A92-56342 p 1058
A92-56343 p 1059
A92-56344 * p 1136
A92-56345 p 1136
A92-56346 p 1059
A92-56347 p 1059
A92-56348 p 1059
A92-56349 p 1032
A92-56350 p 1059
A92-56351 p 1032
A92-56352 p 1032
A92-56353 p 1059
A92-56354 * p 1060
A92-56371 * p 1121
A92-56374 p 1121
A92-56602 * p 1141
A92-56607 p 1122
A92-56726 # p 1094
A92-56727 *# p 1094
A92-56729 # p 1094
A92-56735 # p 1122
A92-56736 # p 1017
A92-56738 # p 1094
A92-56743 *# p 1094
A92-56744 *# p 1094
A92-56745 *# p 1094
A92-56746 # p 1095
A92-56747 *# p 1032
A92-56748 *# p 1095
A92-56749 # p 1095
A92-56750 # p 1032
A92-56752 # p 1033
A92-56753 *# p 1095
A92-56754 # p 1133
A92-56755 # p 1095
A92-56756 *# p 1095
A92-56757 # p 1096
A92-56758 # p 1096
A92-56759 # p 1070
A92-56760 # p 1096
A92-56761 *# p 1096
A92-56765 # p 1122
A92-56767 *# p 1096
A92-56768 *# p 1096
A92-56770 *# p 1096
A92-56771 *# p 1033
A92-56772 # p 1104
A92-56773 # p 1097
A92-56774 # p 1097
A92-56775 # p 1097
A92-56776 *# p 1033
A92-56781 # p 1133
A92-56784 # p 1097
A92-56788 # p 1122
A92-56789 # p 1097
A92-56790 # p 1097
A92-56791 # p 1098
A92-56795 # p 1098
A92-56796 *# p 1098
A92-56797 # p 1098
A92-56798 # p 1098
A92-56802 # p 1098
A92-56803 # p 1071
A92-56805 # p 1071
A92-56806 # p 1098
A92-56807 # p 1099
A92-56809 # p 1060
A92-56810 # p 1033
A92-56815 # p 1099
A92-56816 # p 1099
A92-56818 # p 1099
A92-56824 # p 1122
A92-56825 *# p 1099
A92-56826 # p 1122
A92-56828 *# p 1122
A92-56829 # p 1123
A92-56831 # p 1099
A92-56832 *# p 1033
A92-56834 *# p 1033
A92-56835 # p 1033
A92-56836 *# p 1034
A92-56838 # p 1100
A92-56839 # p 1100
A92-56840 # p 1100
A92-56841 # p 1100
A92-56842 # p 1141
A92-56843 # p 1100
A92-56844 *# p 1141
A92-56845 *# p 1034
A92-56846 *# p 1034
A92-56847 *# p 1104
A92-56850 # p 1100
A92-56851 *# p 1034
A92-56854 *# p 1100
A92-56855 *# p 1034
A92-56856 *# p 1101
A92-56857 *# p 1035
A92-56858 *# p 1035
A92-56860 # p 1123
A92-56861 *# p 1035
A92-56862 # p 1035
A92-56866 p 1123
A92-57034 *# p 1035
A92-57035 # p 1035
A92-57039 p 1123
A92-57098 p 1071
A92-57099 p 1071
A92-57100 * p 1106
A92-57101 p 1106
A92-57102 p 1104
A92-57254 p 1104
A92-57258 p 1105
A92-57259 * p 1105
A92-57288 p 1123
A92-57399 p 1123
A92-57444 p 1133
A92-57445 p 1133
A92-57446 p 1133
A92-57499 p 1035

N92-32265 *# p 1124
N92-32268 *# p 1124
N92-32270 *# p 1124
N92-32292 *# p 1124
N92-32338 # p 1142
N92-32422 *# p 1036
N92-32424 *# p 1047
N92-32435 # p 1086
N92-32447 # p 1064
N92-32452 *# p 1071
N92-32453 # p 1142
N92-32455 # p 1043
N92-32479 p 1036
N92-32480 *# p 1036
N92-32487 p 1086
N92-32494 *# p 1036
N92-32505 # p 1141
N92-32507 *# p 1133
N92-32513 *# p 1106
N92-32514 *# p 1107
N92-32522 *# p 1107
N92-32523 *# p 1107
N92-32525 *# p 1107
N92-32527 *# p 1107
N92-32528 *# p 1107
N92-32536 *# p 1060
N92-32537 # p 1047
N92-32575 *# p 1107
N92-32576 *# p 1108
N92-32577 *# p 1108
N92-32579 *# p 1108
N92-32586 *# p 1108
N92-32595 # p 1136
N92-32606 *# p 1043
N92-32629 # p 1108
N92-32632 # p 1124
N92-32648 *# p 1036
N92-32651 # p 1036
N92-32673 # p 1037
N92-32686 # p 1124
N92-32697 # p 1136
N92-32730 # p 1037
N92-32732 # p 1037
N92-32734 # p 1101
N92-32742 # p 1125
N92-32769 # p 1037
N92-32773 # p 1037
N92-32776 # p 1125
N92-32778 *# p 1086
N92-32780 p 1087
N92-32782 p 1037
N92-32788 *# p 1087
N92-32791 # p 1109
N92-32811 # p 1038
N92-32830 # p 1047
N92-32845 # p 1048
N92-32846 # p 1109
N92-32849 # p 1048
N92-32850 # p 1064
N92-32851 # p 1134
N92-32856 p 1125
N92-32861 # p 1048
N92-32863 *# p 1109
N92-32864 *# p 1087
N92-32865 *# p 1134
N92-32866 *# p 1065
N92-32880 *# p 1134
N92-32887 *# p 1060
N92-32900 # p 1038
N92-32903 # p 1101
N92-32941 # p 1043
N92-32948 *# p 1136
N92-32949 *# p 1136
N92-32950 *# p 1137
N92-32951 *# p 1137
N92-32952 *# p 1137
N92-32955 *# p 1137
N92-32956 *# p 1137
N92-32957 *# p 1137
N92-32958 *# p 1137
N92-32960 *# p 1137
N92-32961 *# p 1138
N92-32962 *# p 1138
N92-32963 *# p 1138
N92-32964 *# p 1125
N92-32988 # p 1087
N92-33005 # p 1043
N92-33033 # p 1109
N92-33036 # p 1109
N92-33044 # p 1109
N92-33048 # p 1110
N92-33049 # p 1110
N92-33050 # p 1110
N92-33054 *# p 1110
N92-33063 *# p 1038
N92-33066 # p 1125
N92-33080 *# p 1044
N92-33098 # p 1048
N92-33102 # p 1071
N92-33104 *# p 1125
N92-33105 # p 1071
N92-33107 *# p 1087
N92-33139 *# p 1125
N92-33147 # p 1142
N92-33149 *# p 1060
N92-33160 *# p 1138
N92-33176 # p 1017
N92-33194 *# p 1044
N92-33220 # p 1129
N92-33237 *# p 1142
N92-33238 # p 1142
N92-33249 # p 1044
N92-33271 # p 1129
N92-33277 # p 1065
N92-33288 # p 1044
N92-33304 *# p 1038
N92-33305 # p 1142
N92-33306 *# p 1038
N92-33307 *# p 1126
N92-33308 # p 1048
N92-33339 *# p 1134
N92-33340 *# p 1065
N92-33351 *# p 1049
N92-33352 *# p 1049
N92-33353 *# p 1049
N92-33354 *# p 1049
N92-33355 *# p 1049
N92-33356 *# p 1050
N92-33358 *# p 1050
N92-33381 *# p 1050
N92-33398 # p 1101
N92-33404 *# p 1060
N92-33407 *# p 1050
N92-33413 *# p 1039
N92-33414 # p 1061
N92-33423 *# p 1110
N92-33424 *# p 1039
N92-33434 # p 1101
N92-33440 p 1126
N92-33479 *# p 1072
N92-33480 # p 1126
N92-33483 *# p 1134
N92-33484 *# p 1039
N92-33498 # p 1126
N92-33499 # p 1017
N92-33501 # p 1126
N92-33502 # p 1061
N92-33536 *# p 1088
N92-33537 *# p 1088
N92-33538 # p 1127
N92-33581 *# p 1039
N92-33582 p 1061
N92-33585 p 1061
N92-33596 # p 1050
N92-33609 *# p 1051
N92-33613 *# p 1110
N92-33618 *# p 1040
N92-33624 # p 1111
N92-33625 *# p 1040
N92-33627 # p 1127
N92-33631 *# p 1040
N92-33645 # p 1072
N92-33656 *# p 1040
N92-33678 # p 1040
N92-33693 # p 1051
N92-33694 # p 1143
N92-33696 *# p 1127
N92-33699 # p 1041
N92-33706 *# p 1041
N92-33719 *# p 1138
N92-33743 # p 1138
N92-33746 *# p 1072
N92-33748 # p 1072
N92-33749 # p 1072
N92-33750 # p 1061
N92-33751 # p 1129
N92-33763 # p 1105
N92-33794 # p 1129
N92-33809 # p 1051
N92-33815 # p 1072
N92-33826 *# p 1101
N92-33837 p 1041
N92-33839 p 1041
N92-33851 p 1041
N92-33874 *# p 1061
N92-33876 *# p 1138
N92-33877 *# p 1139
N92-33878 *# p 1139
N92-33879 *# p 1139
N92-33880 *# p 1139
N92-33881 *# p 1139
N92-33882 *# p 1140
N92-33883 *# p 1140
N92-33884 *# p 1140
N92-33885 *# p 1140
N92-33894 *# p 1134
N92-33916 # p 1127
N92-33920 # p 1135
N92-33948 *# p 1143
N92-33952 p 1061
N92-33953 p 1062
N92-33968 p 1127
N92-33994 # p 1111
N92-34017 *# p 1128
N92-34019 # p 1111
N92-34029 p 1042
N92-34036 p 1128
N92-34039 *# p 1062
N92-34043 *# p 1128
N92-34081 # p 1044
N92-34105 *# p 1044
N92-34107 *# p 1088
N92-34109 *# p 1065
N92-34112 *# p 1128
N92-34131 # p 1088
N92-34141 *# p 1102
N92-34144 *# p 1042
N92-34147 *# p 1042
N92-34148 *# p 1140
N92-34151 # p 1045
N92-34161 # p 1088
N92-34162 # p 1088
N92-34163 # p 1089
N92-34164 # p 1089
N92-34165 # p 1089
N92-34166 # p 1089
N92-34167 # p 1089
N92-34168 # p 1089
N92-34169 # p 1089
N92-34172 * p 1042
N92-34178 *# p 1128
N92-34182 # p 1062
N92-34192 *# p 1045
N92-34193 *# p 1042
N92-34202 *# p 1062

N92-34203 * # p 1051
N92-34207 * # p 1128
N92-34213 * # p 1102
N92-34222 * # p 1102
N92-34236 * # p 1073
N92-34243 * # p 1043
N92-34247 # p 1102

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1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA SP-7037(286)		

4. Title and Subtitle	5. Report Date
Aeronautical Engineering A Continuing Bibliography (Supplement 286)	January 1993
	6. Performing Organization Code JTT
7. Author(s)	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address NASA Scientific and Technical Information Program	11. Contract or Grant No.
	13. Type of Report and Period Covered Special Publication
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546	14. Sponsoring Agency Code

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Serials/Documents Section
140 North Senate Avenue
Indianapolis, IN 46204
(317) 232-3678 FAX: (317) 232-3728

IOWA

UNIV. OF IOWA LIBRARIES
Govt. Publications Dept.
Washington & Madison Streets
Iowa City, IA 52242
(319) 335-5926 FAX: (319) 335-5830

KANSAS

UNIV. OF KANSAS
Govt. Documents & Map Library
6001 Malatt Hall
Lawrence, KS 66045-2800
(913) 864-4660 FAX: (913) 864-5380

KENTUCKY

UNIV. OF KENTUCKY LIBRARIES
Govt. Publications/Maps Dept.
Lexington, KY 40506-0039
(606) 257-3139 FAX: (606) 257-1563; 257-8379

LOUISIANA

LOUISIANA STATE UNIV.
Middleton Library
Govt. Documents Dept.
Baton Rouge, LA 70803
(504) 388-2570 FAX: (504) 388-6992

LOUISIANA TECHNICAL UNIV.
Prescott Memorial Library
Govt. Documents Dept.
305 Wisteria Street
Ruston, LA 71270-9985
(318) 257-4962 FAX: (318) 257-2447

MAINE

TRI-STATE DOCUMENTS DEPOSITORY
Raymond H. Fogler Library
Govt. Documents & Microforms Dept.
Univ. of Maine
Orono, ME 04469
(207) 581-1680

MARYLAND

UNIV. OF MARYLAND
Hornbake Library
Govt. Documents/Maps Unit
College Park, MD 20742
(301) 454-3034 FAX: (301) 454-4985

MASSACHUSETTS

BOSTON PUBLIC LIBRARY
Govt. Documents Dept.
666 Boylston Street
Boston, MA 02117
(617) 536-5400 ext. 226
FAX: (617) 267-8273; 267-8248

MICHIGAN

DETROIT PUBLIC LIBRARY
5201 Woodward Avenue
Detroit, MI 48202-4093
(313) 833-1440; 833-1409
FAX: (313) 833-5039

LIBRARY OF MICHIGAN
Govt. Documents Unit
P.O. Box 30007
Lansing, MI 48909
(517) 373-0640 FAX: (517) 373-3381

MINNESOTA

UNIV. OF MINNESOTA
Wilson Library
Govt. Publications Library
309 19th Avenue South
Minneapolis, MN 55455
(612) 624-5073 FAX: (612) 626-9353

MISSISSIPPI

UNIV. OF MISSISSIPPI
J.D. Williams Library
Federal Documents Dept.
106 Old Gym Bldg.
University, MS 38677
(601) 232-5857 FAX: (601) 232-5453

MISSOURI

UNIV. OF MISSOURI - COLUMBIA
Ellis Library
Govt. Documents
Columbia, MO 65201
(314) 882-6733 FAX: (314) 882-8044

MONTANA

UNIV. OF MONTANA
Maureen & Mike Mansfield Library
Documents Div.
Missoula, MT 59812-1195
(406) 243-6700 FAX: (406) 243-2060

NEBRASKA

UNIV. OF NEBRASKA - LINCOLN
D.L. Love Memorial Library
Documents Dept.
Lincoln, NE 68588
(402) 472-2562

NEVADA

UNIV. OF NEVADA
Reno Library
Govt. Publications Dept.
Reno, NV 89557
(702) 784-6579 FAX: (702) 784-1751

NEW JERSEY

NEWARK PUBLIC LIBRARY
U.S. Documents Div.
5 Washington Street - P.O. Box 630
Newark, NJ 07101-0630
(201) 733-7812 FAX: (201) 733-5648

NEW MEXICO

UNIV. OF NEW MEXICO
General Library
Govt. Publications Dept.
Albuquerque, NM 87131-1466
(505) 277-5441 FAX: (505) 277-6019

NEW MEXICO STATE LIBRARY
325 Don Gaspar Avenue
Santa Fe, NM 87503
(505) 827-3826 FAX: (505) 827-3820

NEW YORK

NEW YORK STATE LIBRARY
Documents/Gift & Exchange Section
Federal Depository Program
Cultural Education Center
Albany, NY 12230
(518) 474-5563 FAX: (518) 474-5786

NORTH CAROLINA

UNIV. OF NORTH CAROLINA - CHAPEL HILL
CB#3912, Davis Library
BA/SS Dept.—Documents
Chapel Hill, NC 27599
(919) 962-1151 FAX: (919) 962-0484

NORTH DAKOTA

NORTH DAKOTA STATE UNIV. LIBRARY
Documents Office
Fargo, ND 58105
(701) 237-8886 FAX: (701) 237-7138
In cooperation with Univ. of North Dakota, Chester Fritz Library
Grand Forks

OHIO

STATE LIBRARY OF OHIO
Documents Dept.
65 South Front Street
Columbus, OH 43266
(614) 644-7051 FAX: (614) 752-9178

OKLAHOMA

OKLAHOMA DEPT. OF LIBRARIES
U.S. Govt. Information Div.
200 NE 18th Street
Oklahoma City, OK 73105-3298
(405) 521-2502, ext. 252, 253
FAX: (405) 525-7804

OKLAHOMA STATE UNIV.
Edmon Low Library
Documents Dept.
Stillwater, OK 74078
(405) 744-6546 FAX: (405) 744-5183

OREGON

PORTLAND STATE UNIV.
Millar Library
934 SW Harrison - P.O. Box 1151
Portland, OR 97207
(503) 725-3673 FAX: (503) 725-4527

PENNSYLVANIA

STATE LIBRARY OF PENN.
Govt. Publications Section
Walnut St. & Commonwealth Ave.
P.O. Box 1601
Harrisburg, PA 17105
(717) 787-3752

SOUTH CAROLINA

CLEMSON UNIV.
Cooper Library
Public Documents Unit
Clemson, SC 29634-3001
(803) 656-5174 FAX: (803) 656-3025
In cooperation with Univ. of South Carolina, Thomas Cooper Library, Columbia

TENNESSEE

MEMPHIS STATE UNIV. LIBRARIES
Govt. Documents
Memphis, TN 38152
(901) 678-2586 FAX: (901) 678-2511

TEXAS

TEXAS STATE LIBRARY
United States Documents
P.O. Box 12927 - 1201 Brazos
Austin, TX 78711
(512) 463-5455 FAX: (512) 463-5436

TEXAS TECH. UNIV. LIBRARY
Documents Dept.
Lubbock, TX 79409
(806) 742-2268 FAX: (806) 742-1920

UTAH

UTAH STATE UNIV.
Merrill Library & Learning Resources Center, UMC-3000
Documents Dept.
Logan, UT 84322-3000
(801) 750-2684 FAX: (801) 750-2677

VIRGINIA

UNIV. OF VIRGINIA
Alderman Library
Govt. Documents
Charlottesville, VA 22903-2498
(804) 924-3133 FAX: (804) 924-4337

WASHINGTON

WASHINGTON STATE LIBRARY
Document Section
MS AJ-11
Olympia, WA 98504-0111
(206) 753-4027 FAX: (206) 753-3546

WEST VIRGINIA

WEST VIRGINIA UNIV. LIBRARY
Govt. Documents Section
P.O. Box 6069
Morgantown, WV 26506
(304) 293-3640

WISCONSIN

ST. HIST. SOC. OF WISCONSIN LIBRARY
Govt. Publications Section
816 State Street
Madison, WI 53706
(608) 262-2781 FAX: (608) 262-4711
In cooperation with Univ. of Wisconsin-Madison, Memorial Library

MILWAUKEE PUBLIC LIBRARY
Documents Div.
814 West Wisconsin Avenue
Milwaukee, WI 53233
(414) 278-2167 FAX: (414) 278-2137

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