NASA SP-7037 (301)
February 1994

p. 367

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(NASA-SP-7037(301)) AERONAUTICAL ENGINEERING: A CONTINUING BIBLIOGRAPHY WITH INDEXES (SUPPLEMENT 301) (NASA) 367 p

N94-28203

Unclas

00/01 0001788

NASA
STI PROGRAM
SCIENTIFIC &
TECHNICAL
INFORMATION

The NASA STI Program ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program plays a key part in helping NASA maintain this important role.

The NASA STI Program provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program is also NASA's institutional mechanism for disseminating the results of its research and development activities.

Specialized services that help round out the Program's diverse offerings include creating custom thesauri, translating material to or from 34 foreign languages, building customized databases, organizing and publishing research results ... even providing videos.

For more information about the NASA STI Program, you can:

- **Phone** the NASA Access Help Desk at (301) 621-0390

- **Fax** your question to the NASA Access Help Desk at (301) 621-0134

- **E-mail** your question via the **Internet** to help@sti.nasa.gov

- **Write** to:

  NASA Access Help Desk
  NASA Center for AeroSpace Information
  800 Elkridge Landing Road
  Linthicum Heights, MD 21090-2934

NASA SP-7037 (301)
February 1994

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

National Aeronautics and Space Administration
Scientific and Technical Information Program
Washington, DC 1994

This publication was prepared by the NASA Center for AeroSpace Information,
800 Elkridge Landing Road, Linthicum Heights, MD 21090-2934, (301) 621-0390.

INTRODUCTION

This issue of *Aeronautical Engineering — A Continuing Bibliography with Indexes* (NASA SP-7037) lists 1291 reports, journal articles, and other documents recently announced in the NASA STI Database.

Accession numbers cited in this issue include:

Scientific and Technical Aerospace Reports (STAR) (N-10000 Series)	N94-10001 — N94-20343
Open Literature (A-10000 Series)	A94-10001 — A94-13149

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 1994 will be published in early 1995.

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

Page intentionally left blank

Page intentionally left blank

TABLE OF CONTENTS

TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

↓↓

ACCESSION NUMBER →	**N94-10675*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.	← CORPORATE SOURCE
TITLE →	**STATIC INTERNAL PERFORMANCE OF A SINGLE EXPANSION RAMP NOZZLE WITH MULTIAXIS THRUST VECTORING CAPABILITY**	
AUTHORS →	FRANCIS J. CAPONE and ALBERTO W. SCHIRMER (George Washington Univ., Hampton, VA.) Washington Jul. 1993 272 p	← PUBLICATION DATE
CONTRACT NUMBER →	(Contract RTOP 505-62-30-01)	
REPORT NUMBERS →	(NASA-TM-4450; L-17163; NAS 1.15:4450) Avail: CASI HC A12/ MF A03	← AVAILABILITY AND PRICE CODE

An investigation was conducted at static conditions in order to determine the internal performance characteristics of a multiaxis thrust vectoring single expansion ramp nozzle. Yaw vectoring was achieved by deflecting yaw flaps in the nozzle sidewall into the nozzle exhaust flow. In order to eliminate any physical interference between the variable angle yaw flap deflected into the exhaust flow and the nozzle upper ramp and lower flap which were deflected for pitch vectoring, the downstream corners of both the nozzle ramp and lower flap were cut off to allow for up to 30 deg of yaw vectoring. The effects of nozzle upper ramp and lower flap cutout, yaw flap hinge line location and hinge inclination angle, sidewall containment, geometric pitch vector angle, and geometric yaw vector angle were studied. This investigation was conducted in the static-test facility of the Langley 16-foot Transonic Tunnel at nozzle pressure ratios up to 8.0. Author (revised)

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

↓

ACCESSION NUMBER →	**A94-10806*** National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.	← CORPORATE SOURCE
TITLE →	**FLIGHT CONTROL APPLICATION OF NEW STABILITY ROBUSTNESS BOUNDS FOR LINEAR UNCERTAIN SYSTEMS**	
AUTHOR →	RAMA K. YEDAVALLI (Ohio State Univ., Columbus) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 6	← AUTHOR'S AFFILIATION AND JOURNAL TITLE
PUBLICATION DATE →	Nov.-Dec. 1993 p. 1032-1037. refs	
CONTRACT NUMBER →	(Contract NAG1-1164) Copyright	

This paper addresses the issue of obtaining bounds on the real parameter perturbations of a linear state-space model for robust stability. Based on Kronecker algebra, new, easily computable sufficient bounds are derived that are much less conservative than the existing bounds since the technique is meant for only real parameter perturbations (in contrast to specializing complex variation case to real parameter case). The proposed theory is illustrated with application to several flight control examples.

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 301)

February 1994

01

AERONAUTICS (GENERAL)

A94-10850
NASA TESTS DEFINING ASTOVL FLOW FIELD
STANLEY W. KANDEBO Aviation Week & Space Technology (ISSN 0005-2175) vol. 139, no. 13 Sept. 27, 1993 p. 40-42. Copyright

Newly developed nonevasive instrumentation based on Rayleigh scattering techniques is being used together with a tenth-scale modular aircraft model to characterize the highly complex flow field surrounding STOVL aircraft during vertical ascent and descent maneuvers. These techniques are described along with the concepts explored in the test effort. AIAA

A94-11355
THE USE OF SIMULATION IN AIRCRAFT ACCIDENT PREVENTION AND INVESTIGATION; PROCEEDINGS OF THE CONFERENCE, LONDON, UNITED KINGDOM, NOV. 11, 12, 1992
London Royal Aeronautical Society 1992 119 p. For individual items see A94-11356 to A94-11367
(ISBN 1-85768-070-7) Copyright

The present conference discusses the use of computer graphics simulations for analysis of the Delta flight 191 wind-shear accident, computer-graphic recreations of aircraft accidents, the integration of simulation and visualization aids in aircraft accident investigations, and the use of simulations in accident-investigator training. Also discussed are the role of the British Defense Research Agency's Advanced Flight Simulator for flight clearance system verification, the use of a generic nonlinear simulation environment for accident investigation, and the simulation and investigation of aircrew error. AIAA

A94-11624
PARABOLIC FLIGHT BY MU-300
DAIRO KAGEYAMA (Diamond Air Service Co., Aichi, Japan) JASMA - Japan Society of Microgravity Application, Journal (ISSN 0915-3616) vol. 10, no. 3 1993 p. 187-197. In JAPANESE Copyright

Characteristics of the parabolic flight by the MU-300, a small Japanese jet plane, are reported. The aircraft's parabolic flight provides microgravity periods of about 20 sec below 0.03 G. Various G conditions between 0.03 and 2.5 G can be provided in excess of 20 sec. AIAA

A94-11625
RADIO TECHNICAL COMMISSION FOR AERONAUTICS, TECHNICAL SYMPOSIUM, PHOENIX, AZ, NOV. 16-18, 1992, PROCEEDINGS
Washington Radio Technical Commission for Aeronautics, Inc. 1992 138 p. No individual items are abstracted in this volume Copyright

Session keynote addresses by the moderators, technical papers, background information on the program participants, and a brief biographical sketch presented at the 1992 RTCA Technical Symposium are reported. Particular attention is given to satellite-supported ATM, new technologies and user needs, decisions on airport surface operations issues including traffic management automation, and aeronautical communications. AIAA

A94-11999
DIGITAL TERRAIN MODELLING FOR RESEARCH AND DEVELOPMENT SIMULATIONS
JERRY MURRAY (Sterling Federal Systems, Inc., Palo Alto, CA) and JIM ZAMPATHAS Oct. 1992 6 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921979) Copyright

This paper addresses how terrain model requirements for research and development simulations differ and propose methods for comparing models implemented in dissimilar formats. Simulations for evaluating prototype mission equipment packages for aircraft often require high resolution digital elevation models (DEMs) and complex cultural feature models, primarily to support computer generated imagery. However, manned research simulations are now placing additional demands on the elevation and feature models. Terrain models are typically described in reference to their specific implementations that makes comparison of models difficult. Identifying terrain model requirements for a simulation involves comparing the cost of the implementation to the utility of the model. One level of modelling is not appropriate at all stages of development and resources can be better utilized if the appropriate models are selected at each stage. In addition to presenting methods for comparing models, this paper discusses how the modelling requirements change during the development of a complex simulation.

A94-12041
WHAT KIND OF EVOLUTION FOR THE HELICOPTER
YVES RICHARD (Eurocopter France, Marignane) Sep. 1992 7 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

A survey is conducted of the technologies whose prospective development will most profoundly affect the configurations of future helicopter designs. These technologies encompass the fields of novel rotor heads, fly-by-wire and fly-by-light flight controls, intensive use of composite materials in primary structures, and the more aggressive development of tilt-rotor-type aircraft. AIAA

A94-12042
CIVIL APPLICATION OF HELICOPTERS
HARRY SCHOEVERS (KLM-ERA Helikopters, Amsterdam, Netherlands) Sep. 1992 6 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

The regulatory framework for the operation of helicopters in the European Economic Community (EEC), within which the European Helicopter Association (EHA) operates as a promoter of the free flow of commercial and private helicopter traffic, is here discussed. EHA strives for the standardization of operationally-oriented legislation in the 13 member nations of the EEC; this legislation relates to offshore operations, the transport of external loads, and helicopter emergency medical services. AIAA

01 AERONAUTICS (GENERAL)

A94-12045
MARITIME APPLICATIONS AND HELICOPTER TECHNOLOGY
P. N. GODDARD (Westland Helicopters, Ltd., Yeovil, United Kingdom) and F. REINA (Agusta S.p.A., Cascina Costa di Samarate, Italy) Sep. 1992 25 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

Maritime operations have seen the helicopter gain initial entry into service, improve in capability, and become an essential element of naval and civil offshore operations. Evolving operations requirements have pushed helicopter technology such that today's aircraft possess a performance beyond the imaginations of the first designers. And this performance is still being pushed forward with the EH101, NH90, and V22 programs. This paper outlines the historical development of the capability and missions of maritime helicopters, describes the current state of the art, and highlights areas where improvements can still be made.

A94-12046
HEALTH AND USAGE MONITORING SYSTEMS
R. M. STEWART (Stewart Hughes, Ltd., Eastleigh, United Kingdom) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

A development status evaluation is presented for Health and Usage Monitoring (HUM) systems applicable to helicopters. A HUM system connected to a flight data recorder is a sophisticated data-gathering device, which in addition to yielding much information on the current status of systems also furnishes 'maintenance credits'. Such credits may offer benefits from reduced 'lifed-parts' life consumption to relaxation or even obviation of inspection tasks. AIAA

A94-12079
A.R.M.S. - A HUMS ON EUROCOPTER FRANCE HELICOPTER
B. FUJARSKI and G. GENOUX (Eurocopter France, Marignane) Sep. 1992 16 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

Eurocopter France's Aircraft Recording and Monitoring System (ARMS) is a health-usage monitoring system for helicopters such as the Super Puma Mk II and Dauphin. ARMS's health monitoring functions encompass the rotor, transmission, and engine; its status-monitoring functions record all in-flight alarms concerning the helicopter's mechanical, hydraulic, and electrical subsystems. An account is given of the ARMS architecture. The system's 'memory card' stores, in addition to subsystems' histories, health-determining algorithms and trends analyses. AIAA

A94-12114
EXPERIENCE IN FABRICATING POLYMERIC COMPOSITE ROTOR BLADES
U. P. GANYUSHKIN Sep. 1992 12 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

A development status evaluation is presented for the use of polymer-matrix composite materials for helicopter main rotor blade construction, giving attention to those design practices that effectively control rotor structural frequency characteristics. Emphasis is placed on those glass fiber-reinforced polymer composites that are representative of Soviet/Russian design practices, as seen in the cases of Ka-15 and Ka-26 helicopters. These composite blades are both more durable than metallic ones and of comparatively low cost. AIAA

A94-12611
CONTROL AND DYNAMIC SYSTEMS. VOL. 52 - INTEGRATED TECHNOLOGY METHODS AND APPLICATIONS IN AEROSPACE SYSTEMS DESIGN
C. T. LEONDES, ED. (California Univ., Los Angeles and La Jolla) San Diego, CA Academic Press, Inc. 1992 561 p. For individual items see A94-12612 to A94-12623
(ISBN 0-12-012752-0) Copyright

This volume contains papers on integrated technologies in aircraft design optimization, active flutter suppression techniques in aircraft wings, techniques in the design of aircraft for maintainability, new techniques for aircraft flight control reconfiguration, robust approximate optimal guidance strategies for aeroassisted plane change missions (a game theoretic approach), and an application of multiple model adaptive algorithms to reconfigurable flight control. Other papers discuss techniques for on-board automatic aid and advisory for pilots of control-impaired aircraft; placement of sensors and actuators in structural control; minimum-exposure near-terrain flight trajectories for rotorcraft; technology integration in advanced commercial aircraft cockpits and operational systems; the development of a pneumatic high-angle-of-attack flush air-data sensing system; and command, control, and communications (the human role in military C3 systems). AIAA

A94-12614
TECHNIQUES IN THE DESIGN OF AIRCRAFT FOR MAINTAINABILITY
ANTHONY E. MAJOROS and HONG C. CHEN (Douglas Aircraft Co., Long Beach, CA) *In* Control and dynamic systems. Vol. 52 - Integrated technology methods and applications in aerospace systems design San Diego, CA Academic Press, Inc. 1992 p. 117-154. refs
Copyright

The paper describes the typical aircraft-maintenance cycle and identifies the particular failure events and repair elements which are fully or partially design controllable. The maintainability requirements are defined, and the design for maintainability techniques are discussed, with particular attention given to the maintainability allocation, the selection and application of design alternatives (CAD techniques with human models, CAD techniques with working envelopes, and design for testability), and the design controls. The paper also discusses design features and checklists and presents diagrams and graphs illustrating the various issues considered. AIAA

A94-12701
CONTROL AND DYNAMIC SYSTEMS. VOL. 54 - SYSTEM PERFORMANCE IMPROVEMENT AND OPTIMIZATION TECHNIQUES AND THEIR APPLICATIONS IN AEROSPACE SYSTEMS
C. T. LEONDES, ED. (California Univ., Los Angeles and La Jolla) San Diego, CA Academic Press, Inc. 1992 532 p. For individual items see A94-12702 to A94-12713
(ISBN 0-12-012754-7) Copyright

Various papers on system performance improvement and optimization technique and their applications in aerospace systems are presented. The individual topics addressed include: techniques for aircraft conceptual design for mission performance comparing nonlinear multiobjective optimization methods; optimization of aerospace structure using mathematical functions of variable reduction; knowledge-based system techniques for pilot aiding; techniques for optimal sensor placement for on-orbit modal identification and correlation of large aerospace system structures; investigation of the use of optimization techniques for helicopter airframe vibrations design studies; size-reduction techniques for the determination of efficient aeroservoelastic models. Also discussed are: sensitivity analysis of eigendata of aeroelastic systems; simplified general solution methodology for transient structural dynamic problem with local nonlinearities; reduction, assignment, and perturbations in balanced systems and structures; response-only measurement techniques for determination of aerospace system structural characteristics; Krylov vector methods for model reduction and control of flexible structures; imaging and nonimaging sensor in maneuvering target tracking. AIAA

N94-10936*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PERFORMANCE AND ROTOR LOADS MEASUREMENTS OF THE LYNX XZ170 HELICOPTER WITH RECTANGULAR BLADES
BENTON H. LAU, ALEXANDER W. LOUIE (Sterling Software, Palo Alto, CA.), NICHOLAS GRIFFITHS (Westland Helicopters Ltd., Yeovil, England.), and COSTANTINOS P. SOTIRIOU (Westland

Helicopters Ltd., Yeovil, England.) May 1993 362 p
(Contract RTOP 505-59-36)
(NASA-TM-104000; A-93039; NAS 1.15:104000) Avail: CASI HC A16/MF A03

This report presents the results of a series of flight tests on the Lynx XZ170 helicopter with rectangular blades. The test objectives were to explore the flight envelope and to measure the performance and structural loads of the Lynx main-rotor system. The tests were conducted as part of the British Experimental Rotor Program (BERP) under a contract with the Ministry of Defense in England. Data were acquired for steady-level flights at five weight coefficients. Some flight conditions were tested at beyond the retreating-blade stall boundary, which was defined by a predetermined limit on the pitchlink vibratory load. In addition to documenting the flight conditions and data, this report describes the aircraft, particularly the rotor system, in detail. Author

N94-12578# Federal Aviation Administration, Washington, DC. Office of Aviation Policy and Plans.
FEDERAL AVIATION ADMINISTRATION AVIATION FORECASTS FY 1993-2004
Feb. 1993 229 p
(AD-A265611; FAA-APO-93-1) Avail: CASI HC A11/MF A03

This report contains the Fiscal Years 1993-2004 Federal Aviation Administration (FAA) forecasts of aviation activity at FAA facilities. These include airports with FAA control towers, air route traffic control centers, and flight service stations. Detailed forecasts were made for the major users of the National Aviation System: air carriers, air taxi/commuters, military, and general aviation. The forecasts have been prepared to meet the budget and planning needs of the constituent units of the FAA and to provide information that can be used by state and local authorities, the aviation industry, and the general public. The lethargy of both the U.S. and world economies during the past several years has caused the aviation industry to experience continuing financial losses. However, the outlook for the 12-year forecast period is for moderate economic growth, stable real fuel prices, and modest inflation. Based on these assumptions, aviation activity for fiscal year 2004 is forecast to increase by 24.6 percent at towered airports and 27.0 percent at air route traffic control centers. The general aviation active fleet and hours flown are forecast to increase by 7.0 and 18.1 percent, respectively, during the same time period. Scheduled domestic revenue passenger miles (RPM's)are forecast to increase 58.3 percent, scheduled international RPM's are forecast to increase by 115.3 percent, and regional/commuter RPM's are forecast to increase by 145.1 percent. DTIC

N94-13108*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AVERAGING TECHNIQUES FOR STEADY AND UNSTEADY CALCULATIONS OF A TRANSONIC FAN STAGE
M. L. WYSS (Cincinnati Univ., OH.), R. V. CHIMA, and D. L. TWEEDT Jul. 1993 12 p Presented at the 24th AIAA Fluid Dynamics Conference, Orlando, FL, 6-9 Jul. 1993; sponsored by AIAA
(Contract RTOP 535-05-10)
(NASA-TM-106231; E-7950; NAS 1.15:106231; AIAA PAPER 93-3065) Copyright Avail: CASI HC A03/MF A01

It is often desirable to characterize a turbomachinery flow field with a few lumped parameters such as total pressure ratio or stage efficiency. Various averaging schemes may be used to compute these parameters. The momentum, energy, and area averaging schemes are described and compared. The schemes were compared for two computed solutions of the midspan section of a transonic fan stage: a steady averaging-plane solution in which average rotor outflow conditions were used as stator inflow conditions, and an unsteady rotor-stator interaction solution. The solutions were computed on identical grids using similar Navier-Stokes codes and an algebraic turbulence model. The unsteady solution is described, some unsteady flow phenomena are discussed, and the steady pressure distributions are compared. Despite large unsteady pressure fluctuations on the stator surface, the steady pressure distribution matched the average unsteady distribution almost exactly. Stator wake profiles, stator loss coefficient, and stage efficiency were computed for the two solutions with the three averaging schemes and are compared. In general, the energy averaging scheme gave good agreement between the averaging-plane solution and the time-averaged unsteady solution, even though certain phenomena due to unsteady wake migration were neglected. Author (revised)

N94-13520# Bombardier, Inc., Montreal (Quebec).
ACTIVITIES OF BOMBARDIER, INC. Annual Report, period ending 31 Jan. 1993
1993 57 p Original contains color illustrations
(ISBN-2-921393-11-5; CTN-93-60863) Copyright Avail: CASI HC A04/MF A01

Bombardier Inc. is a designer, manufacturer, and distributor of transportation equipment and other products and services related to its technology. Its corporate office is in Montreal, Quebec, and its production facilities are located in Canada, the United States, Mexico, Austria, Belgium, France, Finland, and the United Kingdom. Bombardier's Transportation Equipment Group manufactures railroad cars, locomotives, and related products and services. Its aerospace group includes Canadair, maker of the Canadair Regional Jet and the CL-415 amphibious aircraft; de Havilland Inc. (Canada), maker of the Dash-8 turboprop; Learjet Inc. (Wichita, Kansas), maker of the Learjet series of business aircraft; and Short Brothers (Northern Ireland), maker of military aircraft, components, and defense systems. Bombardier also has a consumer products group that makes snowmobiles, water craft and other items. In this 1992-93 annual report, highlights of activities and financial statements and summaries are presented. For 1992-93, Bombardier's income before taxes was $150.9 million on consolidated revenues of $4,448 million. Total aerospace sales were $2.2 billion, with a sales backlog of $3.3 billion. CISTI

N94-13904# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
THE DEVELOPMENT OF INSPECTION AND REPAIR METHODS FOR THE C-17 AFT CARGO DOOR Final Report
ROBERT FREDELL Nov. 1992 54 p
(LR-704; ETN-93-94421) Avail: CASI HC A04/MF A01

The development of field level inspection and repair methods for the C-17 aft cargo door skins, constructed from ARALL 3, are reported. ARALL 3 is an advanced aramid/aluminum laminated sheet material with high strength and excellent fatigue resistance. The major areas of interest covered are: the effect of impact on the structural strength and durability; the effects of scratches on strength and durability; the limits of laminate workshop properties as they apply to repair; the most effective means of on-aircraft nondestructive inspection; and the development of acceptable practices for repair of damaged ARALL structures. The test program was focused on the following objectives: determining if the second cure cycle used in the manufacture of the door affects the fatigue and damage tolerance characteristics of the material; determining the effect of various levels of incidental damage on fatigue and residual strength properties of ARALL 3, and specifying what damage requires repair; and evaluating the structural effectiveness and ease of application of various concepts for base level repair of ARALL 3. The obtained results, conclusions, and recommendations are given. ESA

N94-15120# National Aerospace Lab., Amsterdam (Netherlands).
SYMPOSIUM ON THE FUTURE OF AERONAUTICS IN THE NETHERLANDS [DE TOEKOMST VAN NEDERLAND IN DE LUCHTVAART]
1991 167 p In DUTCH Symposium held in Delft, Netherlands, 26 Apr. 1991
(ETN-93-93780) Avail: CASI HC A08/MF A02

The history of fifty years of the Netherlands Association of Aeronautical Engineers, and the predicted and real developments in the aviation in the period 1961-1991 are depicted. The future of the Schiphol airport and the developments in the European air traffic control are presented. The tasks and prospects of aviation inspection are discussed. The expectations for the future KLM, Fokker the National Aerospace Laboratory, and military aviation in The Netherlands are treated. Developments in the Higher Technical Aerospace Education in the Netherlands and at the Faculty of Aeronautics and Astronautics of the Technical University of Delft are described.

ESA

N94-15121# Netherlands Association of Aeronautical Engineers, Amsterdam.

FIFTY YEARS OF THE NETHERLANDS ASSOCIATION OF AERONAUTICAL ENGINEERS [VIJFTIG JAAR NVVL: EEN TERUGBLIK]

F. J. STERK *In* NAL, Symposium on the Future of Aeronautics in the Netherlands 7 p 1991 In DUTCH

Avail: CASI HC A02/MF A02

The history of fifty years of the Netherlands Association of Aeronautical Engineers is depicted. The guidelines for the foundation of the Association are given. The main activity of the Association was and still is the organization of lectures, symposia, and conferences. ESA

N94-15122# Technische Univ., Delft (Netherlands). Faculteit der Luchtvaart- en Ruimtevaarttechniek.

PREDICTED AND REAL DEVELOPMENT IN THE AVIATION IN THE PERIOD 1961-1991 [VOORSPELDE EN WERKELIJKE ONTWIKKELINGEN IN DE VERKEERSLUCHTVAART (1961-1991)]

H. WITTENBERG *In* NAL, Symposium on the Future of Aeronautics in the Netherlands 43 p 1991 In DUTCH

Avail: CASI HC A03/MF A02

The predictions in developments in aeronautical techniques and aviation given at a symposium in 1966 are taken in a retrospective view and compared with the real developments in the period 1961-1991. It is concluded that the expectations run too high. With respect to technical developments this could be due to the belief in the 'technology push' rather then in the 'market demand'. In general, predictions have to consider social factors ('scenario techniques'). The development of aviation is influenced by many factors, and many efforts are still required to allow predictions based on models. ESA

N94-15127# Fokker B.V., Amsterdam (Netherlands).

EXPECTATIONS FOR THE FUTURE OF FOKKER [TOEKOMSTVERWACHTINGEN FOKKER]

M. VANDERVEEN *In* NAL, Symposium on the Future of Aeronautics in the Netherlands 3 p 1991 In DUTCH

Avail: CASI HC A01/MF A02

The perspectives of the Fokker Aircraft Company are outlined. The main emphasis is on civil regional airlines for 50 to 130 passengers; although, participation in Dutch military projects remains important. Until the year 2000 the emphasis is on the extension of the Fo50 and Fo100 aircraft. After 2000 the emphasis will be on aviation deregulation, environmental issues, integrated flight management, and integrated transportation systems. ESA

N94-15128# Ministry of Defence, The Hague (Netherlands).

EXPECTATIONS FOR THE FUTURE OF MILITARY AVIATION [TOEKOMSTVERWACHTINGEN MILITAIRE LUCHTVAART]

RUDOLF J. W. MERISON *In* NAL, Symposium on the Future of Aeronautics in the Netherlands 12 p 1991 In DUTCH

Avail: CASI HC A03/MF A02

An overview is given of the existing possibilities in the Netherlands in the field of defense oriented aeronautics and astronautics research and development, with emphasis on the Royal Air Force. From a national military strategic point of view there is a growing need for a European defense industry in which The Netherlands can contribute. The program EUCLID (European Cooperation for the Long term in Defense) was started to integrate the defense developments in Europe. ESA

N94-15798*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

NAS TECHNICAL SUMMARIES: NUMERICAL AERODYNAMIC SIMULATION PROGRAM, MARCH 1991 - FEBRUARY 1992

1992 266 p Original contains color illustrations

(NASA-TM-109335; NAS 1.15:109335) Avail: CASI HC A12/MF A03; 176 functional color pages

NASA created the Numerical Aerodynamic Simulation (NAS) Program in 1987 to focus resources on solving critical problems in aeroscience and related disciplines by utilizing the power of the most advanced supercomputers available. The NAS Program provides scientists with the necessary computing power to solve today's most demanding computational fluid dynamics problems and serves as a pathfinder in integrating leading-edge supercomputing technologies, thus benefiting other supercomputer centers in Government and industry. This report contains selected scientific results from the 1991-92 NAS Operational Year, March 4, 1991 to March 3, 1992, which is the fifth year of operation. During this year, the scientific community was given access to a Cray-2 and a Cray Y-MP. The Cray-2, the first generation supercomputer, has four processors, 256 megawords of central memory, and a total sustained speed of 250 million floating point operations per second. The Cray Y-MP, the second generation supercomputer, has eight processors and a total sustained speed of one billion floating point operations per second. Additional memory was installed this year, doubling capacity from 128 to 256 megawords of solid-state storage-device memory. Because of its higher performance, the Cray Y-MP delivered approximately 77 percent of the total number of supercomputer hours used during this year. Author (revised)

N94-17614 National Aerospace Lab., Emmeloord (Netherlands). Structures and Materials Div.

OVERVIEW OF THE FAA/DCA/NLR PROGRAMS RELATED TO AGEING AIRCRAFT

HAROLD H. OTTENS and J. BEN DEJONGE 16 Mar. 1993 24 p Presented at International Workshop on Structural Integrity of Ageing Airplanes, Atlanta, GA, 31 Mar. - 3 Apr. 1992 Limited Reproducibility: More than 20% of this document may be affected by microfiche quality

(NLR-TR-92119-U; ETN-93-94786) Avail: CASI HC A03

An overview of the research currently carried out at the National Aerospace Laboratory (NLR) (The Netherlands), with regard to the problems of ageing aircraft, is given. This research is primarily directed towards the prevention of ageing aircraft problems in future aircraft and is concentrated in two areas: prevention of multiple site damage in lap joints; improved knowledge in operational load experience. The major part of this research is carried out in some form of international cooperation. The Memorandum of Cooperation between Federal Aviation Administration and the Netherlands Civil Aviation Department in the area of aviation safety provides an effective framework for the coordination of research efforts related to ageing aircraft problems. NLR experiences with this cooperation and support from FAA are very stimulating. ESA

N94-18279 General Accounting Office, Washington, DC. National Security and International Affairs Div.

NAVAL AVIATION: CONSIDER ALL ALTERNATIVES BEFORE PROCEEDING WITH THE F/A-18E/F

Aug. 1993 12 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality

(AD-A269302; GAO/NSIAD-93-144) Avail: CASI HC A03

This report discusses the Navy's decision to develop the F/A-18E/F aircraft. The General Accounting Office believes the results of the examination should be fully considered in the ongoing review of the type and mix of fixed-wing tactical aircraft that will be required for future conflicts. Derived from text

N94-18415# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.

HIGH-LIFT SYSTEM AERODYNAMICS [L'AERODYNAMIQUE DES SYSTEMES HYPERSUSTENTATEURS]

Sep. 1993 494 p The 71st Symposium held in Banff, Alberta, 5-8 Oct. 1992
(AGARD-CP-515; ISBN-92-835-0715-0) Copyright Avail: CASI HC A21/MF A04

This report includes the 32 technical papers developed for the High-Lift System Aerodynamics Symposium along with an edited transcript of the Round Table Discussion and a Symposium Evaluation Report. The symposium objectives were to address (1) how the most appropriate high-lift system can be selected; (2) how an efficient design can be produced; and (3) the experimental and analysis techniques which are necessary to explore and enhance the performance of a high-lift system. Thus, although the aerodynamics of high-lift systems was the dominant theme, the very pertinent aspects of weight, simplicity, reliability, and structural and mechanical integrity were an integral part of the Symposium, and were treated in the papers presented. In this sense, this Symposium has attempted to take a broader view of the high-lift system than has been taken by similar conferences in the past.

N94-18416# Defence Research Agency, Farnborough (England). Low Speed Aerodynamics Div.
WHERE IS HIGH-LIFT TODAY? A REVIEW OF PAST UK RESEARCH PROGRAMMES
D. S. WOODWARD and D. E. LEAN *In* AGARD, High-Lift System Aerodynamics 45 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

Some of the history of the development of slotted high-lift systems is reviewed in this paper. In particular, the National High Lift Programme run in the UK during the 1970's is reviewed in some detail. In addition, the research program in high lift since the completion of the National High Lift Programme is described qualitatively and references given. The contents cover techniques of high lift testing, results of positional optimization of slats and flaps, the derivation of a simple prediction method suitable for use with a project optimization method, and the description, with results, of a method for interpreting aerodynamic and weight data on high lift systems in the context of a complete aircraft.
Author (revised)

N94-18441# Fokker B.V., Schipol-Oost (Netherlands).
FORTY YEARS OF HIGH-LIFT R/D: AN AIRCRAFT MANUFACTURER'S EXPERIENCE
E. OBERT *In* AGARD, High-Lift System Aerodynamics 28 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

In the course of four decades a large amount of high-lift applied research and development has taken place at the Fokker Company. In the fifties and sixties the F-27 and the F-28 were developed. In the eighties these aircraft were developed further into the Fokker 50 and Fokker 100. In the seventies an extensive R&D program was performed in preparation of a possible successor to the F-28 leading to the F-29 project study. In each case two- and three-dimensional wind tunnel models were investigated in numerous configurations. In the last decade these investigations have increasingly been preceded by theoretical investigations. Where data are available comparisons have been made with flight test data. Of each development program a detailed account is presented. Particular attention is paid to Reynolds-number effects and the interconnection between the high-speed cruise and low-speed high-lift design requirements.
Author

N94-19383# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany).
RESEARCH AND DESIGN ACTIVITIES AND THE ECONOMIC BALANCE OF MBB Annual Report, FY 1991 [DAS GESCHAEFTSJAHR 1991]
1991 40 p In GERMAN
(ETN-93-94909) Avail: CASI HC A03/MF A01

Research and design activities and economic balance of the company in 1991 are presented. The integration process of MBB into Deutsche Aerospace was continued in 1991. The French company Aerospatiale and MBB decided to collaborate in a new company christened Eurocopter in order to design and develop helicopters such as the Tiger. The Tornado production program was carried out and 35 aircraft were supplied to the German Air Force in Jan. 1992. The fan ranger program, which is based on the collaboration with Rockwell to JPATS (Joint Primary Aircraft Training System) program of U.S. Air Force and Navy, was started. The second test flight of X-31A, which is a program of cooperation with Rockwell for maneuverability studies, was successful. Space programs such as Eutelsat and ASTRO-SPAS satellites, and the Huygens probe, and defense programs were carried out following the predicted plan.
ESA

N94-20035*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SOME VTOL HEAD-UP DISPLAY DRIVE-LAW PROBLEMS AND SOLUTIONS
VERNON K. MERRICK Nov. 1993 45 p
(Contract RTOP 533-02-37)
(NASA-TM-104027; A-93090; NAS 1.15:104027) Avail: CASI HC A03/MF A01

A piloted simulation test was conducted on the Ames Research Center's vertical motion simulator (VMS) in support of the Phase 2A flight test of NASA's V/STOL systems research aircraft (VSRA). During the simulation several problems were found with the head-up display (HUD) symbol drive laws and the flightpath synthesis. These problems and the solutions devised to solve them are described. Most of the resulting HUD drive-law changes were implemented during the simulation and their effectiveness was verified. Subsequently both the HUD symbol drive-law and flightpath-synthesis changes were implemented in the VSRA and tested successfully in the Phase 2A flight tests. Author (revised)

N94-20191# Wichita State Univ., KS. National Inst. for Aviation Research.
AIAA TECHFEST 29 PROCEEDINGS
WILLIAM H. WENTZ, JR., ed. and JACQUELINE R. LUEDTKE, ed. 1993 217 p Conference held in Wichita, KS, 6-7 Nov. 1992
(NIAR-93-1) Avail: CASI HC A10/MF A03

Proceedings for the nineteenth annual techfest are accompanied by visual displays for selected topics. Selected topics in structures include limit-cycle oscillations of aircraft lifting surfaces; automated airframe monitoring; low-cost, high-performance target drone wing manufacturing process comparison; and elevated temperature testing considerations for various material systems. Experimental methods and instrumentation that were discussed included low-cost piloted flight simulation, and overview of doppler global velocimetry, and overview of the NIAR crash-dynamics lab, modernization of the Walter Beech Wind Tunnel, development of a PC-based real-time PCM display and analysis system. Topics in aerodynamics include axial flow fan research underway at the University of Kansas, axial agility and pitch agility of fighter aircraft revisited, an experimental and numerical investigation of a 70 degree delta wing at high angles of attack, and the adaptation of ACSYNT for business jet configuration synthesis.
CASI

02

AERODYNAMICS

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

A94-10329
NUMERICAL SIMULATIONS OF UNSTEADY AERODYNAMIC HEATING PHENOMENA DUE TO SHOCK WAVE REFLECTIONS WITH VIBRATIONAL EQUILIBRIUM
SHIGERU ASO, KEN-ICHI OHYAMA (Kyushu Univ., Fukuoka, Japan), TOSHI FUJIWARA (Nagoya Univ., Japan), and MASANORI

HAYASHI (Nishinippon Inst. of Technology, Fukuoka, Japan) Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160) vol. 53, no. 2 June 1993 p. 47-56. refs

The unsteady aerodynamic heating induced by shock impingement on a ramp surface is presently treated via the 2D thin-layer Navier-Stokes equations. Attention is given to the effect of energy transfer between translational and vibrational components of flow phenomena. The calculations have been conducted for an incident Mach number of 3.0 and a ramp angle of 35 deg, and for initial temperatures from 300 to 2000 K. Significant changes are noted in the heating phenomena with variation of initial temperature; the vibrational energy is found to play a major role in unsteady aerodynamic heating. AIAA

A94-10356

NUMERICAL ANALYSIS OF THE FLOW FIELD THROUGH A TURBINE STAGE WITH TIP CLEARANCE

YOSHIO SHIKANO Japan Society of Mechanical Engineers, Transactions B (ISSN 0387-5016) vol. 59, no. 563 July 1993 p. 2202-2208. In JAPANESE refs

Copyright

A numerical technique for the computation of 3D turbulent flows through a turbine stage with bucket tip clearance is presented. To calculate nozzle and bucket flow regions simultaneously, steady interaction is assumed on the connecting boundaries. To consider the exact flow-region geometry of the bucket tip clearance, an H-type computational grid system, which is also used in the nozzle and bucket flow regions, is used in the tip clearance region. A finite volume method is used to obtain the spatially discretized governing equations, while the damping surface technique is employed for the time integration. In the present analysis, a two-equation model of turbulence is introduced to estimate the turbulence effect. In order to assure the effectiveness of the present method, computations are carried out for the flow through turbine stages of different tip clearance heights. The results clearly show secondary flow phenomena such as the tip leakage vortex and passage vortex motions in the bucket flow region. The effects of the clearance height on the turbine stage flow fields are also well predicted qualitatively by the present method. Author (revised)

A94-10357

THREE-DIMENSIONAL FINITE ELEMENT ANALYSIS OF AERODYNAMIC FORCES ACTING ON AN OSCILLATING SUBSONIC LINEAR CASCADE. I - FINITE ELEMENT FORMULATION AND DETERMINATION OF DISTURBANCES. II - EFFECTS OF DIHEDRAL ANGLE, SWEEP ANGLE AND TAPER RATIO

NOBUHIKO YAMASAKI and MASANOBU NAMBA Japan Society of Mechanical Engineers, Transactions B (ISSN 0387-5016) vol. 59, no. 563 July 1993 p. 2209-2220. In JAPANESE refs

Copyright

This paper presents the 3D finite element formulation for calculating aerodynamic forces acting on oscillating linear cascade blades in a subsonic flow. Under the assumption of the potential flow, the velocity potentials at nodes are determined as the solution for the simultaneous algebraic equations. The expressions of acoustic and wake potentials are also given and used to determine upstream and downstream boundary conditions. The 3D FEM developed to calculate the aerodynamic forces acting on the vibrating cascade blades in a subsonic flow is applied to various flow conditions and geometrical configurations. In most cases, 3D effects due to taper on steady and unsteady aerodynamic forces appear as the effects of decreasing spanwise variation of steady and unsteady forces, respectively, when the angle of attack is uniform along the span. Author (revised)

A94-10410* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

MILESTONES IN BOUNDARY-LAYER TRANSITION RESEARCH WITH INFRARED IMAGING

EHUD GARTENBERG (Old Dominion Univ., Norfolk, VA) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 10.1-10.6. refs (Contract NAS1-18584-58)

Copyright

Since its first use in aerodynamic testing in 1967, IR imaging techniques have made distinctive contributions to two major development programs: the configurational design of the Space Shuttle, and the laminar-flow wing program of the Advanced Technologies Testing Aircraft System (ATTAS). In the case of the Space Shuttle, IR imaging was uniquely able to generate transition and heat-transfer data while retaining full control of thermal protection tile-system surface roughness. In ATTAS, much boundary layer transition data was produced with otherwise unobtainable time- and cost-efficiency. AIAA

A94-10434

JET BOUNDARIES - NEW TYPE OF SELF-STREAMLINING WIND TUNNEL WALL

V. YA. NEJLAND and V. M. NEJLAND (TsAGI, Zhukovski, Russia) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 40.1-40.7. refs

Copyright

New type of self-streamlining (adaptive) flow boundaries formed by thin jets separating the test section walls from the main flow in a wind tunnel is being considered. It is shown that, by adjusting the jet parameter, one can make the separating streamline shapes be similar to the form of a streamline in an unbounded flow. Some results within the theory of jet boundary interference for two-dimensional flows are given. The scheme of a test rig and experimental results for airfoils are presented. The high effectiveness with respect to reduction of wall interference in a transonic speed range is noted.

A94-10435* National Aeronautics and Space Administration, Washington, DC.

ADAPTIVE WALL TECHNOLOGY FOR THREE-DIMENSIONAL MODELS AT HIGH SUBSONIC SPEEDS AND AEROFOIL TESTING THROUGH THE SPEED OF SOUND

M. C. LEWIS, N. J. TAYLOR, and M. J. GOODYER (Southampton Univ., United Kingdom) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 42.1-42.12. Research supported by SERC, Ministry of Defence Procurement Executive, Department of Trade and Industry of United Kingdom, and NASA refs

Copyright

Adaptive wall research at the University of Southampton has been directed towards the development of testing techniques for use in nonporous test sections where two flexible walls are profiled in single curvature. This paper highlights the recent advances that have been made in the testing of 2D airfoils through the speed of sound and the testing of 3D models at high subsonic speeds. Techniques have been developed to accommodate the variety of flow regimes encountered in near sonic airfoil tests. The experimental evidence to date suggests that the new techniques coupled with established procedures allow airfoil data, free from top and bottom wall interference, to be gathered from adaptive flexible walled test sections throughout the entire subsonic, transonic and supersonic speed ranges. Techniques applicable to the testing of 3D models have evolved primarily from experience gained by testing sidewall mounted half-wings. Emphasis has been placed upon models with planforms similar to those of current transport wings. Techniques for high subsonic speeds have now been developed to the point where the residual levels of interference are low. Author (revised)

A94-10436

A NUMERICAL AND EXPERIMENTAL EVALUATION OF THE SIDEWALL BOUNDARY LAYER EFFECTS ON AEROFOILS TESTED IN WIND TUNNEL FACILITIES

D. J. JONES, Y. Y. CHAN, and Y. NISHIMURA (National Research Council of Canada, Inst. for Aerospace Research, Ottawa) *In*

Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 43.1-43.10. refs
Copyright

The effect of sidewall boundary layers in wind tunnel testing is analysed using an inviscid wing code coupled with a small crossflow boundary layer method to compute the sidewall boundary layer. The method is used to predict effects on the so called A4 supercritical airfoil in the IAR 1.5X1.5m wind tunnel. This can be operated in a 2-D mode with a 0.38m wide insert in the working section giving usually a width to chord ratio of about 1.5. Although sidewall boundary layer effects are alleviated to some extent by allowing for controlled suction on the walls surrounding the airfoil, it is shown in the present paper that a residual effect is still experienced in such a narrow facility. Also analysis is made for the A4 airfoil tested in the full span 1.5m wind tunnel facility at IAR and for the RAE 5225 airfoil tested in the RAE 8x8ft facility. The results of the analysis are compared vis a vis wind tunnel experimental data obtained for the A4 airfoil in the IAR large span facility.

A94-10437
WALL CORRECTION METHOD FOR MODELS WITH PROPELLER INDUCED SLIPSTREAM
A. KUEPPER (DLR, Braunschweig, Germany) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 44.1-44.11. refs
Copyright

A method is presented for calculating wall corrections for wind tunnel measurements in the case of models with propeller-generated slipstreams which takes into account that (1) this additional lift force, and (2) the additional pitching moment exerted on the additional propeller-stream-wetted portions of the wing and horizontal stabilizer are not due to higher circulation around these flow regions. They are instead due to increased kinetic pressure, and may not contribute to the wall constraint.
AIAA

A94-10697
PARAMETRIC STUDY OF THE FLUTTER STABILITY OF A SEMI-RIGID 3-D WING-WITH-ENGINE NACELLE MODEL IN SUBSONIC FLOW
H. FOERSCHING and J. M. KNAACK (DLR, Inst. fuer Aeroelastik, Goettingen, Germany) Journal of Fluids and Structures (ISSN 0889-9746) vol. 7, no. 6 Aug. 1993 p. 567-593. refs
Copyright

Results of a parametric investigation of the aeroelastic flutter stability behavior of a semirigid 3D wing-with-engine nacelle model in subsonic flow are presented. The system under consideration is a wind tunnel model that was flutter tested some years ago. It consists of a swept-back half wing with a pylon-mounted engine nacelle, representative of a modern large transport aircraft, and is elastically restrained at its wing root, so that it may execute decoupled (rigid body) rolling and pitching oscillations about two orthogonal axes. Numerical results are presented for several systematic parameter variations and Mach numbers, where special emphasis is placed on the effects of the motion-induced unsteady airloads acting on the engine nacelle, the position of the rotation axes, and the frequency ratio of the two modes in roll and pitch. A comparison with some wind tunnel test results is made. AIAA

A94-10698
NUMERICAL SIMULATION OF SHOCK-STALL FLUTTER OF AN AIRFOIL USING THE NAVIER-STOKES EQUATIONS
K. ISOGAI (National Aerospace Lab., Tokyo, Japan) Journal of Fluids and Structures (ISSN 0889-9746) vol. 7, no. 6 Aug. 1993 p. 595-609. refs
Copyright

In order to confirm qualitatively that the experimentally observed, unusual flutter phenomenon for a high-aspect-ratio (non-tailored) forward swept wing model is indeed shock-stall flutter, the aeroelastic response calculation of a two-dimensional airfoil whose vibration characteristics are similar to those of the typical section of a forward swept wing, has been performed by solving the compressible Navier-Stokes equations. By examination of the flow pattern, pressure distribution and the behavior of the unsteady aerodynamic forces during the diverging oscillation of the airfoil, it is concluded that (i) this is a shock-stall flutter, in which the large-scale shock-induced flow separation plays a dominant role and (ii) there is a mechanism of energy input into the elastic system of the airfoil, leading to nearly a single-degree-of-freedom flutter.

A94-10704
COMPUTATION AND DISCUSSION OF A NEARLY CONSTANT DEGREE OF REACTION TURBINE STAGE
JIYA CUI (Beijing Univ. of Aeronautics and Astronautics, China) Journal of Propulsion Technology (ISSN 1001-4055) no. 4 Aug. 1993 p. 14-17. In CHINESE refs

An effort is made to obtain a nearly constant degree of reaction from a turbine stage. The tension spline streamline curvature method is applied to a nearly constant shroud diameter flowpath, and the nozzle vanes leading edge positive lean angle is increased to 18. Nozzle vane conventional exit angle twist is 22.5 deg. The variations of main gas dynamic parameters, total pressure loss coefficients, and stage efficiencies along the blade height are shown, together with the corresponding conventional stage of same flowpath for comparison. A reaction difference of only 0.032 is achieved, but, due to the stage exit pressure being highest at shroud, the nozzle exit pressure is also at its maximum at the shroud. In order to minimize nozzle vane secondary flow and shroud clearance leakage losses, an optimum pressure gradient along nozzle vane exit is needed. Author (revised)

A94-10759
ADVANCES IN HYPERSONICS. VOL. 2 - MODELING HYPERSONIC FLOWS
JOHN J. BERTIN, ED. (Sandia National Labs., Albuquerque, NM), JACQUES PERIAUX, ED. (Dassault Aviation, Saint-Cloud, France), and JOSEF BALLMANN, ED. (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) Boston, MA Birkhaeuser 1992 280 p. For individual items see A94-10760 to A94-10766 (ISBN 0-8176-3663-3) Copyright

This volume contains seven papers, including those on turbulence modeling for hypersonic flows, advanced topics in turbulence theory, different levels of air dissociation chemistry, and modeling hypersonic reacting flows. The other papers discuss modeling hypersonic nonequilibrium flows; wall catalytic recombination and boundary conditions; and physical aspects of hypersonic flow, namely fluid dynamics and nonequilibrium phenomena. AIAA

A94-10760* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TURBULENCE MODELING FOR HYPERSONIC FLOWS
J. G. MARVIN and T. J. COAKLEY (NASA, Ames Research Center, Moffett Field, CA) *In* Advances in hypersonics. Vol. 2 - Modeling hypersonic flows Boston, MA Birkhaeuser 1992 p. 1-43. refs

Turbulence modeling for high-speed compressible flows is described and discussed. Starting with the compressible Navier-Stokes equations, methods of statistical averaging are described by means of which the Reynolds-averaged Navier-Stokes equations are developed. Unknown averages in these equations are approximated using various closure concepts. Zero-, one-, and two-equation eddy viscosity models, algebraic stress models, and Reynolds stress transport models are discussed. Computations of supersonic and hypersonic flows obtained using several of the models are discussed and compared with experimental results. Specific examples include attached boundary-layer flows, shock-wave boundary-layer interactions, and compressible shear layers. From these examples, conclusions regarding the status of modeling and recommendations for future studies are discussed.

A94-10763* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MODELING OF HYPERSONIC REACTING FLOWS
CHUL PARK (NASA, Ames Research Center, Moffett Field, CA) *In* Advances in hypersonics. Vol. 2 - Modeling hypersonic flows Boston, MA Birkhaeuser 1992 p. 104-127. refs

The effect of nonequilibrium thermochemical processes on the aerodynamic and heat transfer characteristics of a hypersonic vehicle is illustrated with examples. It is shown that the conventional method of predicting chemical reactions always predict that the flow is closer to equilibrium than it actually is, leading to incorrect predictions of aerodynamic characteristics of a vehicle. A method is presented for predicting chemical processes using a two-temperature kinetic model, which is developed on the basis of combining conservation equations for vibrational energy and for electron electronic energy, which are also derived. The validity of the two-temperature model is proven using two types of experimental data: radiation and shock shapes. AIAA

A94-10764
MODELING OF HYPERSONIC NONEQUILIBRIUM FLOWS
F. GRASSO and V. BELLUCCI (Rome I, Univ., Italy) *In* Advances in hypersonics. Vol. 2 - Modeling hypersonic flows Boston, MA Birkhaeuser 1992 p. 128-175. Research supported by ESA refs
Copyright

In the present work the influence of hypersonic flow models in the presence of finite rate chemistry and gas-surface interaction has been critically evaluated, and a solution methodology based on a finite volume approach has been developed. The technique relies on a second order accurate total variation diminishing formulation and it uses an efficient point implicit algorithm coupled with a multistage Runge Kutta technique. Applications of the model to compute viscous hypersonic flows over a wedge have shown the overwhelming influence of wall catalyticity.

A94-10765* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
WALL CATALYTIC RECOMBINATION AND BOUNDARY CONDITIONS IN NONEQUILIBRIUM HYPERSONIC FLOWS - WITH APPLICATIONS
CARL D. SCOTT (NASA, Johnson Space Center, Houston, TX) *In* Advances in hypersonics. Vol. 2 - Modeling hypersonic flows Boston, MA Birkhaeuser 1992 p. 176-250. refs

The meaning of catalysis and its relation to aerodynamic heating in nonequilibrium hypersonic flows are discussed. The species equations are described and boundary conditions for them are derived for a multicomponent gas and for a binary gas. Slip effects are included for application of continuum methods to low-density flows. Measurement techniques for determining catalytic wall recombination rates are discussed. Among them are experiments carried out in arc jets as well as flow reactors. Diagnostic methods for determining the atom or molecule concentrations in the flow are included. Results are given for a number of materials of interest to the aerospace community, including glassy coatings such as the RCG coating of the Space Shuttle and for high temperature refractory metals such as coated niobium. Methods of calculating the heat flux to space vehicles in nonequilibrium flows are described. These methods are applied to the Space Shuttle, the planned Aeroassist Flight Experiment, and a hypersonic slender vehicle such as a transatmospheric vehicle. Author (revised)

A94-10766
PHYSICAL ASPECTS OF HYPERSONIC FLOW - FLUID DYNAMICS AND NON-EQUILIBRIUM PHENOMENA
MAURIZIO PANDOLFI (Torino, Politecnico, Turin, Italy) *In* Advances in hypersonics. Vol. 2 - Modeling hypersonic flows Boston, MA Birkhaeuser 1992 p. 251-268. refs
Copyright

The features which characterize fluid dynamics in hypersonic flow are discussed, with special attention given to the interaction between fluid dynamics and nonequilibrium phenomenology. Equations are derived for nonequilibrium flow and for frozen and equilibrium flows, along with equations in quasi-linear form for reacting flows. Consideration is also given to the speed of sound in reacting media, the problem of nonequilibrium tending to frozen and to equilibrium flows, and propagation of waves in reacting media. AIAA

A94-10767
ADVANCES IN HYPERSONICS. VOL. 3 - COMPUTING HYPERSONIC FLOWS
JOHN J. BERTIN, ED. (Sandia National Labs., Albuquerque, NM), JACQUES PERIAUX, ED. (Dassault Aviation, Saint-Cloud, France), and JOSEF BALLMANN, ED. (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) Boston, MA Birkhaeuser 1992 436 p. *For individual items see A94-10768 to A94-10774* (ISBN 0-8176-3664-1) Copyright

The present volume on hypersonic flows addresses approximate two-layer methods for modeling aerothermodynamic environments, second-order effects in hypersonic boundary layers, unstructured-grid algorithms for high-speed CFD analysis, and numerical simulation of 3D hypersonic viscous flows. Attention is also given to viscous nonequilibrium flow calculations, the finite pointset method for hypersonic flows in the rarefied gas regime, and computation of flowfields for hypersonic flight at high altitudes. AIAA

A94-10768 National Aeronautics and Space Administration, Washington, DC.
APPROXIMATE TWO LAYER (INVISCID/VISCOUS) METHODS TO MODEL AEROTHERMODYNAMIC ENVIRONMENTS
FRED R. DEJARNETTE (Mars Mission Research Center, Raleigh, NC) *In* Advances in hypersonics. Vol. 3 - Computing hypersonic flows Boston, MA Birkhaeuser 1992 p. 1-20. Research supported by U.S. Navy and USAF refs
(Contract NAGW-1072; NAGW-1331; NCC1-100)
Copyright

Approximate inviscid and boundary layer techniques for aerodynamic heating calculations are discussed. An inviscid flowfield solution is needed to provide surface pressures and boundary-layer edge properties. Modified Newtonian pressures coupled with an approximate shock shape will suffice for relatively simple shapes like sphere-cones with cone half-angles between 15 and 45 deg. More accurate approximate methods have been developed which make use of modified Maslen techniques. Slender and large angle sphere-cones and more complex shapes generally require an Euler code, like HALIS, to provide that information. The boundary-layer solution is reduced significantly by using the axisymmetric analog and approximate heating relations developed by Zoby, et al. (1981). Analysis is presented for the calculation of inviscid surface streamlines and metrics. Entropy-layer swallowing effects require coupling the inviscid and boundary-layer solutions. Author (revised)

A94-10769
SECOND-ORDER EFFECTS IN HYPERSONIC BOUNDARY LAYERS
B. AUPOIX, J. PH. BRAZIER, J. COUSTEIX (ONERA, Centre d'Etudes et de Recherches de Toulouse, France), and F. MONNOYER (MBB GmbH, Munich, Germany) *In* Advances in hypersonics. Vol. 3 - Computing hypersonic flows Boston, MA Birkhaeuser 1992 p. 21-61. refs
Copyright

Ways of extending the boundary-layer approach to account for thick boundary layers and for variable edge conditions are investigated. A defect approach accounting for arbitrary variations of the outer flow in the boundary layer thickness is proposed. The approach uses the defect equations which include the Van Dyke equations and terms of higher order in Van Dyke's approach. It is concluded that incompressible flows with external shear are better predicted with the defect approach than with Van Dyke's approach requiring second-order solutions as the displacement effect is important. The defect approach is capable of providing fair predictions with a first-order approximation. AIAA

A94-10770
UNSTRUCTURED-GRID ALGORITHMS FOR HIGH-SPEED CFD ANALYSIS
A. DERVIEUX, J.-A. DESIDERI, L. FEZOUI, M.-V. SALVETTI (INRIA, Sophia-Antipolis, France), M. MALLET, J. PERIAUX, and B. STOUFFLET (Dassault Aviation, Saint-Cloud, France) *In* Advances in hypersonics. Vol. 3 - Computing hypersonic flows Boston, MA Birkhaeuser 1992 p. 62-169. Research supported by CNES and ESA refs
Copyright

Conservative shock-capturing methods applicable to finite-element simplicial triangulation for the calculation of high Mach number flow of both ideal and real gases are considered. Particular attention is given to the computation of external high Mach number Euler flows using finite element upwind schemes based on Van Leer (1983) and performance and portability of methodologies using SIMD or MIMD parallel machines. The proposed methodologies are extended to upwind finite volume computations and analysis of hypersonic nonequilibrium reactive flows around simple geometries. Consideration is also given to an Euler solver based on a second-order accurate upwind scheme using Van Leer's flux-vector splitting or Osher's approximate Riemann solver, and a Navier-Stokes solver using a streamline upwind Petrov-Galerkin entropy simulation. Hypersonic flow computations around Space-Shuttle-like geometries are also considered. AIAA

A94-10771
NUMERICAL SIMULATION OF THREE-DIMENSIONAL HYPERSONIC VISCOUS FLOWS
W. KORDULLA, B. MUELLER, S. RIEDELBAUCH, W. WETZEL, and G. BRENNER (DLR, Goettingen, Germany) *In* Advances in hypersonics. Vol. 3 - Computing hypersonic flows Boston, MA Birkhaeuser 1992 p. 169-220. Research supported by CNES and ESA refs
(Contract DFG-RU-334/1-6)
Copyright

Numerical approaches to simulate viscous hypersonic flows in the continuum- as well as in the gaskinetic-flow regimes are discussed with emphasis on three-dimensional flows. The ideal-gas continuum flow is simulated with an explicit/implicit finite-difference method for the thin-layer approximation of the time-dependent Navier-Stokes equations. In two dimensions real-gas effects are implemented using curve-fitting routines for the air properties in chemical equilibrium. Gaskinetic flows are considered based on the direct simulation Monte Carlo approach for the solution of the Boltzmann equation. Real-gas effects are included via an extended Borgnakke-Larsen model in two dimensions. In all approaches the major problem is the lack of appropriate experiments for code validation.

A94-10772* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
NUMERICAL SIMULATION OF ENTRY FLOW OVER BLUNT SWEPT-WING PLANES
C. P. LI (NASA, Johnson Space Center, Houston, TX) *In* Advances in hypersonics. Vol. 3 - Computing hypersonic flows Boston, MA Birkhaeuser 1992 p. 220-298. refs
Copyright

Viscous, heat-conducting flow with chemical and vibrational relaxation processes of the constituent gases surrounding winged spacecraft is considered in the continuum regime. The Navier-Stokes equations are appended by additional vibrational energy and species rate equations and supplemented by the equations of state and the phenomenological laws based on mixture rules or collisional cross sections. Numerical convective flux can be obtained from several forms of one-dimensional Riemann solver, with or without entropy correction. High-order accuracy is obtained from two types of reconstructive interpolation. A number of explicit and implicit numerical schemes have been implemented as a means to yield converged solutions. Both shock-fitting, finite-difference and shock-capturing, finite-volume techniques have been tested for configurations such as a sphere, double ellipsoid, blunt-edge delta wing, a European Hermes vehicle, and the U.S. Shuttle Orbiter. The shock-fitting code provides excellent results only for simple configurations, whereas the shock-capturing code leads to overall satisfying solutions for complex geometries.
Author (revised)

A94-10773
THE FINITE POINTSET METHOD FOR HYPERSONIC FLOWS IN THE RAREFIED GAS REGIME
H. NEUNZERT and J. STRUCKMEIER (Kaiserslautern Univ., Germany) *In* Advances in hypersonics. Vol. 3 - Computing hypersonic flows Boston, MA Birkhaeuser 1992 p. 342-370. Research sponsored by Dassault Aviation refs
Copyright

A finite pointset method that belongs to the class of particle methods, which contain a large variety of schemes differing in handling the collision term on the right-hand side of the Boltzmann equation, is discussed. The simplest case of a monoatomic gas without chemistry is considered. It is shown that particle methods provide numerical approximations of the real solutions as finite differences or finite elements do. AIAA

A94-10774* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATION OF FLOWFIELDS FOR HYPERSONIC FLIGHT AT HIGH ALTITUDES
JAMES N. MOSS (NASA, Langley Research Center, Hampton, VA) *In* Advances in hypersonics. Vol. 3 - Computing hypersonic flows Boston, MA Birkhaeuser 1992 p. 371-427. refs
Copyright

Recent direct simulation Monte Carlo methods are reviewed focusing on the nonequilibrium aspects of rarefied hypersonic flows typical of reentry conditions. The calculations identify the altitudes for which the onset of dissociation occurs, the magnitude of the surface temperature variations, the effect of the shock wave structure on the chemistry of a dissociating gas, and the radiation emisssion for reentry flowfields. AIAA

A94-10776
ADVANCES IN HYPERSONICS. VOL. 1 - DEFINING THE HYPERSONIC ENVIRONMENT
JOHN J. BERTIN, ED. (Sandia National Labs., Albuquerque, NM), JACQUES PERIAUX, ED. (Dassault Aviation, Saint-Cloud, France), and JOSEF BALLMANN, ED. (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) Boston, MA Birkhaeuser 1992 448 p. For individual items see A94-10777 to A94-10784
(ISBN 0-8176-3639-0) Copyright

The present volume on advances in hypersonics discusses aerothermodynamic phenomena and the design of atmospheric hypersonic airplanes, concepts of hypersonic aircraft, and hypersonic wind tunnel testing. Attention is given to wind-tunnel based definition of the Aeroassist Flight Experiment aerothermodynamic environment, high-enthalpy testing and hypersonic shock tunnels, and low-density facilities. Topics addressed include hypersonic boundary-layer transition and some viscous interactions affecting the design of hypersonic intakes and nozzles. AIAA

A94-10783
HYPERSONIC BOUNDARY-LAYER TRANSITION
KENNETH F. STETSON (USAF, Wright Lab., Wright-Patterson AFB, OH) *In* Advances in hypersonics. Vol. 1 - Defining the hypersonic environment Boston, MA Birkhaeuser 1992 p. 324-417. refs

A survey of research on hypersonic boundary-layer transition is presented. Hypersonics boundary-layer instability phenomena are discussed, with emphasis on stability theory and stability experiments. Attention is given to parametric trends, with the focus on the effects of Mach number, nosetip bluntness, crossflow, unit Reynolds number, the environment, wall temperature, surface roughness, pressure gradient, mass transfer, high temperature/nonequilibrium, and vibration. Mechanisms described and not described by a linear theory are discussed. Also examined are configuration differences, some problems of wind tunnel transition data, length of the transition region, and some problems with flow-field calculations. Prediction methods are also examined. AIAA

A94-10784

SOME VISCOUS INTERACTIONS AFFECTING THE DESIGN OF HYPERSONIC INTAKES AND NOZZLES

J. L. STOLLERY (Cranfield Inst. of Technology, United Kingdom) *In* Advances in hypersonics. Vol. 1 - Defining the hypersonic environment Boston, MA Birkhaeuser 1992 p. 418-437. refs

Copyright

The paper discusses four topics relevant to hypersonic vehicle engine flows: (1) hypersonic viscous interaction which can modify the effective shape of both intake and exhaust nozzle; (2) shock/shock interaction leading to very high heat transfer rates on the leading edges of cowls and struts; (3) 3D glancing interaction causing complex separated flows along side-walls; (4) 2D shock/boundary-layer interactions, caused by oblique shocks and/or compression corners, leading to possible separation in the intake and combustion chamber. Wherever possible laminar, transitional, and turbulent flows are considered though little information is available for the transitional case. Reference is made to both experimental data and the growing volume of results from mathematical modeling. The main objective of the paper is to describe some of the difficult aerodynamic problems that the aircraft designer must overcome in the engine. Although much of the discussion concentrates on the intake some of the comments are concerned with the nozzle and combustion chamber flows. Author (revised)

A94-10804 National Aeronautics and Space Administration, Washington, DC.

IDENTIFICATION OF AERODYNAMIC COEFFICIENTS USING COMPUTATIONAL NEURAL NETWORKS

DENNIS J. LINSE and ROBERT F. STENGEL (Princeton Univ., NJ) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 6 Nov.-Dec. 1993 p. 1018-1025. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0172. Previously cited in issue 08, p. 1168, Accession no. A92-23783 Research supported by FAA refs

(Contract NGL-31-001-252; DAAL03-89-K-0092)

Copyright

A94-10855* National Aeronautics and Space Administration, Washington, DC.

FULL NAVIER-STOKES ANALYSIS OF AN AXISYMMETRIC SCRAMJET INLET

YEU-CHUAN HSIA (Rockwell International Corp., Canoga Park, CA) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 6 Nov.-Dec. 1993 p. 827-833. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992, AIAA Paper 92-3100. Previously cited in issue 20, p. 3472, Accession no. A92-48742 Research supported by National Aero-Space Plane Joint Program Office refs

(Contract F33657-91-C-2012)

Copyright

A94-10856* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

COMPUTATIONAL ANALYSIS OF VENTED SUPERSONIC EXHAUST NOZZLES USING A MULTIBLOCK/MULTIZONE STRATEGY

JOHN R. CARLSON, S. P. PAO (NASA, Langley Research Center, Hampton, VA), and KHALED S. ABDOL-HAMID (Analytical Services and Materials, Inc., Hampton, VA) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 6 Nov.-Dec. 1993 p. 834-839. AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991, AIAA Paper 91-0125. Previously cited in issue 06, p. 846, Accession no. A91-19149 refs

Copyright

A94-10858* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AIRFOIL WAKE AND LINEAR THEORY GUST RESPONSE INCLUDING SUB- AND SUPERRESONANT FLOW CONDITIONS

GREGORY H. HENDERSON and SANFORD FLEETER (Purdue Univ., West Lafayette, IN) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 6 Nov.-Dec. 1993 p. 847-857. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992, AIAA Paper 92-3074. Previously cited in issue 20, p. 3471, Accession no. A92-48724 Research sponsored by NASA refs

Copyright

A94-10887

AERODYNAMICS OF HORIZONTAL-AXIS WIND TURBINES

A. C. HANSEN (Utah Univ., Salt Lake City) and C. P. BUTTERFIELD (National Renewable Energy Lab., Golden, CO) *In* Annual review of fluid mechanics. Vol. 25 Palo Alto, CA Annual Reviews, Inc. 1993 p. 115-149. Research supported by DOE refs

Copyright

Recent research and development pertaining to the aerodynamics of the horizontal-axis wind turbine rotor is reviewed. Attention is given to airfoil characteristics, rotor performance analysis, dynamic loads analysis, unsteady aerodynamics, and the effects of turbulence on rotor loads. It is noted that new airfoils have been designed specifically for use on stall-controlled wind turbines. Dynamic loads can be predicted accurately for normal operation of turbines whose structural dynamics and airfoil characteristics are well understood. Understanding the importance of rotational sampling of atmospheric turbulence by a rotor blade has clarified the role of turbulence in fatigue design. AIAA

A94-10888

UP-TO-DATE GASDYNAMIC MODELS OF HYPERSONIC AERODYNAMICS AND HEAT TRANSFER WITH REAL GAS PROPERTIES

G. A. TIRSKIJ (Moscow State Univ., Russia) *In* Annual review of fluid mechanics. Vol. 25 Palo Alto, CA Annual Reviews, Inc. 1993 p. 151-181. refs

Copyright

This review considers the influence of multicomponent diffusion, thermodynamic and chemical nonequilibrium processes, heterogeneous reactions, and the generation of vibrationally and electronically excited particles by recombination on resistance and heat transfer in hypersonic flow past bodies at low and moderate Reynolds numbers. The main feature of recent real gas hypersonic flow studies is that they take into account the various atomic-molecular and ionic processes simultaneously, considering viscosity, heat conduction, and diffusion in the framework of PNS (parabolized Navier-Stokes), VSL (viscous shock layer), or the complete Navier-Stokes equations. AIAA

A94-10889

COMPUTATIONAL METHODS FOR THE AERODYNAMIC DESIGN OF AIRCRAFT COMPONENTS

TH. E. LABRUJERE and J. W. SLOOFF (National Aerospace Lab., Amsterdam, Netherlands) *In* Annual review of fluid mechanics. Vol. 25 Palo Alto, CA Annual Reviews, Inc. 1993 p. 183-214. Previously announced in STAR as N93-31148 refs

Copyright

The state of the art in the field of computational aerodynamic design methods is summarized. The review is limited to methods aiming directly at the determination of geometries such that certain specified aerodynamic properties will be obtained, with or without constraints in the geometry. Moreover, only methods considered as being representative for different types of approach and methods illustrating the latest developments are presented. Methods for airfoil and wing design are emphasized. The problem of target pressure distribution specification is discussed.

A94-10892* National Aeronautics and Space Administration, Washington, DC.

PERSPECTIVES ON HYPERSONIC VISCOUS FLOW RESEARCH

H. K. CHENG (Southern California Univ., Los Angeles, CA) *In* Annual review of fluid mechanics. Vol. 25 Palo Alto, CA Annual Reviews, Inc. 1993 p. 455-484. Research supported by DOD refs

(Contract NAGW-1061)

Copyright

Issues and advances in current hypersonic flow research perceived to be of interest in theoretical fluid/gas dynamics are reviewed. Particular attention is given to the hypersonic aircraft as waverider, computational methods and theoretical development in the study of viscous interaction, and boundary-layer instability and transition studies. In the present framework the study of viscous hypersonic flow faces transition problems of two kinds which represent the two major areas of current research: the turbulence transition in the high Re range and the transition to the free-molecule limit. AIAA

A94-10927

CALCULATION OF THREE-DIMENSIONAL FLOW OF A VISCOUS GAS IN A STRAIGHT CASCADE [RASCHET TREKHMERNOGO TECHENIYA VYAZKOGO GAZA V PRYAMOJ RESHETKE PROFILEJ]

M. YA. IVANOV and V. G. KRUPA Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 4 July-Aug. 1993 p. 58-68. In RUSSIAN refs

Copyright

The problem of three-dimensional viscous cascade flow is solved by the numerical integration of Navier-Stokes equations using an implicit second-order Godunov scheme. The turbulence effects are modeled by using a two-parameter differential turbulence model, which is highly compatible with the numerical integration procedure used for the Navier-Stokes equations. The computed results are found to be in good agreement with experimental data. AIAA

A94-10932

AERODYNAMIC CHARACTERISTICS OF V-SHAPED WINGS WITH A DETACHED SHOCK WAVE AT THE LEADING EDGE AT HYPERSONIC FLIGHT VELOCITIES [AEHRODINAMICHESKIE KHARAKTERISTIKI V-OBRAZNYKH KRYL'EV S OTOSHEDSHEJ UDARNOJ VOLNOJ NA PEREDNIKH KROMKAKH PRI GIPERZVUKOVYKH SKOROSTYAKH POLETA]

N. A. OSTAPENKO Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 4 July-Aug. 1993 p. 145-154. In RUSSIAN refs

Copyright

A solution is presented for the direct problem of hypersonic flow past a V-shaped wing with a detached shock wave at the leading edge. Calculations for the reduced normal force coefficient and lift-drag ratio are presented for a configuration with a V-shaped lower surface and flow-aligned upper surface. It is shown that, in accordance with the theory of a thin shock layer, the V-shaped wing is particularly efficient, in comparison with a flat delta wing, in flow regimes with a shock wave attached to the leading edge. AIAA

A94-10934

SUPERSONIC FLOW AT ANGLE OF ATTACK PAST A STAR-SHAPED BODY WITH NO PLANES OF SYMMETRY [SVERKHZVUKOVOE OBTEKANIE POD UGLOM ATAKI ZVEZDOOBRAZNOGO TELA, NE IMEYUSHCHEGO PLOSKOSTEJ SIMMETRII]

M. I. FOLLEH Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 4 July-Aug. 1993 p. 164-173. In RUSSIAN refs

Copyright

The problem of supersonic flow at angle of attack past star-shaped bodies is investigated here in the general case of a star-shaped body without planes of symmetry. The results of the study indicate that the retention of the resultant forces in the angle of attack plane is a fundamental property of star-shaped bodies which is not related to the presence of planes of symmetry. The conditions for the reversal of the torque are determined; the torque of star-shaped bodies is shown to be independent of the angle of attack. AIAA

A94-10935

NONSTATIONARY INTERACTION OF A SPHERE WITH ATMOSPHERIC TEMPERATURE INHOMOGENEITIES IN SUPERSONIC FLOW PAST A BODY [NESTATSIONARNOE VZAIMODEJSTVIE SFERY S ATMOSFERNYMI TEMPERATURNYMI NEODNORODNOSTYAMI PRI SVERKHZVUKOVOM OBTEKANII]

P. YU. GEORGIEVSKIJ and V. A. LEVIN Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 4 July-Aug. 1993 p. 174-183. In RUSSIAN refs

Copyright

The structure of shock layer flow and the resulting pulsed aerodynamic loads during the nonstationary interaction of a sphere with atmospheric temperature inhomogeneities of various forms and intensities are investigated analytically in the case where Euler equations are applicable. It is shown that such an interaction is accompanied by new qualitative effects that have not been noted to date by any other authors. AIAA

A94-10936

THE NEED FOR AN END FACE IN THE OPTIMAL REAR SECTION OF A TWO-DIMENSIONAL BODY IN THE PRESENCE OF A BOUNDARY LAYER [O NEOBKHODIMOSTI DONNOGO TORTSA DLYA OPTIMAL'NOJ KORMOVOJ CHASTI DVUMERNOGO TELA PRI NALICHII POGRANICHNOGO SLOYA]

R. K. TAGIROV Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 4 July-Aug. 1993 p. 199-203. In RUSSIAN refs

Copyright

The effect of the boundary layer on flow past a body is examined with particular reference to supersonic flow past the rear section of a plane body. In the analysis, no constraints are imposed on the aspect ratio of the body. Results are presented for a rear section with and without an end face. It is shown that, in the presence of a boundary layer, an optimal rear section must always have an end face. Thus, for example, it is not necessary to have a sharp trailing edge between a nozzle and the rear section of the exhaust. It is noted that this conclusion is also valid in the case of subsonic flow. AIAA

A94-10942

OPTIMAL BODY SHAPES WITH LIMITS ON LOCAL HEAT FLUX [OPTIMAL'NYE FORMY TEL PRI OGRANICHENII NA LOKAL'NYJ TEPLOVOJ POTOK]

M. A. ARGUCHINTSEVA and N. N. PILYUGIN Kosmicheskie Issledovaniya (ISSN 0023-4206) vol. 31, no. 3 May-June 1993 p. 57-63. In RUSSIAN refs

Copyright

The paper is concerned with the problem of determining optimal shapes of plane and axisymmetric bodies which would limit local heat overloads in addition to reducing the total (convective and radiative) heating of a body during the entry into a planet atmosphere. Examples of calculations of optimal body shapes and heat flow distributions over the body surface are presented. The aerodynamic and thermal characteristics of such bodies are compared with those of other bodies. AIAA

A94-10953

EVOLUTION OF A TURBULENT BOUNDARY LAYER UNDER THE EFFECT OF A SHOCK WAVE FOLLOWED BY RAREFACTION WAVES [RAZVITIE TURBULENTNOGO POGRANICHNOGO SLOYA PRI POSLEDOVATEL'NOM VOZDEJSTVII SKACHKA UPLOTNENIYA I VOLN RAZREZHENIYA]

M. A. GOL'DFEL'D Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 3 May-June 1993 p. 61-68. In RUSSIAN refs
Copyright
Results of a wind tunnel of the effect of shock and rarefaction waves on the evolution of a turbulent boundary layer are reported. The experiments were conducted at Mach 3 and 4 and Reynolds numbers of 3.5 x 10 exp 7 and 5.6 x 10 exp 7/m, respectively, using an axisymmetric model. It is found that prior exposure to a shock wave significantly weakens the effect of the Reynolds number on the boundary layer characteristics behind the rarefaction waves, prevents relaminarization, and reduces the length of the boundary layer relaxation region. AIAA

A94-10954
A NUMERICAL STUDY OF THE MIXED THREE-DIMENSIONAL BOUNDARY LAYERS OF FLOW PAST AN ELLIPSOID AT ANGLES OF ATTACK [CHISLENNOE ISSLEDOVANIE TECHENIJ V SMESHANNYKH PROSTRANSTVENNYKH POGRANICHNYKH SLOYAKH EHLLIPSOIDA OBTEKAEMOGO S UGLAMI ATAKI]
YU. N. KARPEEV Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 3 May-June 1993 p. 69-77. In RUSSIAN refs
Copyright
Two cases of mixed flow in three-dimensional boundary layers on an ellipsoid of revolution are investigated numerically, for angles of attack of 10 and 5 deg, using a finite difference method. The closure equation for flows in the transition and turbulent regions is obtained by using the principle of superposition of viscous and turbulent stresses and the 'mixing path' model, extended to three dimensions. It is found that turbulent mixing significantly weakens three-dimensional effects, leading to the shifting of three-dimensional separation zones further downstream and to the reduction of their size. AIAA

A94-10956
A NUMERICAL STUDY OF STEADY-STATE SUPERSONIC SEPARATED FLOW PAST THREE-DIMENSIONAL LIFTING SYSTEMS [CHISLENNOE ISSLEDOVANIE STATSIONARNOGO OTRYVNOGO OBTEKANIYA PROSTRANSTVENNYKH NESUSHCHIKH SISTEM SVERKHZVUKOVYM POTOKOM]
S. S. GRAS'KIN Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 3 May-June 1993 p. 142-148. In RUSSIAN refs
Copyright
A numerical method is proposed for studying supersonic flow past complex three-dimensional configurations. The method is an extension of well-known approaches that are commonly used for solving similar problems in subsonic aerodynamics. To illustrate the method, calculations of the aerodynamic characteristics of wings and three-dimensional lifting systems are performed. AIAA

A94-10957
SUPERSONIC FLOW OF A VISCOUS GAS PAST THE FRONT SURFACE OF PLANE BLUNT BODIES [SVERKHZVUKOVOE OBTEKANIE LOBOVOJ POVERKHNOSTI PLOSKIKH ZATUPLENNYKH TEL VYAZKIM GAZOM]
YU. P. GOLOVACHEV and N. V. LEONT'EVA Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 3 May-June 1993 p. 169-172. In RUSSIAN refs
Copyright
The problem of supersonic flow past the windward part of plane wings of infinite span at angles of attack is solved using full Navier-Stokes equations and boundary conditions including slip and a temperature discontinuity. The use of this model makes it possible to significantly expand the range of flow conditions of interest to lower Mach and Reynolds numbers. The solutions obtained are compared with results based on models of a thin and completely viscous shock layer. AIAA

A94-11040
OPTIMAL AERODYNAMIC SHAPES IN RAREFIED GAS [OB OPTIMAL'NYKH AEHRODINAMICHESKIKH FORMAKH V RAZREZHENNOM GAZE]
R. N. MIROSHIN Sankt-Peterburgskij Universitet, Vestnik, Seriya 1 - Matematika, Mekhanika, Astronomiya (ISSN 0024-0850) no. 1 Jan. 1993 p. 77-82. In RUSSIAN refs
Copyright
An isoperimetric problem concerned with the optimization of a convex body shape in rarefied gas is formulated. A two-stage procedure for solving the problem is presented. The solution is based on the theory of local interaction and employs the Chebyshev-Markov theorem. AIAA

A94-11922
FINITE ELEMENT ANALYSIS OF LIFT BUILD-UP DUE TO AEROFOIL INDICIAL MOTION
JUN SHI and DENNIS HITCHINGS (Imperial College of Science, Technology, and Medicine, London, United Kingdom) International Journal for Numerical Methods in Fluids (ISSN 0271-2091) vol. 17, no. 5 Sept. 15, 1993 p. 401-416. refs
Copyright
Results of an investigation of the problem of impulsively started aerofoil or sudden change of incidence of an aerofoil in incompressible potential flow are presented. The problem is addressed by representing a timely and spatially varying wake in a largely irrotational potential flow field. This is achieved by representing the wake through the velocity potential difference, which is argued to be the only way of imposing a velocity difference condition in the finite element context with velocity potentials as the basic unknowns. Superposition is employed to meet various boundary conditions, which is justified by the linearity of the problem. The finite element solutions are compared with those from the singularity method. AIAA

A94-11972
ANALYSIS OF THE EFFECT OF HEAT STRIPS ON BOUNDARY LAYER DEVELOPMENT OVER A FLAT PLATE
SCOTT J. SCHMID and BRUCE P. SELBERG (Missouri-Rolla Univ., Rolla) Oct. 1992 14 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921923) Copyright
Two dimensional fourth order boundary layer calculations were made for flows over a flat plate with and without flush mounted surface heating. Constant wall temperature, increasing wall temperature and decreasing wall temperature heating cases were studied for different surface heating lengths. The boundary layer properties; temperature, tangential velocity, normal velocity, vorticity and transition location were studied for these temperature distributions. The boundary layer results indicate that with the proper selection of surface temperature variation and length the transition location can be either increased or decreased. Modified boundary layer properties, due to heating are shown to persist well after heating is stopped, even when the flow is turbulent. The results indicate that this technique may be useful in modifying transition and separation locations over airfoils.

A94-11973
CFD ANALYSIS OF EJECTION SEAT ESCAPE SYSTEMS
S. D. HABCHI, A. J. PRZEKWAS (CFD Research Corp., Huntsville, AL), T. MARQUETTE, and P. AYOUB (U.S. Navy, Naval Air Warfare Center, Warminster, PA) Oct. 1992 16 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921924) Copyright
Computational Fluid Dynamics techniques are used to study the full aerodynamic behavior of a typical ejection seat and occupant. A three-dimensional advanced Navier-Stokes code with a turbulence model has been adapted to study the flow field details in the immediate surroundings of high speed ejection seats. The CFD code has been validated and demonstrated against available wind tunnel test data. Comparison of force and moment coefficients has shown good agreement between experimental and predicted

results. Consequently, the model has been used to study the aerodynamic characteristics of various Navy ejection seat design concepts at different seat yaw orientation.

A94-11975* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

COMPARATIVE STUDY OF MACCORMACK AND TVD MACCORMACK SCHEMES FOR THREE-DIMENSIONAL SEPARATION AT WING/BODY JUNCTIONS IN SUPERSONIC FLOWS

BALAKRISHNAN LAKSHMANAN and SURENDRA N. TIWARI (Old Dominion Univ., Norfolk, VA) Oct. 1992 11 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(Contract NAG1-530)
(SAE PAPER 921926) Copyright

A robust, discontinuity-resolving TVD MacCormack scheme containing no dependent parameters requiring adjustment is presently used to investigate the 3D separation of wing/body junction flows at supersonic speeds. Many production codes employing MacCormack schemes can be adapted to use this method. A numerical simulation of laminar supersonic junction flow is found to yield improved separation location predictions, as well as the axial velocity profiles in the separated flow region. AIAA

A94-11976* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

NUMERICAL ANALYSIS OF TURBINE BLADE TIP TREATMENTS

NATH S. GOPALASWAMY and KEVIN W. WHITAKER (Alabama Univ., Tuscaloosa) Oct. 1992 11 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Research supported by NASA refs
(SAE PAPER 921928) Copyright

Three-dimensional solutions of the Navier-Stokes equations for a turbine blade with a turning angle of 180 degrees have been computed, including blade tip treatments involving cavities. The geometry approximates a preliminary design for the GGOT (Generic Gas Oxidizer Turbine). The data presented here will be compared with experimental data to be obtained from a linear cascade using original GGOT blades. Results have been computed for a blade with 1 percent clearance, based on chord, and three different cavity sizes. All tests were conducted at a Reynolds number of 4 x 10 exp 7. The grid contains 39,440 points with 10 spanwise planes in the tip clearance region of 5.008E-04 m. Streamline plots and velocity vectors together with velocity divergence plots reveal the general flow behavior in the clearance region. Blade tip temperature calculations suggest placement of a cavity close to the upstream side of the blade tip for reduction of overall blade tip temperature. The solutions do not account for the relative motion between the endwall and the turbine blade. The solutions obtained are generally consistent with previous work done in this area, Author (revised)

A94-12003* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

STREAMLINE-CURVATURE EFFECT IN THREE-DIMENSIONAL BOUNDARY LAYERS

HELEN L. REED, RAY-SING LIN, and MEDIA M. PETRAGLIA (Arizona State Univ., Tempe) Oct. 1992 9 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Research supported by NASA and NSF refs
(SAE PAPER 921987) Copyright

The effect of including wall and streamline curvature terms in swept-wing boundary-layer stability calculations is studied. The linear disturbance equations are cast on a fixed, body-intrinsic, curvilinear coordinate system. Those nonparallel terms which contribute mainly to the streamline-curvature effect are retained in this formulation and approximated by their local finite-difference values. Convex-wall curvature has a stabilizing effect, while streamline curvature is destabilizing if the curvature exceeds a critical value. Author (revised)

A94-12004

INFLUENCE OF TWO-DIMENSIONAL IMPERFECTIONS ON LAMINAR FLOW

A. H. NAYFEH (Virginia Polytechnic Inst. and State Univ., Blacksburg) Oct. 1992 37 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921990) Copyright

The physics of the instability of flows around surface imperfections such as humps, dips, and forward- and backward-facing steps is investigated. The mean flow is calculated using interacting boundary layers, thereby accounting for strong viscous/inviscid interaction and separation bubbles. Then, the two- and three-dimensional linear and subharmonic instabilities of this flow are analyzed and the amplification factors (i.e., N-factors) are computed. The results of this approach have been validated by using Navier-Stokes solutions and the experimental results or Walker and Greening for bulges and Dovgal and Kozlov for steps. The effects of suction, heal transfer, and compressibility (Mach numbers up to 0.8) on the stability of these flows are investigated. The results show that although compressibility significantly reduces the amplification factor in the case of a smooth surface, this stabilizing effect decreases as the hump height increases. In the absence of separation, it is found that increasing the imperfection height results in an increase in the amplification factors of both the primary and subharmonic waves. In the case of separation, the amplification factors are considerably increased.

A94-12005* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THREE-DIMENSIONAL BOUNDARY LAYER STABILITY AND TRANSITION

M. R. MALIK and F. LI (High Technology Corp., Hampton, VA) Oct. 1992 21 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Research supported by NASA refs
(Contract F49620-91-C-0014)
(SAE PAPER 921991) Copyright

Nonparallel and nonlinear stability of a three-dimensional boundary layer, subject to crossflow instability, is investigated using parabolized stability equations (PSEs). Both traveling and stationary disturbances are considered and nonparallel effect on crossflow instability is found to be destabilizing. Our linear PSE results for stationary disturbances agree well with the results from direct solution of Navier-Stokes equations obtained by Spalart (1989). Nonlinear calculations have been carried out for stationary vortices and the computed wall vorticity pattern results in streamwise streaks which resemble remarkably well with the surface oil-flow visualizations in swept-wing experiments. Other features of the stationary vortex development (half-mushroom structure, inflected velocity profiles, vortex doubling, etc.) are also captured in our nonlinear calculations. Nonlinear interaction of the stationary amplitude of the stationary vortex is large as compared to the traveling mode, and the stationary vortex dominates most of the downstream development. When the two modes have the same initial amplitude, the traveling mode dominates the downstream development owing to its higher growth rate, and there is a tendency for the stationary mode to be suppressed. The effect of nonlinear wave development on the skin-friction coefficient is also computed.

A94-12006 National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

OVERVIEW OF SUPERSONIC LAMINAR FLOW CONTROL RESEARCH ON THE F-16XL SHIPS 1 AND 2

BIANCA T. ANDERSON and MARTA BOHN-MEYER (NASA, Flight Research Center, Edwards, CA) Oct. 1992 14 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Previously announced in STAR as N93-11221 refs
(Contract RTOP 533-02-39)
(SAE PAPER 921994) Copyright

NASA is directing research to develop technology for a high-speed civil transport. Supersonic laminar flow control has been identified as a program element, since it offers significant drag-reduction benefits and is one of the more promising technologies for producing an economically viable aircraft design. NASA is using two prototype F-16XL aircraft to research supersonic laminar flow control. The F-16XL planform is similar to design planforms of high-speed civil transports. The planform makes the aircraft ideally suited for developing technology pertinent to high-speed transports. The supersonic laminar flow control research programs for both aircraft are described. Some general results of the ship-1 program demonstrate that significant laminar flow was obtained using laminar flow control on a highly swept wing at supersonic speeds.

A94-12008 National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

A SUMMARY OF THE FOREBODY HIGH-ANGLE-OF-ATTACK AERODYNAMICS RESEARCH ON THE F-18 AND THE X-29A AIRCRAFT

LISA J. BJARKE, JOHN H. DEL FRATE, and DAVID F. FISHER (NASA, Flight Research Center, Edwards, CA) Oct. 1992 19 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Previously announced in STAR as N93-12353 refs
(Contract RTOP 505-68-71; RTOP 533-02-38)
(SAE PAPER 921996) Copyright

High-angle-of-attack aerodynamic studies have been conducted on both the F18 High Alpha Research Vehicle (HARV) and the X-29A aircraft. Data obtained include on- and off-surface flow visualization and static pressure measurements on the forebody. Comparisons of similar results are made between the two aircraft where possible. The forebody shapes of the two aircraft are different and the X-29A forebody flow is affected by the addition of nose strakes and a flight test noseboom. The forebody flow field of the F-18 HARV is fairly symmetric at zero sideslip and has distinct, well-defined vortices. The X-29A forebody vortices are more diffuse and are sometimes asymmetric at zero sideslip. These asymmetries correlate with observed zero-sideslip aircraft yawing moments.

A94-12014

STALL WARNING USING CONTAMINATION DETECTING AERODYNAMICS

PAUL A. CATLIN (Jet Electronics & Technology, Inc., Grand Rapids, MI) Oct. 1992 9 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922010) Copyright

Aerodynamically monitoring the performance of an aircraft's lifting surface provides the missing component in stall warning. The missing component is the ability to measure the premature loss of lift due to contamination such as insect deposits, snow, slush, or ice on the lifting surface. Conventional stall warning systems, which use a fuselage mounted angle of attack sensor, do not measure the actual stalling condition at the wing. The key to determining an early stall due to the presence of contamination is to measure the flow directly at the lifting surface. Local velocity changes in a region above the upper surface of the wing provide a consistent indication of an approaching aerodynamic stall even when contamination is present. This method of stall warning also offers new levels of safety during low level windshear recovery and takeoff performance monitoring.

A94-12050

COMPUTATION OF THE LOADS ON THE AH-1/OLS MODEL ROTOR IN FORWARD FLIGHT AND COMPARISON WITH WIND TUNNEL TESTS

M. SCHAFFAR and J. HAERTIG (Saint-Louis, French-German Research Inst., France) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

An aerodynamic code for computing the loads on helicopter rotor blades based on the vortex lattice method is described along with a local conformal mapping method to thicken the helicopter blade. The application of the method to a flight test of the AH-1/OLS model rotor in advancing flight is presented. The results are compared with measurements, and areas of agreement and discrepancy are noted. AIAA

A94-12051

A GENERAL BOUNDARY ELEMENT METHOD FOR AERODYNAMICS AND AEROACOUSTICS OF ROTORS

L. MORINO, M. GENNARETTI, U. IEMMA, and F. MASTRODDI (Roma I, Univ., Rome, Italy) Sep. 1992 14 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by Centro Italiano Ricerche Aerospaziale refs

A boundary element method for the unified analysis of aerodynamics and aeroacoustics of potential, steady, and unsteady, subsonic and transonic flows around rotors is presented. In the subsonic formulation, the integrals are limited to the rotor and wake surfaces, whereas in the transonic formulation, the nonlinear terms yield the presence of an integral over the fluid volume. The method has been applied to the following problems: (1) subsonic aerodynamics of isolated helicopter rotors in hover and forward flight, (2) steady 2D transonic (TSP and full-potential, non-conservative and conservative) aerodynamics, (3) unsteady 2D transonic (TSP, non-conservative) aerodynamics, (4) steady 3D transonic (TSP, non-conservative) aerodynamics of helicopter rotors in hover, and (5) aeroacoustics of isolated propellers. The comparison with existing results is highly satisfactory.

A94-12056

UNSTEADY CALCULATION FOR FLOWFIELD OF HELICOPTER ROTOR WITH VARIOUS TIP SHAPE

TAKASHI AOYAMA (Tokyo Univ., Japan), KEIJI KAWACHI (Research Center for Advanced Science and Technology, Tokyo, Japan), and SHIGERU SAITO (National Aerospace Lab., Chofu, Japan) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The 3D Euler equations are solved to analyze the flowfield of the helicopter with various tip shape in forward flight. An implicit finite difference method is used to solve the equations. The Newton iterative method is applied in order to obtain the unsteady solution in the forward flight condition of a helicopter rotor. The algebraic method is adopted to generate the grid, and all the boundary conditions are explicitly specified. The surface pressure distributions of a model helicopter rotor with rectangular tip shape predicted by the present method are in good agreement with the experimental data both in nonlifting and lifting forward flight conditions. In the case of swept-back tip shape, the agreement with the experimental data is reasonable. The location of the shock wave on the blade surface is improved in the nonlifting condition by using the fan-shaped grid. The effect of the tip shape on the generation and growth of the shock wave is investigated on the blade surface passing through the advancing side in a forward flight condition.

A94-12057

VALIDATION OF A BOUNDARY INTEGRAL FORMULATION FOR THE AERODYNAMIC ANALYSIS OF ROTORS IN FORWARD FLIGHT

P. RENZONI, A. VISINGARDI, and A. PAGANO (Centro Italiano Ricerche Aerospaziali, Capua, Italy) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by EEC refs

A boundary integral formulation for helicopter rotor aerodynamics is validated both in nonlifting and lifting forward flight conditions. In nonlifting conditions the formulation is compared to a finite difference code. The method gives accurate results in the linear flow regime. In lifting conditions, induced velocities on a plane approximately one chord above the tip-path-plane are compared to experiment and to an industrial lifting-line rotor code. There is good agreement with experimental data where fuselage effects are small. Similarities between the lifting-line rotor code and the incompressible version of the boundary integral formulation indicate that classical lifting-line rotor codes may not be 'fully' compressible.

A94-12058

EXPERIMENTAL AND COMPUTATIONAL ANALYSIS OF A HELICOPTER CIRCULATION CONTROLLED TAIL BOOM

ALAN NURICK and CORNELIS GROESBEEK (Univ. of the

Witwatersrand, Johannesburg, South Africa) Sep. 1992 16 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The flowfield and torque characteristics of a circulation controlled helicopter tail boom about the main rotor axis of a hovering rotor were investigated experimentally and computationally. Empirical relationships between the boom torque, rotor torque and thrust, and circulation air pressure are developed from the experimental results for the geometry considered. The limiting cases of tail boom torque due to the circulation control air in the absence of rotor downwash and the effects of the rotor torque in the absence of circulation control air on the boom torque are included. The flowfield on the tail boom, without rotor downwash, is analyzed using a 2D Navier-Stokes code. Turbulent eddy viscosity is modeled in regions close to the surface of the tail boom using van Driest's method and in other areas by means of a k-epsilon model. Good correlation was obtained between the experimental and computationally derived velocity profiles in the boundary layer, its point of separation, and the torque developed by the tail boom when the constants for the k-epsilon model were adjusted slightly. Author (revised)

A94-12059

DEVELOPMENT AND VALIDATION OF A VORTEX LATTICE METHOD TO CALCULATE THE FLOWFIELD OF A HELICOPTER ROTOR INCLUDING FREE WAKE DEVELOPMENT

L. ZERLE and S. WAGNER (Stuttgart Univ., Germany) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

Calculated helicopter rotor inflow velocities in forward flight are presented and compared to laser Doppler anemometer measurements. Basing on linear potential theory, the code works as a time-stepping simulation program, using the vortex lattice method. Wake prolongation at blade trailing edge is performed during each timestep, shedding blade doublet strength into the wake. Additional wake self-induction is calculated and added to wake motion. Unsteady wake roll up, even at the inboard lattice parts, are observed. With the exception of the vortex core model, there is no empirical input to obtain the results. Improved blade vortex interaction and rotor-fuselage interference predictions are the expected benefits of the free wake model. Comparisons demonstrate that the inflow velocity field is very well represented in tendency. Flow speed values in the outer radial rotor region also agree well with measurement. Neglecting the missing fuselage in the calculation results in differences at the inner rotor area. Author (revised)

A94-12060

UNSTEADY SEPARATED FLOWS ON ROTOR-AIRFOILS - ANALYSIS AND VISUALIZATION OF NUMERICAL DATA

W. GEISSLER and H. VOLLMERS (DLR, Goettingen, Germany) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

Unsteady viscous flows with separation may be dominant on retreating rotor blades of helicopters in forward flight. These flows are investigated by a time-accurate numerical solution of the 2D Navier-Stokes equations on deformable meshes. Lift and moment characteristics are compared with experimental data. Compressibility effects are found to be of considerable importance with respect to the development of the dynamic stall process. Large sets of field data (i.e. pressure, density, velocities, vorticity, etc.) are available to investigate the details of the flow. Suitable visualization techniques are necessary to sufficiently interpret these data.

A94-12062

UNSTEADY LIFT OF AN AIRFOIL WITH A TRAILING-EDGE FLAP BASED ON INDICIAL CONCEPTS

J. G. LEISHMAN (Maryland Univ., College Park) Sep. 1992 15 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs
(Contract DAAL03-92-G-0121)

A practical method is described for computing the unsteady lift on an airfoil due to arbitrary motion of a trailing-edge flap. The result for the incompressible case is obtained in state-space (differential equation) form by means of Duhamel superposition and employing an exponential approximation to Wagner's indicial lift function. For subsonic compressible flow, the indicial lift at small values of time due to impulsive trailing-edge flap deflection is obtained from linear theory in conjunction with the aerodynamic reciprocal theorems. These exact results are used to help obtain complete exponential approximations for the indicial response due to impulsive flap deflection. The final result for the unsteady lift due to an arbitrary flap deflection in subsonic flow is obtained in state-space form. Numerical results are shown illustrating the overall significance of both unsteady effects and compressibility effects on airfoils with unsteady trailing-edge flap motions in a simulated helicopter rotor environment. The effects of Mach number on the aerodynamic response were shown to be especially significant, and essentially manifest themselves as larger aerodynamic lags at higher Mach numbers.

A94-12063

SECTIONAL PREDICTION OF 3D EFFECTS FOR SEPARATED FLOW ON ROTATING BLADES

H. SNEL (Netherlands Energy Research Foundation, Petten), R. HOUWINK, and W. J. PIERS (National Aerospace Lab., Amsterdam, Netherlands) Sep. 1992 19 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

A method is presented which allows the computation of airload coefficients for rotor blade sections at attached and separated flow conditions, including leading effects of blade rotation. The method consists of an existing computer code for 2D unsteady flow with strong viscous-inviscid interaction, in which the turbulent boundary layer integral method has been modified by including leading terms for steady 3D effects on a high aspect ratio rotating blade. A summary is presented of the approach made, and a first set of results is compared with wind-tunnel data for a wind-turbine model. Computed 2D polars and corresponding pressure distributions for a non-rotating and rotating blade section appear to be qualitatively similar to experimental data, including the high values of the lift coefficient measured at 30 percent of the tip radius. For sufficient accuracy in practice, however, various aspects of the method need further analysis and improvement. Author (revised)

A94-12064

AN EXAMINATION OF THE AERODYNAMIC MOMENT ON ROTOR BLADE TIPS USING FLIGHT TEST DATA AND ANALYSIS

THOMAS H. MAIER and WILLIAM G. BOUSMAN (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) Sep. 1992 23 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The analysis CAMRAD/JA is used to model two aircraft, a Puma with a swept-tip blade, and a UH-60A Black Hawk. The accuracy of the analysis to predict the torsion loads is assessed by comparing the predicted loads with measurements from flight test. The influence of assumptions in the analytical model is examined by varying model parameters and comparing the predicted results to baseline values for the torsion loads. Flight test data from a research Puma are used to identify the source of torsion loads. This data indicates that the aerodynamic section moment in the region of the blade tip dominates torsion loading in high speed flight. Both the aerodynamic section moment at the blade tip and the pitch-link loads are characterized by large positive (nose-up) moments in the first quadrant with rapid reversal of load so that the moment is negative in the second quadrant. Both the character and magnitude of this loading are missed by the CAMRAD/JA analysis.

A94-12065

THE INFLUENCE OF VARIABLE FLOW VELOCITY ON UNSTEADY AIRFOIL BEHAVIOR

BEREND G. VAN DER WALL (DLR, Braunschweig, Germany) and

J. G. LEISHMAN (Maryland Univ., College Park) Sep. 1992 17 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The effects of an oscillating freestream on the unsteady aerodynamic lift of an airfoil are examined. Existing theories are investigated and their simplifications and limitations are identified. The theories are compared to show the differences between them for different conditions: first, for constant angle of attack, second, for in-phase pitch motion, and third, for 90-deg out-of-phase pitch with respect to velocity oscillations. The exact theory is extended to pitch about an arbitrary axis and plunge motion. The results are also compared to a finite difference scheme of the arbitrary motion theory. It was found that the arbitrary motion theory is best suited for calculating the unsteady aerodynamic lift even in an oscillating freestream. The results of the exact theory are validated using an Euler code for very low Mach numbers.

Author (revised)

A94-12066

AN EXAMINATION OF THE EFFECTS OF BLADE-VORTEX INTERACTION ON FLOWS NEAR THE BLADE TIP

M. B. HORNER and R. A. MCD. GALBRAITH (Glasgow Univ., United Kingdom) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by Ministry of Defence and Defence Research Agency of United Kingdom refs

The experimental results of a blade-vortex interaction study are examined for influences of the three-dimensional rotor up flows. Pressure data collected near the rotor up are found qualitatively and quantitatively similar to corresponding data from more inboard locations. Differences between data collected near the tip and at more inboard locations are noted, and serve to highlight three-dimensional qualities of flows generated near the rotor tip. Data collected near the rotor tip during oblique interactions reveals the combined effects of the oblique intersection angle and of the tip-generated flows noted during parallel interactions.

A94-12067

MEASUREMENT OF HELICOPTER ROTOR TIP VORTICES USING THE 'FLOW VISUALIZATION GUN' TECHNIQUE

REINERT H. G. MUELLER (Forschungsinstitut fuer Bildverarbeitung, Umvelttechnik und Stroemungsmechanik, Duesseldorf, Germany) Sep. 1992 8 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by DFG refs

The flow-visualization gun technique visualizes 'time-lines' in the flow fields of helicopter wind tunnel model rotors; this facilitates the observation of such complex flow patterns as the vortex structure over comparatively long time-periods. Turbulent flow regions can also be visualized in this way, and the images thus obtained furnish not only qualitative information on the flow, but also quantitative measurements of flow velocities. The Lagrangian character and long observation times of the gun technique furnish significant advantages over the conventionally employed LDA technique.

AIAA

A94-12069

FACTOR ANALYSIS OF COAXIAL ROTORS AERODYNAMICS IN HOVER

VADIM N. KVOKOV (Kamov Helicopter Scientific and Technology Co., Lyubertsy, Russia) Sep. 1992 9 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

Disk vortex theory has been used as the basis of an aerodynamic design method for hovering coaxial rotors in which the rotor structure is represented by uniformly distributed radial vortices with radius-variable circulation. The airflow passes through the disk, and the blade vortices are aligned with the streamlines; the streamlines form a spiral surface for a general case involving variable pitch. The airstream shape of the spiral surface is cambered to the rotor axes.

AIAA

A94-12070* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

COMPUTATION OF HIGH RESOLUTION UNSTEADY AIRLOADS USING A CONSTANT VORTICITY CONTOUR FREE WAKE MODEL

T. R. QUACKENBUSH, C.-M. G. LAM (Continuum Dynamics, Inc., Princeton, NJ), and D. B. BLISS (Duke Univ., Durham, NC) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

(Contract NAS1-19023)

Recent work in the study of helicopter aerodynamic loading for acoustics applications has involved research on the development of an exceptionally efficient simulation of the velocity field induced by the rotor's vortex wake. This paper summarizes the work to date on the development of this analysis, which builds on the refined constant vorticity contour (CVC) free wake model recently developed for application to the study of vibratory loading. The particular focus of this paper is on demonstrations of a reconstruction approach that efficiently computes both the flow fields and airloads induced by CVC wakes on lifting rotor blades. Results of recent calculations on both main rotor and tail rotors are presented. These calculations show that by employing flow field reconstruction it is possible to apply the CVC wake analysis with temporal and spatial resolution suitable for acoustics applications while reducing the computation time required by one to two orders of magnitude relative to the direct calculations used in traditional methods.

A94-12071

INFLUENCE OF NON-PLANAR BLADE TIPS ON ROTOR PERFORMANCE

B. M. J. BEESTEN (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

(Contract DFG-SFB-25)

To investigate the influence of such winglets on rotor performance, measurements of rotor force and power are presented. A fully articulated helicopter rotor model was studied in low-speed wind tunnel tests. Two-bladed and four-bladed rotors have been investigated at different values of forward velocity and rotor speed while blade loading has been varied from non-lifting to stalled conditions. The results show that winglets can reduce induced drag significantly. The best results have been found for twisted winglets. Compared to a reference configuration, a reduction of the required power up to more than 10 percent was obtained for a highly loaded hovering rotor. The improvement results mainly from the non-planarity, as the comparison with a planar blade of the same planform shows. Forward flight tests indicate that the winglets of the current shape are favorable up to medium forward flight speeds (advance ratio of 0.2), while disadvantages are to be expected at faster forward flight. Moreover, winglets were found to be more effective at four-bladed than at two-bladed rotors.

Author (revised)

A94-12072

DYNAMIC STALL STUDY OF A MULTI-ELEMENT AIRFOIL

CHEE TUNG, KENNETH W. MCALISTER (U.S. Army, Aeroflightdynamics Directorate; NASA, Ames Research Center, Moffett Field, CA), and CLIN M. WANG (Georgia Inst. of Technology, Atlanta) Sep. 1992 19 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

Unsteady flow behavior and load characteristics of a VR-7 airfoil with and without a slat were studied in the water tunnel of the Aeroflightdynamics Directorate, NASA Ames Research Center. Both airfoils were oscillated sinusoidally between 5 and 25 degrees at a Reynolds number of 200,000 to obtain the unsteady lift, drag and pitching moment data. A fluorescing dye was released from an orifice located at the leading edge of the airfoil for the purpose of visualizing the boundary layer and wake flow. The flow field and load predictions of an incompressible Navier-Stokes code based on a velocity-vorticity formulation were compared with the test data. The test and predictions both confirm that the slatted VR-7 airfoil delays both static and dynamic stall as compared to the VR-7 airfoil alone.

A94-12074
EXPERIMENTAL INVESTIGATIONS IN THE FIELD OF AN AIR JET NOZZLE CONTROLLED HELICOPTER AERODYNAMICS
V. A. ANIKIN Sep. 1992 7 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

A major Russian helicopter manufacturer has conducted trials of a NOTAR-like, tail-rotorless helicopter stabilization/control system that allows 3D thrust-vector control. Attention is given to the efficiency of system components, the influence of ground-proximity effects, and the geometry of the nozzle's gasdynamic path. The system was flown aboard a Ka-26 helicopter testbed. AIAA

A94-12110
CALCULATION OF THE STEADY ROTOR FLOW USING AN OVERLAPPING EMBEDDED GRID TECHNIQUE
R. STANGL and S. WAGNER (Stuttgart Univ., Germany) Sep. 1992 11 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

A novel grid technique is here applied to either implicit or explicit 3D Euler methods in order to treat very complex configurations, as well as arbitrary blade motions, in the flow field around a helicopter rotor in hover. This 'embedded grids' method uses common regions as the means of matching solutions between subdomains. One such subdomain can be partially or completely embedded within another; the computation is conducted separately in each grid, and the flow variables are interchanged as boundary conditions in defined zones. AIAA

A94-12117
AN INVESTIGATION OF DYNAMIC STALL THROUGH THE APPLICATION OF LEADING EDGE ROUGHNESS
R. B. GREEN and R. A. MCD. GALBRAITH (Glasgow Univ., United Kingdom) Sep. 1992 17 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by SERC, USAF, Defence Research Agency, and Westland Helicopters, Ltd refs

The dynamic stall characteristics of a series of aerofoil models performing ramp-up motions are considered. Pressure data show the development and convection of structures at the leading and trailing edges, which indicate differing degrees of what are described as leading edge and trailing edge stall mechanisms. When a transition strip is placed at the leading edge, the characteristics of leading edge stall predominate, and the growth of the structure at the trailing edge is suppressed. In addition the stall vortex convection speed is observed to alter significantly, which is interpreted as a change in the vortex origin, size, strength, and trajectory.

A94-12199
CAVITY DRAG AT TRANSONIC SPEEDS
L. C. SQUIRE and S. H. NASSER (Cambridge Univ., United Kingdom) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 967 Aug.-Sept. 1993 p. 247-256. refs
Copyright

This paper presents the results of an investigation of the flow around rectangular and chamfered cavities at high subsonic and low supersonic speeds. Pressures measured on the faces of the cavities are integrated to find the pressure drag of the cavities. The types of cavity tested range from simple sawcuts to cavities so long that the two ends can be regarded as independent and the results for these are compared with the sum of the drags of isolated forward and rear facing steps. Although the Reynolds numbers of the tests are similar to those in flight conditions the maximum depth of the cavities tested is only 6 mm so that the pressure resolution on the vertical faces of the cavities is limited. In spite of this it is estimated that the maximum error in the drag of any particular cavity is less than the skin friction drag on a smooth surface equal in area to half the plan area of the cavity.

A94-12200
PROPULSION STREAMTUBES IN SUPERSONIC FLOW AND SUPERCRITICAL INTAKE COWL
C. L. BORE (British Aerospace, PLC, Kingston, United Kingdom) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 967 Aug.-Sept. 1993 p. 257-259. refs
Copyright

The proper treatment of the pre-entry and post-exit streamtubes of supersonic aircraft and their 'corresponding' windtunnel models was considered in some depth for supersonic lighter designs and investigated in wave drag research, but as a result of the cancellations of the major supersonic fighter programs the results were not published. This note sets out the salient conclusions. The development of the first supercritical air intake cowl is also outlined. Author (revised)

A94-12343
MULTIPLE-ZONE POTENTIAL SOLUTIONS AROUND *WING-BODY CONFIGURATIONS*
M. M. ALISHAHI (Minnesota Univ., Minneapolis) and M. DARBANDI (Sharif Univ. of Technology, Teheran, Iran) Journal of Aerospace Engineering (ISSN 0893-1321) vol. 6, no. 4 Oct. 1993 p. 329-346. refs
Copyright

An existing computer code to solve a supersonic potential equation around 3D configurations was modified. Using a generalized boundary-conforming coordinate system, a full potential equation in conservation form was upwind differenced in supersonic direction. Grids were generated in each 2D cross-flow plane using the algebraic method. A new topology for grid generation produced appropriate grids around thin wings and wing bodies. Usage of orthogonal grid generation in cross-flow plane improved results and extended the various cases that can be handled by the code. A zonal flow field solution was obtained using a new method for the implementation of boundary conditions at wing locations on the boundaries of each zone. Approximate factorizations were used to solve the resulting equations implicitly. Using these capabilities, thin-wing and wing-body results are presented that compare well with other results. The capability of running this code on microcomputers makes this program a potentially valuable design tool in primary and middesign stages. Author (revised)

A94-12420
EXPERIMENTAL ANALYSIS OF GOERTLER VORTICES IN HYPERSONIC WEDGE FLOW
L. DE LUCA and G. GARDONE (Napoli, Univ., Naples, Italy) *In* Thermosense XIV; Proceedings of the International Conference on Thermal Sensing and Imaging Diagnostic Applications, Orlando, FL, Apr. 22-24, 1992 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1992 p. 271-281. refs
Copyright

Results are presented of an experimental investigation to analyze the presence of Goertler vortices in hypersonic flow and their effects on the wall heat transfer. Measurements using a computerized IR imaging system were performed in a blowdown wind tunnel for Mach numbers equal to 7 and 8.15 and for different Reynolds numbers. Tested models represent a flat plate with flap (2D interaction) and a delta wing with flap (3D interaction). The vortices' wavelength is found to be smaller for 3D interaction than for 2D interaction; in all cases it decreases as unit Reynolds number increases. Mach number seems to have a minor influence, at least within the limited range of tested values. These experimental findings are found to agree with theoretical predictions based on the interaction nature and on the linear theory of the Goertler instability. AIAA

A94-12649* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SIMULTANEOUS MEASUREMENT OF VELOCITY AND TEMPERATURE FLUCTUATIONS IN THE BOUNDARY LAYER OF A SUPERSONIC FLOW
DOUGLAS R. SMITH and ALEXANDER J. SMITS (Princeton Univ., NJ) Experimental Thermal and Fluid Science (ISSN 0894-1777)

vol. 7, no. 3 Oct. 1993 p. 221-229. refs
(Contract NAG3-1032; AF-AFOSR-89-0420)
Copyright

The instantaneous velocity and temperature behavior of a Mach 3 turbulent boundary layer was studied using two closely spaced constant temperature hot wires. By operating the wires at different temperatures, it was possible to obtain the instantaneous velocity and temperature fluctuations and to evaluate the strong Reynolds analogy. Our analysis revealed that the strong Reynolds analogy is a good approximation for describing the instantaneous velocity and temperature behavior for the inner 70 percent of the boundary layer. Author (revised)

A94-12795

A STUDY OF CHEMICALLY NONEQUILIBRIUM FLOW PAST BODIES WITH ALLOWANCE FOR VIBRATIONAL RELAXATION [ISSLEDOVANIE KHIMICHESKI NERAVNOVESNOGO OBTEKANIYA TEL S UCHETOM KOLEBATEL'NOJ RELAKSATSII]

YU. V. GLAZKOV and V. G. SHCHERBAK Moskovskij Universitet, Vestnik, Seriya 1 - Matematika, Mekhanika (ISSN 0579-9368) no. 3 May-June 1993 p. 41-47. In RUSSIAN refs
Copyright

The problem of supersonic steady flow of a multicomponent nonequilibrium dissociating viscous gas past a blunt body is formulated in terms of parabolized Navier-Stokes equations for the case where the vibrational relaxation times are comparable with the dissociation reaction time and with the time during which a liquid particle remains in the vicinity of the body. The problem is solved numerically using iterations in terms of the pressure gradient, proposed previously for homogeneous gas flows. The effect of thermodynamic nonequilibrium on the profiles of the unknown quantities and heat flow toward the body surface is examined. AIAA

A94-12796

CALCULATION OF THE AERODYNAMIC INTERACTION BETWEEN AN AIRFOIL AND A VORTEX [RASCHET AEHRODINAMICHESKOGO VZAIMODEJSTVIYA PROFILYA I VIKHRYA]

A. A. ZAJTSEV and M. M. TISHCHENKO Moskovskij Universitet, Vestnik, Seriya 1 - Matematika, Mekhanika (ISSN 0579-9368) no. 3 May-June 1993 p. 47-51. In RUSSIAN refs
Copyright

The interaction between a helicopter rotor profile and a free vortex cord is modeled by solving the problem of nonstationary potential flow of an ideal incompressible fluid with a free vortex past a wing profile. The interaction between a free vortex and a vortex sheet is demonstrated. It is shown, in particular, that the free vortex accelerates the transformation of the sheet to a vortex cluster, while the latter deflects the free vortex. AIAA

A94-12799

A FINITE ELEMENT METHOD FOR CALCULATING THE NONSTEADY STATE AERODYNAMIC CHARACTERISTICS OF A SUBSONIC CASCADE OF VIBRATING AIRFOILS [METOD KONECHNYKH EHLEMENTOV DLYA RASCHETA NESTATSIONARNYKH AEHRODINAMICHESKIKH KHARAKTERISTIK DOZVUKOVOJ RESHETKI VIBRIRUYUSHCHIKH PROFILEJ]

A. A. OSIPOV Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki (ISSN 0044-4669) vol. 33, no. 6 June 1993 p. 919-935. In RUSSIAN refs
Copyright

A numerical method is developed for calculating the linear oscillations of subsonic flow of an ideal gas near a vibrating plane cascade of airfoils. Attention is given to harmonic vibrations of airfoils with a constant phase shift between any two adjacent airfoils in a cascade. The computational scheme is based on the finite element method used in conjunction with the variational principle. A modified formulation of the boundary value problem is used in order to reduce the errors associated with the large inhomogeneities of the main steady state flow near the leading and trailing edges of the airfoils. AIAA

A94-12800

VARIATIONAL INVERSE BOUNDARY VALUE PROBLEMS IN AEROHYDRODYNAMICS FOR SUBSONIC GAS FLOW [VARIATSIONNYE OBRATNYE KRAEVYE ZADACHI AEHROGIDRODINAMIKI DLYA DOZVUKOVOGO TECHENIYA GAZA]

A. M. ELIZAROV, E. V. FEDOROV, and D. A. FOKIN Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki (ISSN 0044-4669) vol. 33, no. 6 June 1993 p. 958-968. In RUSSIAN refs
Copyright

Variational problems of determining the shape of nonporous wing profiles with a maximum lift-drag ratio in steady state subsonic flow of a viscous gas with large Reynolds numbers are solved numerically. The viscosity is considered in the boundary layer approximation, while gas compressibility is accounted for in the framework of Chaplygin's gas model. Examples of optimized profiles are presented, as are numerical calculations. AIAA

A94-12818

DYNAMICS OF SWIRLED GAS FLOW BETWEEN DISKS IN THE CASE OF A ROTATING BLADELESS DIFFUSER [DINAMIKA PREDVARITEL'NO ZAKRUCHENNOGO GAZOVOGO POTOKA V MEZHDISKOVOM ZAZORE V SLUCHAE BEZLOPATOCHNOGO VRASHCHAYUSHCHEGOSYA DIFFUZORA]

A. A. KHALATOV, M. M. GOJKHENBERG, and T. V. MENDELEEVA (ANU, Inst. Tekhnicheskoj Teplofiziki, Kiev, Ukraine) Promyshlennaya Teplotekhnika (ISSN 0204-3602) vol. 14, no. 4-6 July-Dec. 1992 p. 43-48. In RUSSIAN refs
Copyright

A mathematical model is developed which describes swirled gas flow between disks in a rotating bladeless diffuser. The model is used to develop an algorithm and a computer program for calculating pressure increase in the disk zone. Results of the computational experiments are generalized in terms of similarity theory, and universal relations are obtained for the correction of the input parameters. AIAA

A94-12889

CALCULATION OF DISCONTINUOUS SOLUTIONS FOR BOUNDARY LAYER EQUATIONS [K RASCHETU RAZRYVNYKH RESHENIJ URAVNENIJ POGRANICHNOGO SLOYA]

S. V. KHOKHLOV and E. YU. SHAL'MAN *In* The boundary layer Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya 1990 p. 6-13. In RUSSIAN refs
Copyright

Flows with discontinuities are analyzed using the integral method for calculating three-dimensional boundary layers. The approach is used to calculate a model flow on a plate with lateral injection and flow in a straight compressor cascade. In the latter case, the calculated location of the discontinuity is found to be in satisfactory agreement with the experimentally observed location of the wall flow boundary line on the blade back. AIAA

A94-12892

A METHOD FOR MEASURING THE VELOCITY FIELD IN THREE-DIMENSIONAL FLOW BY MEANS OF A FIVE-TUBE NONORIENTED PROBE [METODIKA IZMERENIYA POLYA SKOROSTEJ V TREKHMERNOM TECHENII PYATITRUBCHATYM NEORIENTIRUEMYM NASADKOM]

E. B. SHUBIN *In* The boundary layer Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya 1990 p. 42-50. In RUSSIAN refs
Copyright

The design of a five-tube nonoriented probe for measuring the magnitude and direction of the velocity vector in three-dimensional space is described. A probe calibration procedure is described for incoming flow velocities up to Mach 0.3. Results of systematic velocity profile measurements are presented for a boundary layer beyond the point of flow reattachment in a rectangular duct with a step. Results of measurements in the blade passage of a compressor cascade are presented as an example of the practical applications of a five-tube probe. AIAA

A94-12893
CALCULATION OF BOUNDARY LAYERS IN NOZZLES WITH HEAT TRANSFER AND HIGH STAGNATION PARAMETERS [RASCHET POGRANICHNYKH SLOEV V SOPLAKH S TEPLOOBMENOM PRI VYSOKIKH PARAMETRAKH TORMOZHENIYA]
E. K. KHOLSHCHEVNIKOVA *In* The boundary layer Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya 1990 p. 51-59. In RUSSIAN refs
Copyright

Friction and heat transfer characteristics are determined for a Laval nozzle with cooled walls in the case of a high expansion ratio over a wide range of stagnation parameters. Under these conditions, the flow regimes that are realized in the nozzle may include laminar, transient, and turbulent flows. Results are obtained by solving numerically a system of partial differential equations including a turbulent viscosity equation. AIAA

A94-12894
USING THE BOUNDARY LAYER THEORY FOR CALCULATING SEPARATED FLOWS [PRIMENENIE TEORII POGRANICHNOGO SLOYA DLYA RASCHETA OTRYVNYKH TECHENIJ]
V. I. VASIL'EV, S. V. KHOKHLOV, and E. YU. SHAL'MAN *In* The boundary layer Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya 1990 p. 60-83. In RUSSIAN refs
Copyright

Methods are developed for solving the inverse boundary layer problem. The solution of the inverse problem for the separation zone in a turbulent boundary layer is used to compare various turbulence models. Methods are also developed for calculating internal and external flows with thin separation zones. A new algorithm is proposed for matching solutions in a boundary layer and potential flow. AIAA

A94-12897
EFFECT OF FLOW INTERACTION AT THE TRAILING EDGE OF A SEPARATOR ON THE EFFECTIVE AREAS [VLIYANIE VZAIMODEJSTVIYA POTOKOV U ZADNEJ KROMKI RAZDELITELYA NA EHFFEKTIVNYE PLOSHCHADI]
V. I. VASIL'EV *In* The boundary layer Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya 1990 p. 101-119. In RUSSIAN refs
Copyright

The influence of flow inhomogeneity near the trailing edge of a separator and viscous effects on the effective channel areas is estimated. A method is developed for the numerical calculation of flow at the trailing edge of a separator in the path of viscous fluid flows with different total pressures. It is shown that a separation zone is formed at the lee-side of a separator when the trailing edge of the separator is positioned at an angle to the incoming flow. The separation zone closes at the trailing edge; the dimensions of the separation zone depend on the flow velocity on the other side of the separator. AIAA

A94-12900
CALCULATION OF A TURBULENT NONISOTHERMAL MIXING REGION ALONG A JET ISSUING FROM A SINGLE-FLOW OR A BYPASS ENGINE AT ABOVE THE CRITICAL PRESSURE [RASCHET TURBULENTNOJ NEIZOTERMICHESKOJ ZONY SMESHENIYA VDOL' NERASCHETNOJ STRUI, ISTEKAYUSHCHEJ IZ ODNOKONTURNOGO ILI DVUKHKONTURNOGO DVIGATELYA]
N. L. EFREMOV and R. K. TAGIROV *In* The boundary layer Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya 1990 p. 149-160. In RUSSIAN refs
Copyright

A method is proposed for calculating a jet outflowing at above the critical pressure into a stationary medium or wake flow, with the effects of boundary layers and a nonisothermal mixing region at the jet boundary taken into account. The nonviscous core of the internal and external flows is described by using Euler equations and a finite difference scheme; integral conservation equations are used for the mixing region. The jet calculation method is used to determine the local and integral characteristics of the axisymmetric exhausts of bypass engines with allowance for external flow, boundary layers, and nonisothermal mixing region. AIAA

N94-10350# National Aerospace Lab., Tokyo (Japan). Advanced Aircraft Research Group.
AN INVESTIGATION ON THE EFFECTIVENESS OF THE PIPING INTERFERENCE REMOVAL SYSTEM FOR STOL AIRCRAFT WIND TUNNEL TESTS [STOL ZENKI MOKEI HAIKAN KANSHOU JOKYU SOUCHI KOUKA SHIKEN]
HITOSHI TAKAHASHI, TERUOMI NAKAYA, MASAYOSHI NOGUTI, OSAMU NONAKA, HIDEO HOSHINO, and TAKASHI INOUE Apr. 1992 28 p In JAPANESE
(ISSN 0452-2982)
(NAL-TM-647; JTN-93-80448) Avail: CASI HC A03/MF A01

The piping interference removal system, developed at the National Aerospace Laboratory (NAL) to reduce the interference on the balance caused by the high-pressure piping, was studied using force measurements from wind tunnel tests. A model was employed which utilized a simulated engine powered by high pressure air through the high pressure air hoses. It was founded that the interference effects on the measured forces were negligible; thus, no piping interference corrections were necessary for STOL aircraft wind tunnel tests used with the simulated engine. System usefulness was also confirmed since little difference occurred between the resultant aerodynamic coefficients and those obtained in tests using the previous high-pressure air hose system. Author (NASDA)

N94-10357 Toronto Univ. (Ontario).
NONLINEAR ASPECTS OF TRANSONIC AEROELASTICITY Ph.D. Thesis
HEMA SANDHYARANI MURTY 1992 213 p
Avail: Univ. Microfilms Order No. DANN73808

Flutter analysis of airfoils in transonic flow has traditionally assumed linearity of the aerodynamic loads and moment with motion amplitude. However, the nonlinear nature of the mixed flow, incorporating large amplitude shock wave motion, may significantly invalidate the linearity assumption. The effect of nonlinear transonic aerodynamics on the flutter analysis is analyzed utilizing a simplified linear structural model. The aerodynamic conditions under which these effects are significant are determined for specific cases using the NACA 64A010 airfoil. In order to accurately determine the aerodynamic loads and moment, an unsteady full potential code was developed. This code was joined to an algorithm which integrates the structural equations of motion in time. A flutter analysis based on the assumption of linear aerodynamics was carried out to determine the neutral stability conditions defined by a set of structural and aerodynamic parameters. These neutral stability conditions were then used in the structural equations of motion with nonlinear aerodynamic loads and moment. These equations were then integrated in time to determine the response of the system. If the time response was not neutrally stable, then the structural parameter, Mu, the airfoil-to-air mass ratio was varied until the time response was neutrally stable. If the difference in the value of the 'nonlinear' Mu to 'linear' Mu was greater than 10 percent, then that case was considered to exhibit significant nonlinearities. Dissert. Abstr.

N94-10363# National Aerospace Lab., Tokyo (Japan). Airframe Div.
ESTIMATION OF CRITICAL VALUES AND VIBRATION CHARACTERISTICS ON SUPERSONIC DELTA WINGS. PART 1: ON-LINE TIME SERIES ANALYSIS OF STATIONARY RANDOM RESPONSE [CHOUONSOKU DERUTAYOKU NO SHINDOU TOKUSEI TO ANTEI GENKAI NO SUITEI. DAI 1 POU: TEIJOUNA FUKISOKU OUTOU NO ONRAIN JIKEIRETSU KAISEKI]
YASUKATSU ANDOU, YUUJI MATSUZAKI, MASAKATSU MINEGISHI, HIROSHI EJIRI, SEIZOU SAKAKIBARA, JUNICHI NODA, and KIYOMICHI ISHIDA Apr. 1992 20 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1153; JTN-93-80434; DE93-767977) Avail: CASI HC A03/MF A01

A personal computer based, on-line time series analysis system is described which estimates the flutter boundary and vibration-mode parameter of a flutter model. The system software is written in BASIC (Beginner's All-purpose Symbolic Instruction Code) and uses an autoregressive process. Ground vibration and wind tunnel flutter tests were conducted on supersonic delta wing models to enable system evaluation. Stationary random response of the wings was subsequently applied into the system and its practical use was confirmed using the estimated results.
Author (NASDA)

N94-10433*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RECOMMENDATIONS FOR FUTURE RESEARCH IN HYPERSONIC INSTRUMENTATION
S. L. OCHELTREE *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 2 p Apr. 1993
Copyright Avail: CASI HC A01/MF A04

An overview of the NATO Advanced Research Workshop is presented. It describes the process followed to obtain a group consensus on the main technical recommendations for each of the five technical sessions of the Workshop and presents the general conclusions and recommendations for future research agreed upon by the workshop participants. Author (revised)

N94-10434*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LOCAL MEASUREMENT OF TEMPERATURES AND CONCENTRATIONS: A REVIEW FOR HYPERSONIC FLOWS
C. DANKERT (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, Germany.), R. CATTOLICA (California Univ., San Diego.), and W. SELLERS *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 10 p Apr. 1993
Copyright Avail: CASI HC A02/MF A04

The quality of reentry simulation for Shuttle, HERMES, Sanger, and NASP systematically suffers from the strong non-equilibrium of rotational and vibrational temperature due to the rapid acceleration of the test gas in the nozzle. Therefore the determination of temperatures is necessary and, if possible, preferable by a non-intrusive technique. The specific interests of this review are optical techniques such as electron beam fluorescence, laser-induced fluorescence, and coherent anti-Stokes Raman scattering. The capabilities available for local measurements with temporal resolution and quantitative accuracy are discussed for velocity, temperature, density, species concentrations, and fluctuations due to turbulence. The applicability of these methods of measurement is presented and discussed for the coming topic in aerothermodynamics: experimental techniques of hot gases in high enthalpy flows. Author

N94-10435*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PRESSURE AND FORCE MEASUREMENTS ON MODELS SET IN HYPERSONIC FLOWS: A REVIEW
CHARLES G. MILLER *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 11 p Apr. 1993
Copyright Avail: CASI HC A03/MF A04

A review of measurement techniques used to obtain aerodynamic forces and moments and surface/flow field pressures for models tested in impulse hypersonic-hypervelocity facilities and in conventional-type hypersonic wind tunnels is presented. Although force and moment measurement techniques presently used in hypersonic wind tunnels are relatively unchanged from the 1960's and 1970's, significant advances have recently been made for impulse facilities. For both hypersonic wind tunnels and impulse facilities, the state-of-the-art has advanced via refinements, improved test techniques, and advances in semiconductor technology, data acquisition systems, and computers. The introduction of electronically scanned pressure systems over a decade ago 'revolutionized' pressure measurements in hypersonic wind tunnels and a second 'revolution' is impending with the development and application of optical, two-dimensional, global pressure measurement techniques. The development and continued refinement of miniature piezoresistive transducers has provided the capability to perform detailed surface pressure measurements on relatively small, complex models in impulse facilities; these transducers also provided the capability for intrusive flow field pressure measurements with miniature survey rakes.
Author (revised)

N94-10445# Sandia National Labs., Albuquerque, NM. Aerodynamics Dept.
JOINT COMPUTATIONAL AND EXPERIMENTAL AERODYNAMIC RESEARCH ON A HYPERSONIC VEHICLE
WILLIAM L. OBERKAMPF, DANIEL P. AESCHLIMAN, and MARY MCWHERTER WALKER *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 11 p Apr. 1993
(Contract DE-AC04-76DP-00789)
Copyright Avail: CASI HC A03/MF A04

A closely coupled computational and experimental aerodynamics research program was conducted on a hypersonic vehicle configuration at Mach 8. Aerodynamic force and moment measurements and flow visualization results were obtained in the Sandia National Laboratories hypersonic wind tunnel for laminar boundary layer conditions. Parabolized and iterative Navier-Stokes simulations were used to predict flow fields and forces and moments on the hypersonic configuration. The basic vehicle configuration is a spherically blunted 10 deg cone with a slice parallel with the axis of the vehicle. On the slice portion of the vehicle, a flap can be attached; flap deflection angles of 10 deg, 20 deg, and 30 deg were used. Comparisons are made between experimental and computational results to evaluate the quality of each and to identify areas where improvements are needed. This extensive set of high-quality experimental force and moment measurements is recommended for use in the calibration and validation of computational aerodynamics codes.
Author (revised)

N94-10446*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ISSUES AND APPROACH TO DEVELOP VALIDATED ANALYSIS TOOLS FOR HYPERSONIC FLOWS: ONE PERSPECTIVE
GEORGE S. DEIWERT *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 10 p Apr. 1993
Copyright Avail: CASI HC A02/MF A04

Critical issues concerning the modeling of low density hypervelocity flows where thermochemical nonequilibrium effects are pronounced are discussed. Emphasis is on the development of validated analysis tools, and the activity in the NASA Ames Research Center's Aerothermodynamics Branch is described. Inherent in the process is a strong synergism between ground test and real gas computational fluid dynamics (CFD). Approaches to develop and/or enhance phenomenological models and incorporate them into computational flowfield simulation codes are discussed. These models were partially validated with experimental data for flows where the gas temperature is raised (compressive flows). Expanding flows, where temperatures drop, however, exhibit somewhat different behavior. Experimental data for these expanding flow conditions is sparse and reliance must be made on intuition and guidance from computational chemistry to model transport processes under these conditions. Ground based experimental studies used to provide necessary data for model development and validation are described. Included are the performance characteristics of high enthalpy flow facilities, such as shock tubes and ballistic ranges. Author (revised)

N94-10449*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THREE-DIMENSIONAL HYPERSONIC RAREFIED FLOW CALCULATIONS USING DIRECT SIMULATION MONTE CARLO METHOD
M. CEVDET CELENLIGIL (Middle East Technical Univ., Ankara, Turkey.) and JAMES N. MOSS *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 12 p Apr. 1993
Copyright Avail: CASI HC A03/MF A04
A summary of three-dimensional simulations on the hypersonic rarefied flows in an effort to understand the highly nonequilibrium flows about space vehicles entering the Earth's atmosphere for a realistic estimation of the aerothermal loads is presented. Calculations are performed using the direct simulation Monte Carlo method with a five-species reacting gas model, which accounts for rotational and vibrational internal energies. Results are obtained for the external flows about various bodies in the transitional flow regime. For the cases considered, convective heating, flowfield structure and overall aerodynamic coefficients are presented and comparisons are made with the available experimental data. The agreement between the calculated and measured results are very good. Author (revised)

N94-10451*# Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.
STABILITY OF HYPERSONIC BOUNDARY-LAYER FLOWS WITH CHEMISTRY
HELEN L. REED, GREGORY K. STUCKERT, and TIMOTHY S. HAYNES *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 13 p Apr. 1993 Sponsored by NASA. Langley Research Center; NASA. Ames Research Center; NSF; McDonnell-Douglas Corp.; and General Dynamics/Fort Worth (Contract F49620-88-C-0076)
Copyright Avail: CASI HC A03/MF A04
The effects of nonequilibrium chemistry and three dimensionality on the stability characteristics of hypersonic flows are discussed. In two-dimensional (2-D) and axisymmetric flows, the inclusion of chemistry causes a shift of the second mode of Mack to lower frequencies. This is found to be due to the increase in size of the region of relative supersonic flow because of the lower speeds of sound in the relatively cooler boundary layers. Although this shift in frequency is present in both the equilibrium and nonequilibrium air results, the equilibrium approximation predicts modes which are not observed in the nonequilibrium calculations (for the flight conditions considered). These modes are superpositions of incoming and outgoing unstable disturbances which travel supersonically relative to the boundary-layer edge velocity. Such solutions are possible because of the finite shock stand-off distance. Their corresponding wall-normal profiles exhibit an oscillatory behavior in the inviscid region between the boundary-layer edge and the bow shock. For the examination of three-dimensional (3-D) effects, a rotatinq cone is used as a model of a swept wing. An increase of stagnation temperature is found to be only slightly stabilizing. The correlation of transition location ($N = 9$) with parameters describing the crossflow profile is discussed. Transition location does not correlate with the traditional crossflow Reynolds number. A new parameter that appears to correlate for boundary-layer flow was found. A verification with experiments on a yawed cone is provided. Author (revised)

N94-10452# Manchester Univ. (England). Dept. of Engineering.
REAL GAS AND SURFACE TRANSPIRATION EFFECTS UPON SWEPT LEADING EDGE HIGH SPEED FLOW INCLUDING TRANSITION
D. I. A. POLL *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 16 p Apr. 1993
Copyright Avail: CASI HC A03/MF A04
The extension of simple methods for the prediction of skin friction and heat transfer at an infinite-swept attachment line to cover the hypervelocity flight regime including the effects of surface transpiration is considered. The analysis is limited to the situation where the flow is in thermochemical equilibrium everywhere. Real gas effects are identified and their influence is quantified. The importance of freestream conditions and attachment-line inclination are assessed. Consideration is also given to the issue of boundary layer transition. Author (revised)

N94-10455# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
CALCULATIONS OF VISCOUS NONEQUILIBRIUM FLOWS IN NOZZLES [CALCULS D'ECOULEMENTS VISQUEUX EN DESEQUILIBRE DANS DES TUYERES]
C. MARMIGNON, V. JOLY, and F. COQUEL *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 9 p Apr. 1993 In FRENCH Previously announced in IAA as A93-38574
Copyright Avail: CASI HC A02/MF A04
An implicit finite-volume method for investigating viscous flows in a state of chemical and vibrational nonequilibrium in nozzles is presented. The ideal-fluid flux terms are calculated by a decentered Roe-type scheme that is second order in space, and the viscous fluxes are determined using a centered scheme. The numerical fluxes and the sources terms are coupled completely at the implicit stage. The proposed method is illustrated by application to two flow configurations: (1) a test case from the Antibes Workshop on hypersonic flows, and (2) a nozzle flow in the ONERA F4 wind tunnel. AIAA

N94-10463*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
A COMPARISON OF HIGH RESOLUTION UPWIND SOLVERS ON 3-D INVISCID HYPERSONIC FLOWS
M. MANNA (Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese, Belgium.), H. DECONINCK (Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese, Belgium.), C. P. LI, and E. MA *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 14 p Apr. 1993
Copyright Avail: CASI HC A03/MF A04
A detailed comparison of numerical results obtained by solving the Euler equations for the inviscid flow over delta wings in reentry configurations is presented. The investigation involves a side-by-side comparison between independently developed upwind Euler solvers at VKI (M3D) and NASA Johnson Space Center (E3D) using identical grids. In both solvers the governing equations are integrated by means of time marching finite volume shock capturing methods, based on a cell centered upwind evaluation of the cell face fluxes and nonlinear limiters. High resolution schemes are obtained via MUSCL characteristic variable extrapolation to ensure total variation diminishing (TVD) properties and therefore monotonic discontinuity capturing. Further comparisons are made with several published results by other authors based on both upwind and central discretizations. The present results contribute in asserting the high resolution upwind TVD schemes as the most reliable numerical technique to handle the strong discontinuities typical of high speed flows. The performances of the two upwind solvers are satisfactory and the numerical results in good agreement. However, the important issue of reaching a grid converged solution for the present complex three-dimensional inviscid flow problems was not achieved. Author (revised)

N94-10464# Avions Marcel Dassault, Saint-Cloud (France).
LOCAL AEROTHERMAL PROBLEMS DURING HERMES RE-ENTRY
A. NAIM, M. MALLET, P. ROSTAND, and J. M. HASHOLDER *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 16 p Apr. 1993 In FRENCH Original contains color

illustrations
Copyright Avail: CASI HC A03/MF A04
The objective is to present results obtained with the Navier Stokes code used by Dassault Aviation for aerothermal reentry problems. We will emphasize the strategy employed and only give an outline of the numerical technique developed for each solver involved in the calculation. The method is designed to have a wide range of application. It involved a sequence of calculations using different modules and interfaces. This tool is not only multi-codes but also multi-computers. The preparation of the initial solution sets for computations were performed on our IBM ES 9000/820 with MVS ESA operating system, and most of the computation was done on a NEC SX3 (at NLR in the Nederlands) and on a CRAY YMP (at C.I.R.A. in Italy) with UNIX operating system. We shall present a validation case using the complete sequence, and afterwards a number of critical points of microaerothermodynamics. The validation test case is a Complete Hermes canopy of the 0.0 geometry (shape number 185 in Dassault catalog). A model of this shape was tested in R3CH ONERA wind tunnel yielding experimental results that are used for comparison. For the flight cases we plan to compute: various canopy shapes; a meteorite impact on the Hermes noze cap; and joint between tiles (in first tile position). Author (revised)

N94-10466# National Aerospace Lab., Tokyo (Japan).
PROCEEDINGS OF THE 10TH NAL SYMPOSIUM ON AIRCRAFT COMPUTATIONAL AERODYNAMICS: CFD WORKSHOP ON GK AIRFOIL AND ONERA M5 GEOMETRY
Mar. 1993 111 p In JAPANESE Symposium held in Tokyo, Japan, 10-12 Jun. 1992
(ISSN 0289-260X)
(NAL-SP-20) Avail: CASI HC A06/MF A02
The papers of the Computational Fluid Dynamics Workshop on the Garabedian-Korn airfoil and the ONERA M5 configuration are presented. Computational results from each of the Workshop contributors are summarized and compared.

N94-10467# National Aerospace Lab., Tokyo (Japan).
DESCRIPTION OF 2D PROBLEM: AERODYNAMIC ANALYSIS OF GARABEDIAN-KORN 75-06-12 AIRFOIL
NAOKI HIROSE *In its* Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 1-3 Mar. 1993 In JAPANESE
Avail: CASI HC A01/MF A02
Some 2D problems related to the analysis of the Garabedian-Korn 75-06-12 airfoil are addressed. The Problem A is to compute a shock-less flow of a Garabedian-Korn 75-06-12 airfoil at design conditions of Mach number, 0.75, C(sub 1), 0.63 and Reynolds number, 6 and 20 x 10(exp 6). Problem B is to obtain the aerodynamic characteristics of Mach number sweep and angle of attack sweep. The reference point is the same condition in Problem A. The output data format is described. Author (revised)

N94-10468# Nagoya Univ. (Japan). Dept. of Aeronautical Engineering.
AERODYNAMIC CHARACTERISTICS ANALYSIS OF GARABEDIAN-KORN 75-06-12 AIRFOIL
ANDI EKA SAKYA and YOSHIAKI NAKAMURA *In* NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 5-6 Mar. 1993 In JAPANESE
(PAPER-2D-2) Avail: CASI HC A01/MF A02
A Navier-Stokes code based on the implicit Yee-Harten TVD scheme is applied to compute the aerodynamic characteristics of Garabedian-Korn GK 75-06-12 airfoil at transonic speed. The algebraic turbulence model is employed to close the system of equations. Author

N94-10469# Fuji Heavy Industries Ltd., Utsunomiya (Japan).
AERODYNAMIC CHARACTERISTICS ANALYSIS OF GARABEDIAN-KORN 75-06-12 AIRFOIL
KYOKO HIGAKI, YASUHIRO KOSHIOKA, and KOHEI TANAKA *In* NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 7-8 Mar. 1993 In JAPANESE
(PAPER-2D-3) Avail: CASI HC A01/MF A02
The flow field around a GK75-06-12 airfoil is analyzed by solving the two-dimensional compressible Navier-Stokes equations. The calculation was carried out, under the condition of Reynolds number 6 x 10(exp 6) and 2 x 10(exp 7), in each case CL (lift coefficient) was adjusted to 0.63. Author

N94-10470# Kawasaki Heavy Industries Ltd., Gifu (Japan). Technical Inst.
AERODYNAMIC CHARACTERISTICS ANALYSIS OF GARABEDIAN-KORN 75-06-12 AIRFOIL: COMPUTATION USING Q-OMEGA 2 EQUATION TURBULENCE MODEL
EIJI SHIMA and KOUICHI EGAMI *In* NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 9-10 Mar. 1993 In JAPANESE
(PAPER-2D-4) Avail: CASI HC A01/MF A02
Reynolds-averaged Navier-Stokes equations for perfect gas are solved numerically for flow around GK75-06-12 airfoil at the design conditions. Coakley's 2 equation turbulence model is used. In order to solve the q-omega equations stably some improvements are added to the numerical scheme. Two turbulence models, the q-omega model in this paper, and the Baldwin-Lomax model in another paper, are used for this workshop, then some characteristics of each solutions are compared. It is found that (1) surface pressure distributions are almost identical; and (2) q-omega solution has larger skin friction that B-L solution and that causes thicker boundary layer and bigger drag. The effect of the difference of initial and boundary conditions of q and omega variables are shown. Author (revised)

N94-10471# Kawasaki Heavy Industries Ltd., Gifu (Japan). Technical Inst.
AERODYNAMIC CHARACTERISTICS ANALYSIS OF GARABEDIAN-KORN 75-06-12 AIRFOILS: COMPUTATION USING BALDWIN-LOMAX TURBULENCE MODEL
EIJI SHIMA and KOUICHI EGAMI *In* NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 11-12 Mar. 1993 In JAPANESE
(PAPER-2D-5) Avail: CASI HC A01/MF A02
Flow around a Garabedian-Korn 75-06-12 Airfoil is simulated numerically using Navier-Stokes equations. Baldwin-Lomax's algebraic turbulence model is adopted, but wake modeling is not used because it was shown by the previous investigation that turbulence viscosity in wake region has only little influence on pressure distribution and boundary layer characteristics. The equations are computed by the cell centered finite volume method using an implicit upwind scheme. C-type grid, which is generated algebraicly by the transfinite interpolation, is used. The large linear equations arising from the implicit scheme are solved approximately using the multi-color Gauss-Seidel method. Numerical experiments show that optimum inner iteration for rapid convergence is about 10. Author (revised)

N94-10472# Chiba Univ. (Japan). Dept. of Mechanical Engineering.
AERODYNAMIC CHARACTERISTICS ANALYSIS OF GARABEDIAN-KORN 75-06-12 AIRCRAFT
NOBUHIDE NISHIKAWA and NOBORU MORI *In* NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 13-14 Mar. 1993 In JAPANESE
(PAPER-2D-7) Avail: CASI HC A01/MF A02
The flow structure of compressible flow around an aerofoil is numerically analyzed by TVD-MacCormack schemes. After calculating the Euler equations on transformed coordinates, the flow variables are interpolated for the fine mesh(AF mesh) for

Navier-Stokes equations, and then calculation is continued for the case Re = 6 x 10(exp 6) with the Baldwin-Lomax turbulence model. Author (revised)

N94-10473# Fujitsu Ltd., Tokyo (Japan).
AERODYNAMIC CHARACTERISTICS ANALYSIS OF GARABEDIAN-KORN 75-06-12 AIRFOIL
KISA MATSUSHIMA and SUSUMU TAKANASHI (National Aerospace Lab., Tokyo, Japan.) *In* NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 15-16 Mar. 1993 In JAPANESE
(PAPER-2D-8) Avail: CASI HC A01/MF A02

The parametric study of Navier-Stokes computations has been performed to find an angle of attack which realizes a shockless pressure distribution over the Garabedian-Korn airfoil under the Mach number of 0.75. It would be almost impossible to realize a shockless solution by Navier-Stokes equations because of the viscous effect. A pressure distribution with weak shock has been attained, and it agrees with the theoretical pressure distribution quite well except in close vicinity to the location of a shock wave. In addition, a comparison has been made between computations using two different turbulence models. Author (revised)

N94-10474# Mitsubishi Heavy Industries Ltd., Tokyo (Japan).
AERODYNAMIC CHARACTERISTICS ANALYSIS OF GARABEDIAN-KORN 75-06-12 AIRFOIL
TAKESHI KAIDEN and JUN OGINO *In* NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 17-18 Mar. 1993 In JAPANESE
(PAPER-2D-9) Avail: CASI HC A01/MF A02

Aerodynamic characteristics analysis of Garabedian-Korn 75-06-12 airfoil is presented. The governing equation is the thin layer Reynolds-averaged Navier-Stokes equation. The code is based on scalar pentadiagonal ADI scheme with a nonlinear artificial dissipation model and local time stepping. The turbulence modeling is added as the algebraic model of Baldwin-Lomax type. The grid system for the airfoil as C-type is generated solving the parabolic equation. The computations with 20,230 points are performed on a Convex 220. Author (revised)

N94-10475# National Aerospace Lab., Tokyo (Japan).
AERODYNAMIC CHARACTERISTICS ANALYSIS OF GARABEDIAN-KORN 75-06-12 AIRFOIL: COMPENDIUM OF RESULTS
NAOKI HIROSE *In its* Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 19-55 Mar. 1993 In JAPANESE
Avail: CASI HC A03/MF A02

A compendium of results of the 2D problem 'Garabedian-Korn Airfoil' is given. All of the submitted computation results were plotted on the respective figures to see the differences. Problem A: Design Point Computation was discussed significantly. Although pressure distribution gives fairly good agreement, turbulent boundary layer characteristics along chord, velocity profiles and eddy viscosity coefficient distributions in the boundary layer and wake disclosed scattered variation. The factors leading to the present results were discussed along with required future improvements. Author (revised)

N94-10476# National Aerospace Lab., Tokyo (Japan).
DESCRIPTION OF 3D PROBLEM: FLOW ANALYSIS AROUND ONERA MODEL M5 CONFIGURATION
JIRO NAKAMICHI *In its* Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 57-61 Mar. 1993 In JAPANESE
Avail: CASI HC A01/MF A02

A description of the 3D Problem and Sub-problems A, B and C concerning flow analysis around the ONERA M5 configuration is presented. Problem A is to compute the flow at freestream conditions of Mach number 0.84, Reynolds number 1 x 10(exp 6), and angle of attack alpha = -1 degrees, with free transition condition. Problem B is to compute the flow at freestream conditions of Mach number 0.84, Reynolds number 6 x 10(exp 7), and angle of attack alpha = -1 degree with full turbulence condition. Problem C is to compute the aerodynamic characteristics of the model at freestream conditions of Mach number 0.84, Reynolds number 2 x 10(exp 6), and angles of attack, alpha = -3 degrees, -2 degrees and -1 degree, and to make plots of C(sub L)-alpha, C(sub L)-C(sub D) and C(sub L)-C(sub M) curves. The output formats are specified for all computed results. Author (revised)

N94-10477# Fuji Heavy Industries Ltd., Utsunomiya (Japan).
FLOW ANALYSIS AROUND ONERA MODEL M5 CONFIGURATION
TETSUO YAMAZAKI, KYOKO HIGAKI, YASUHIRO KOSHIOKA, and KOHEI TANAKA *In* NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 63-64 Mar. 1993 In JAPANESE
(PAPER-3D-1) Avail: CASI HC A01/MF A02

Navier-Stokes code was used for flow analysis around the ONERA Model M5 configuration. This code utilizes the LU-ADI scheme and an algebraic turbulence model that was proposed by B.S. Baldwin and H. Lomax. The body surface grid used for this analysis was obtained by using the Master Dimension System, and the whole grid system was constructed in C-H type topology. The results of this analysis are in good agreement with wind tunnel test results. Author (revised)

N94-10478# Kawasaki Heavy Industries Ltd., Gifu (Japan). Technical Inst.
FLOW ANALYSIS AROUND ONERA MODEL M5 CONFIGURATION
TAKUJI KISHIMOTO *In* NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 65-66 Mar. 1993 In JAPANESE
(PAPER-3D-2) Avail: CASI HC A01/MF A02

Numerical simulation of transonic flow around the ONERA model M5 configuration have been carried out by solving Navier-Stokes equations. The numerical grid used in this analysis is generated by an algebraic method with a multi-block transformation. The grid generation around the given configuration consists of more than 5 million points. We adopt as governing equations Reynolds-averaged thin-layer approximate Navier-Stokes equations with a q-omega two equation turbulence model for a turbulent viscous flow. These equations are solved by an implicit finite volume TVD upwind scheme with Roe's approximate Riemann solver to estimate convective fluxes. Author (revised)

N94-10479# Fujitsu Ltd., Tokyo (Japan).
FLOW ANALYSIS AROUND ONERA MODEL M5 CONFIGURATION
YOKO TAKAKURA, SATORU OGAWA (National Aerospace Lab., Tokyo, Japan.), and YASUHIRO WADA (National Aerospace Lab., Tokyo, Japan.) *In* NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 67-68 Mar. 1993 In JAPANESE
(PAPER-3D-3) Avail: CASI HC A01/MF A02

The numerical analysis of NAL transonic wind-tunnel flows around the ONERA aircraft model M5 has been tried to investigate the reliability of numerical simulation. The multi-domain technique is used to realize flow computations about the complicated configuration, and a simple modeling-method for the outflow/inflow through the perforated wall of a transonic wind-tunnel is presented. As a result it is known that this trial is successful since the numerical solutions agree with experiments well. Author (revised)

N94-10480# National Aerospace Lab., Tokyo (Japan).
FLOW ANALYSIS AROUND ONERA MODEL M5 CONFIGURATION

SUSUMU TAKANASHI, RYOZO ITOH, and MASAKAZU TACHIBANA *In its* Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 69-70 Mar. 1993 In JAPANESE
(PAPER-3D-4) Avail: CASI HC A01/MF A02

Numerical simulation of the transonic flow about ONERA model M5 configuration has been carried out. The governing equations are the Reynolds-averaged thin-layer Navier-Stokes equations. The numerical algorithm used here is the implicit finite volume method based on the upwind TVD scheme. A computational grid with an O-C topology is generated by the point-charge distribution method. The computational results are also compared with the wind tunnel test data. Author (revised)

N94-10481# Mitsubishi Heavy Industries Ltd., Tokyo (Japan).
FLOW ANALYSIS AROUND ONERA MODEL M5 CONFIGURATION
TAKESHI KAIDEN and JUN OGINO *In* NAL, Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 71-72 Mar. 1993 In JAPANESE
(PAPER-3D-5) Avail: CASI HC A01/MF A02

Flow analysis around the ONERA Model M5 Configuration is presented. The governing equation is the thin-layer Reynolds-averaged Navier-Stokes equation. The code is based on the scalar pentadiagonal ADI scheme with nonlinear artificial dissipation model and local time stepping. The turbulence modeling is also added as the algebraic model of Baldwin-Lomax type. The grid system for this configuration is generated utilizing the algebraic interpolation. The computations with 1,221,500 points are performed on a Fujitsu VP-2600. Author (revised)

N94-10482# National Aerospace Lab., Tokyo (Japan).
FLOW ANALYSIS AROUND ONERA MODEL M5 CONFIGURATION: COMPENDIUM OF RESULTS
JIRO NAKAMICHI *In its* Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry p 73-108 Mar. 1993 In JAPANESE
Avail: CASI HC A03/MF A02

A compendium of results of the 3D problem - flow analysis around ONERA M5 configuration - is given. All of the submitted computation results were compared to see the differences between the computed results and experimental data. In Problem A (flow analysis with freestream condition of Mach number 0.84, alpha = -1 degree, Reynolds number 1 x 10(exp 6), with free transition condition) and Problem B (flow analysis with freestream condition of Mach number 0.84, alpha = -1 degree, Reynolds number 6 x 10(exp 7) with fully turbulent conditions) the pressure distributions and Cp contours on the lifting surface and the fuselage were compared. Experimental data with Reynolds number 1 x 10(exp 6) were also shown. In Problem A, the computed transition lines of the main wing surface were compared. In Problem C (computation of aerodynamic characteristics of the Model aircraft) the C(sub L)-alpha, C(sub L)-C(sub D) and C(sub L)-C(sub M) curves are shown in comparison with experimental data. The factors leading to the present results were discussed along with necessary future improvements. Author (revised)

N94-10672*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
METHOD OF REDUCING DRAG IN AERODYNAMIC SYSTEMS Patent
FRANK J. HRACH, inventor (to NASA) 17 Aug. 1993 6 p Filed 11 Sep. 1992 Supersedes N92-34243 (30 - 24, p 4111)
(NASA-CASE-LEW-14791-1; US-PATENT-5,236,155; US-PATENT-APPL-SN-943659; US-PATENT-CLASS-244-208; US-PATENT-CLASS-244-130; US-PATENT-CLASS-244-209; INT-PATENT-CLASS-B64C-21/04) Avail: US Patent and Trademark Office

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

N94-10673* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
UNDERWING COMPRESSION VORTEX ATTENUATION DEVICE Patent
JAMES C. PATTERSON, JR., inventor (to NASA) 27 Jul. 1993 4 p Filed 22 May 1992 Supersedes N93-19053 (31 - 6, p 1408)
(NASA-CASE-LAR-14744-1; US-PATENT-5,230,486; US-PATENT-APPL-SN-886998; US-PATENT-CLASS-244-199; US-PATENT-CLASS-244-198; INT-PATENT-CLASS-B64C-23/06) Avail: US Patent and Trademark Office

A vortex attenuation device is presented which dissipates a lift-induced vortex generated by a lifting aircraft wing. The device consists of a positive pressure gradient producing means in the form of a compression panel attached to the lower surface of the wing and facing perpendicular to the airflow across the wing. The panel is located between the midpoint of the local wing cord and the trailing edge in the chord-wise direction and at a point which is approximately 55 percent of the wing span as measured from the fuselage center line in the spanwise direction. When deployed in flight, this panel produces a positive pressure gradient aligned with the final roll-up of the total vortex system which interrupts the axial flow in the vortex core and causes the vortex to collapse.
Official Gazette of the U.S. Patent and Trademark Office

N94-10675*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STATIC INTERNAL PERFORMANCE OF A SINGLE EXPANSION RAMP NOZZLE WITH MULTIAXIS THRUST VECTORING CAPABILITY
FRANCIS J. CAPONE and ALBERTO W. SCHIRMER (George Washington Univ., Hampton, VA.) Washington Jul. 1993 272 p
(Contract RTOP 505-62-30-01)
(NASA-TM-4450; L-17163; NAS 1.15:4450) Avail: CASI HC A12/MF A03

An investigation was conducted at static conditions in order to determine the internal performance characteristics of a multiaxis thrust vectoring single expansion ramp nozzle. Yaw vectoring was achieved by deflecting yaw flaps in the nozzle sidewall into the nozzle exhaust flow. In order to eliminate any physical interference between the variable angle yaw flap deflected into the exhaust flow and the nozzle upper ramp and lower flap which were deflected for pitch vectoring, the downstream corners of both the nozzle ramp and lower flap were cut off to allow for up to 30 deg of yaw vectoring. The effects of nozzle upper ramp and lower flap cutout, yaw flap hinge line location and hinge inclination angle, sidewall containment, geometric pitch vector angle, and geometric yaw vector angle were studied. This investigation was conducted in the static-test facility of the Langley 16-Foot Transonic Tunnel at nozzle pressure ratios up to 8.0. Author (revised)

N94-10707*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
EXTRACTION OF STABILITY AND CONTROL DERIVATIVES FROM ORBITER FLIGHT DATA
KENNETH W. ILIFF and MARY F. SHAFER Washington Jun. 1993 49 p Presented at the Orbiters Experiments (OEX) Aerothermodynamics Symposium, Williamsburg, VA, 27-30 Apr. 1993
(Contract RTOP 505-68-50)
(NASA-TM-4500; H-1912; NAS 1.15:4500) Avail: CASI HC A03/MF A01

The Space Shuttle Orbiter has provided unique and important information on aircraft flight dynamics. This information has provided the opportunity to assess the flight-derived stability and control derivatives for maneuvering flight in the hypersonic regime. In the case of the Space Shuttle Orbiter, these derivatives are required to determine if certain configuration placards (limitations on the flight envelope) can be modified. These placards were determined on the basis of preflight predictions and the associated uncertainties. As flight-determined derivatives are obtained, the placards are reassessed, and some of them are removed or modified. Extraction of the stability and control derivatives was justified by operational considerations and not by research considerations. Using flight results to update the predicted database of the orbiter is one of the most completely documented processes for a flight vehicle. This process followed from the requirement for analysis of flight data for control system updates and for expansion of the operational flight envelope. These results show significant changes in many important stability and control derivatives from the preflight database. This paper presents some of the stability and control derivative results obtained from Space Shuttle flights. Some of the limitations of this information are also examined. Author

N94-10758*# Stanford Univ., CA. Dept. of Aeronautics and Astronautics.

NAVIER-STOKES FLOWFIELD COMPUTATION OF WING/ROTOR INTERACTION FOR A TILT ROTOR AIRCRAFT IN HOVER

IAN G. FEJTEK Jul. 1993 156 p
(Contract NCC2-55)
(NASA-CR-4532; A-93096; NAS 1.26:4532) Avail: CASI HC A08/MF A02

The download on the wing produced by the rotor-induced downwash of a tilt rotor aircraft in hover is of major concern because of its severe impact on payload-carrying capability. A method has been developed to help gain a better understanding of the fundamental fluid dynamics that causes this download, and to help find ways to reduce it. In particular, the method is employed in this work to analyze the effect of a tangential leading edge circulation-control jet on download reduction. Because of the complexities associated with modeling the complete configuration, this work focuses specifically on the wing/rotor interaction of a tilt rotor aircraft in hover. The three-dimensional, unsteady, thin-layer compressible Navier-Stokes equations are solved using a time-accurate, implicit, finite difference scheme that employs LU-ADI factorization. The rotor is modeled as an actuator disk which imparts both a radical and an azimuthal distribution of pressure rise and swirl to the flowfield. A momentum theory blade element analysis of the rotor is incorporated into the Navier-Stokes solution method. Solution blanking at interior points of the mesh has been shown here to be an effective technique in introducing the effects of the rotor and tangential leading edge jet. Results are presented both for a rotor alone and for wing/rotor interaction. The overall mean characteristics of the rotor flowfield are computed including the flow acceleration through the rotor disk, the axial and swirl velocities in the rotor downwash, and the slipstream contraction. Many of the complex tilt rotor flow features are captured including the highly three-dimensional flow over the wing, the recirculation fountain at the plane of symmetry, wing leading and trailing edge separation, and the large region of separated flow beneath the wing. Mean wing surface pressures compare fairly well with available experimental data, but the time-averaged download/thrust ratio is 20-30 percent higher than the measured value. The discrepancy is due to a combination of factors that are discussed. Leading edge tangential blowing, of constant strength along the wing span, is shown to be effective in reducing download. The jet serves primarily to reduce the pressure on the wing upper surface. The computation clearly shows that, because of the three-dimensionality of the flowfield, optimum blowing would involve a spanwise variation in blowing strength. Author

N94-10820*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

SPACE SHUTTLE HYPERSONIC AERODYNAMIC AND AEROTHERMODYNAMIC FLIGHT RESEARCH AND THE COMPARISON TO GROUND TEST RESULTS

KENNETH W. ILIFF and MARY F. SHAFER Jun. 1993 29 p
Presented at the 17th Aerospace Ground Testing Conference, Nashville, TN, 6-8 Jul. 1992 Previously announced in IAA as A92-56812
(Contract RTOP 506-69-50)
(NASA-TM-4499; H-1894; NAS 1.15:4499; AIAA PAPER 92-3988) Avail: CASI HC A03/MF A01

Aerodynamic and aerothermodynamic comparisons between flight and ground test for the Space Shuttle at hypersonic speeds are discussed. All of the comparisons are taken from papers published by researchers active in the Space Shuttle program. The aerodynamic comparisons include stability and control derivatives, center-of-pressure location, and reaction control jet interaction. Comparisons are also discussed for various forms of heating, including catalytic, boundary layer, top centerline, side fuselage, OMS pod, wing leading edge, and shock interaction. The jet interaction and center-of-pressure location flight values exceeded not only the predictions but also the uncertainties of the predictions. Predictions were significantly exceeded for the heating caused by the vortex impingement on the OMS pods and for heating caused by the wing leading-edge shock interaction. Author

N94-10855# National Aerospace Lab., Tokyo (Japan). Advanced Aircraft Research Group.

SIMULATED WAKE CHARACTERISTICS OF TAPERED ANNULAR WINGS BY A DISCRETE VORTEX METHOD [USUYOKU NIOKERU TEPA TSUKI ENKANYOKU NO KOURYUU TO USEI]

MASAHIRO OKUYAMA and MITSUO MAKINO May 1992 18 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1156; JTN-93-80441) Avail: CASI HC A03/MF A01

This paper describes the wake characteristics of tapered annular wings which were numerically simulated by a discrete vortex method. In addition, two thin-wing models were employed to observe these characteristics using wind-tunnel tests. Author (NASDA)

N94-10856# National Aerospace Lab., Tokyo (Japan). Advanced Aircraft Research Group.

SIMULATED AND EXPERIMENTAL AERODYNAMIC CHARACTERISTICS OF TAPERED ANNULAR WINGS [USUYOKU NIOKERU TEPA TSUKI ENKANYOKU NO KUURIKI TOKUSEI]

MASAHIRO OKUYAMA and MITSUO MAKINO May 1992 35 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1157; JTN-93-80442) Avail: CASI HC A03/MF A01

The longitudinal aerodynamic characteristics of Tapered Annular Wings (TAWs) were numerically simulated by extending the equations of the Quasi-Vortex Lattice Method (QVLM) for planar wings. Wind-tunnel experiments using two thin-wing models were also conducted to obtain the longitudinal and lateral characteristics of the TAW. The longitudinal aerodynamic characteristics of the experimental and calculational results were compared. As a result, the agreement was good except the drag coefficient. Author (NASDA)

N94-10860# National Aerospace Lab., Tokyo (Japan). Advanced Aircraft Research Group.

NEW AERODYNAMIC INFORMATION OBTAINED FROM THE SOLUTION OF THE INVERSE PROBLEM FOR AEROFOILS [YOKUGATA MAWARI NO NAGARE TO SONO KEISANHOU NI KANSHITE GYAKUMONDAI NO KAI KARA ERARERU KUUKIRIKIGAKU TEKINA CHIKEN]

MASASHI SHIGEMI Jul. 1992 14 p In JAPANESE

(ISSN 0389-4010)
(NAL-TR-1172; JTN-93-80446) Avail: CASI HC A03/MF A01

Direct and inverse problem solutions for an aerofoil are used for contrastive purposes, i.e., direct problems analyze flow around an aerofoil whose shape is prescribed, whereas inverse problems determine the aerofoil shape which realizes prescribed (and usually, idealized) flow conditions around it. In the present study, the solution of the inverse problem is applied differently because the flow input was measured in a wind tunnel experiment rather than being idealized. Investigation of the resultant aerofoil shape provided useful information on the real viscous flow characteristics around the aerofoil as well as on the feature of direct problem solution method to analyze it. The aerofoil shape from the inverse problem solution was found to be thicker than that of the one installed in the wind tunnel, with its trailing edge open. This difference is due to the boundary layer around the wind tunnel aerofoil, since inviscid flow was assumed in the computation and the actual fluid in the wind tunnel was viscous. The additional thickness of the converged aerofoil is of the same order as the displacement thickness of the boundary layer, hence, demonstrating the reliability of the popular approach to incorporate viscous effects into the inviscid analysis by solving the direct problem for an aerofoil with its shape modified by adding the displacement thickness of the boundary layer to the original shape. Inviscid flow analysis around the output shape showed that the applied inverse problem solution was quite accurate when the Reynolds number was 1.0 x 10(exp 5). Author (NASDA)

N94-11133*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LASER ANEMOMETER MEASUREMENTS AND COMPUTATIONS FOR TRANSONIC FLOW CONDITIONS IN AN ANNULAR CASCADE OF HIGH TURNING CORE TURBINE VANES
LOUIS J. GOLDMAN Washington Jul. 1993 33 p
(Contract RTOP 505-62-52)
(NASA-TP-3383; E-7662; NAS 1.60:3383) Avail: CASI HC A03/MF A01

An advanced laser anemometer (LA) was used to measure the axial and tangential velocity components in an annular cascade of turbine stator vanes operating at transonic flow conditions. The vanes tested were based on a previous redesign of the first-stage stator in a two-stage turbine for a high-bypass-ratio engine. The vanes produced 75 deg of flow turning. Tests were conducted on a 0.771-scale model of the engine-sized stator. The advanced LA fringe system employed an extremely small 50-micron diameter probe volume. Window correction optics were used to ensure that the laser beams did not uncross in passing through the curved optical access port. Experimental LA measurements of velocity and turbulence were obtained at the mean radius upstream of, within, and downstream of the stator vane row at an exit critical velocity ratio of 1.050 at the hub. Static pressures were also measured on the vane surface. The measurements are compared, where possible, with calculations from a three-dimensional inviscid flow analysis. Comparisons were also made with the results obtained previously when these same vanes were tested at the design exit critical velocity ratio of 0.896 at the hub. The data are presented in both graphical and tabulated form so that they can be readily compared against other turbomachinery computations. Author (revised)

N94-11154 Tennessee Univ., Knoxville.
WALL INTERFERENCE CORRECTION BASED ON INTERFACE MEASUREMENTS IN SUBSONIC WIND TUNNEL TESTING Ph.D. Thesis
NORBERT MANFRED HERM ULBRICH 1992 163 p
Avail: Univ. Microfilms Order No. DA9306700

Two types of wall interference correction methods in subsonic wind tunnel testing are investigated which are based on interface measurements of velocities or pressures in the flow field. The first method, called Two-Interface method, is derived from a small perturbation solution of the two-dimensional potential equation in subsonic flow. A surface pressure coefficient and angle of attack correction is calculated using axial velocity measurements on the first interface and vertical velocity measurements on the second interface in the wind tunnel. The method only requires the measurement of axial velocities on the first interface, if the solid wall of a wind tunnel is selected as the second interface. The method is applied to available experimental data. Corrected surface pressure coefficients show reasonable agreement with test data recorded in unconfined flow. The second method, called Wall Signature method, can be used to determine wall interference corrections in three-dimensional incompressible wind tunnel testing. Modifications of the Wall Signature method are presented. Pressure measurements on a limited number of wall locations are combined with influence functions to obtain an equivalent body representation of the test article and its wake in terms of surface panel elements. Blockage corrections in a wind tunnel with non-rectangular cross-section are computed using this equivalent body description and an existing three-dimensional panel code. A direct comparison of equivalent body and test article geometry is possible. The analysis of the symmetric part of the wall signature is improved by introducing a least squares fit based on a Gaussian. Advantages and disadvantages of Two-Interface and Wall Signature method are compared. The Two-Interface method is applicable in subsonic wind tunnel testing as long as the small perturbation assumption holds. This method uses explicit equations to compute wall interference corrections which makes it suited for on-line operation. The modified Wall Signature method is not restricted to slender bodies and can even be applied to high angle of attack tests. In its present form, however, the modified Wall Signature method is only applicable in post-test analysis as the method is computationally intensive. Dissert. Abstr.

N94-11195*# MCAT Inst., San Jose, CA.
PHYSICS OF FOREBODY FLOW CONTROL
GABRIEL I. FONT Aug. 1993 45 p
(Contract NCC2-729)
(NASA-CR-193626; NAS 1.26:193626; MCAT-93-12) Avail: CASI HC A03/MF A01

Performance in the high angle of attack regime is required by many different types of aircraft. Military aircraft, such as fighters, utilize flight in this regime to improve maneuverability. Civilian aircraft, such as supersonic or hypersonic transports, will also need to operate in this regime during take off and landing, due to their small highly swept wings. Flight at high angles of attack is problematic due to the vortices being created on the nose of the aircraft. The vortices tend to become asymmetric and produce side forces. At the same time, the rudders are less effective because they are becoming immersed in the flow separating from the wings and fuselage. Consequently, the side force produced by the vortices on the nose tend to destabilize the aircraft. This situation may be corrected through the use of a forebody flow control system such as tangential slot blowing. In this concept, a jet is blown from the nose in an effort to alter the flow field around the nose and diminish the destabilizing side force. Alternately, the jet may be used to create a side force which could be used to augment the rudders. This would allow the size of the rudders to be decreased which would, in turn, diminish the cruise drag. Therefore, the use of a tangential slot blowing system has the potential for improving both the maneuver performance and the cruise performance of an aircraft. The present study was conducted to explore the physics of forebody flow control. The study consisted of two major thrusts: (1) exploration of forebody flow control with tangential slot blowing; (2) investigation of flow and field response to a general perturbation. Author

N94-11203*# Toledo Univ., OH.
BLADING MODELS FOR TURBAN AND CSPAN TURBOMACHINE DESIGN CODES Final Report
ARTHUR J. GLASSMAN Jul. 1993 9 p
(Contract NAG3-1165; RTOP 505-69-50)
(NASA-CR-191164; E-7997; NAS 1.26:191164) Avail: CASI HC A02/MF A01

Blading models added to TURBAN, an axial turbine meanline design code, and CSPAN, an axial compressor spanline design code, are presented. Calculations of blade chord length, blade axial length, and number of blades for each blade row are now provided by each code. In order to accomplish this, computational models for axial solidity and stagger angle were added to TURBAN. For a compressor, where solidity and chord were already available from input, the modeling additions to CSPAN were for stagger angle and for the blade angles to include incidence and deviation. All added computations utilized models already available in the literature. Author

N94-11857 Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.
NONLINEAR ASPECTS OF TRANSONIC AEROELASTICITY Thesis, 1992
HEMA SANDHYARANI MURTY Jan. 1993 212 p
(ISSN 0082-5255)
(UTIAS-RN-345) Copyright Avail: CASI HC A10/MF A03
Flutter analysis of airfoils in transonic flow has traditionally assumed linearity of the aerodynamic loads and moment with motion amplitude. However, the nonlinear nature of the mixed flow, incorporating large amplitude shock wave motion, may significantly invalidate the linearity assumption. In this thesis, the effect of nonlinear transonic aerodynamics on the flutter analysis is analyzed utilizing a simplified linear structural model. The aerodynamic conditions under which these effects are significant are determined for specific cases using the NACA 64A010 airfoil. In order to accurately determine the aerodynamic loads and moment, an unsteady full potential code was developed. This code was joined to an algorithm which integrates the structural equations of motion in time. A flutter analysis based on the assumption of linear aerodynamics was carried out to determine the neutral stability conditions defined by a set of structural and aerodynamic parameters. These neutral stability conditions were then used in the structural equations of motion with nonlinear aerodynamic loads and moment. These equations were then integrated in time to determine the response of the system. If the time response was not neutrally stable, then the structural parameter, mu, the airfoil-to-air mass ratio was varied until the time response was neutrally stable. If the difference in the value of the 'nonlinear'mu to 'linear' mu was greater than 10 percent, then that case was considered to exhibit significant nonlinearities. Author (revised)

N94-11870# Army Research Lab., Aberdeen Proving Ground, MD.
COMPUTATION OF HYPERSONIC NOSETIP HEAT TRANSFER RATES FOR AN M829-LIKE PROJECTILE
BERNARD J. GUIDOS and WALTER B. STUREK Apr. 1993 28 p
(Contract DA PROJ. 1L1-62618-AH-80)
(AD-A263226; ARL-MR-52) Avail: CASI HC A03/MF A01
Computational predictions are presented of in-flight blunt nosetip heat transfer rates for an M829-like projectile configuration. Predictions are made for higher-than-conventional flight velocities up to 3 km/sec (Mach 8.8), for both laminar and turbulent flows. Comparisons are made between two predictive approaches: (1) a time-dependent Navier-Stokes numerical technique, and (2) a boundary-layer engineering analysis technique (known as ASCC). Additional comparison is made with wind-tunnel heat transfer measurements for a hemisphere-cylinder configuration at Mach 6.82. The Navier-Stokes predictions agree with the experimental data to within the estimated measurement accuracy. The comparisons between the two predictive approaches show agreement with 10 percent for laminar flow. For turbulent flow, the two codes agree within 10 percent at the stagnation point, and within about 30-40 percent further downstream. The heat transfer rates presented provide a boundary condition model for subsequent analysis of projectile transient thermal response. Author (revised)

N94-11888# Aircraft Research Association Ltd., Bedford (England).
THE MODELLING OF AERODYNAMIC FLOWS BY SOLUTION OF THE EULER EQUATIONS ON MIXED POLYHEDRAL GRIDS
A. J. PEACE and J. A. SHAW Apr. 1992 44 p Previously announced in IAA as A93-21218
(Contract SLS41B/2437)
(ARA-84) Avail: CASI HC A03/MF A01
An algorithm for obtaining solutions to the compressible Euler equations on mixed polyhedral grids is described. These grids, which are in general composed of hexahedral, pentahedral, and tetrahedral elements are used in the modeling of aerodynamic flows over complex three-dimensional geometries. The hexahedra are grouped into regular blocks, while the other elements are part of irregular grid regions, giving rise to the term 'hybrid grid approach'. The interconnection of the grid elements is defined by an efficient data structure, which supplies the required information to drive the Euler algorithm. In fact, cell-vertex and cell-center spatial discretization variants of this algorithm are detailed, along with an explicit time-marching scheme for obtaining steady state solutions. Results on two geometrically simple configurations provide an evaluation of these solution techniques, while the focus on a third, complex configuration, demonstrates the potential of the method in addressing the flow over general aircraft geometries. Author (revised)

N94-11889# Florida Agricultural and Mechanical Univ., Tallahassee.
UNSTEADY FLOW PAST A NACA 0012 AIRFOIL PITCHING AT CONSTANT RATES Final Report, 1 Nov. 1988 - 31 Oct. 1992
LUIZ M. LOURENCO, A. KROTHAPALLI, L. VANDOMMELEN, and C. SHIH 13 Apr. 1993 82 p
(Contract F49629-89-C-0014)
(AD-A265159; FMRL-TR-8; AFOSR-93-0363TR) Avail: CASI HC A05/MF A01
The dynamic stall process of a NACA 0012 airfoil undergoing a constant-rate pitching-up motion is studied experimentally in a water towing tank facility. This study focuses on the detailed measurement of the unsteady separated flow in the vicinity of the leading and trailing edges of the airfoil. The measurements are carried out using the Particle Image Velocimetry (PIV) technique. This technique provides the two-dimensional velocity and associated vorticity fields, at various instants in time, in the mid-span of the airfoil. Near the leading edge, large vortical structures emerge as a consequence of Van Dommelen and Shen type separation and a local vorticity accumulation. The interaction of these vortices with the reversing boundary layer vorticity initiates a secondary flow separation and the formation of a secondary vortex. The mutual induction of this counter-rotating vortex pair eventually leads to the ejection process of the dynamic stall vortex from the leading edge region. DTIC

N94-12377# Brown Univ., Providence, RI. Div. of Applied Mathematics.
COMPUTATIONAL METHODS FOR PROBLEMS IN AERODYNAMICS USING PARALLEL AND VECTOR ARCHITECTURES Final Report, 1 Dec. 1989 - 30 Nov. 1992
DAVID GOTTLIEB 7 May 1993 12 p
(Contract AF-AFOSR-0093-90)
(AD-A265626; AFOSR-93-0404TR) Avail: CASI HC A03/MF A01
The effort to use spectral methods to simulate flows with shock waves is summarized in four published papers. In one of the papers, the authors study uniform high order spectral methods to solve multi-dimensional Euler equations for gas dynamics. Uniform high order spectral approximations with spectral accuracy in smooth regions of solutions are constructed by introducing the idea of the Essentially Non-Oscillatory (ENO) polynomial interpolations into the spectral methods. Based on the new approximations, nonoscillatory spectral methods which possess the properties of both upwinding difference schemes and spectral methods were proposed. Numerical results are presented for the inviscid Burger's equation, and for one dimensional Euler equations including the interactions between a shock wave and density disturbance, Sod's and Lax's shock tube problems, and the blast wave problem. Finally, the interaction between a Mach 3 two dimensional shock wave and a rotating vortex is simulated. DTIC

N94-12421*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A DETERMINATION OF THE EXTERNAL FORCES REQUIRED TO MOVE THE BENCHMARK ACTIVE CONTROLS TESTING MODEL IN PURE PLUNGE AND PURE PITCH
JONATHAN DCRUZ Jul. 1993 31 p
(Contract RTOP 505-63-50-15)
(NASA-TM-107743; NAS 1.15:107743) Avail: CASI HC A03/MF A01

In view of the strong need for a well-documented set of experimental data which is suitable for the validation and/or calibration of modern Computational Fluid Dynamics codes, the Benchmark Models Program was initiated by the Structural Dynamics Division of the NASA Langley Research Center. One of the models in the program, the Benchmark Active Controls Testing Model, consists of a rigid wing of rectangular planform with a NACA 0012 profile and three control surfaces (a trailing-edge control surface, a lower-surface spoiler, and an upper-surface spoiler). The model is affixed to a flexible mount system which allows only plunging and/or pitching motion. An approximate analytical determination of the forces required to move this model, with its control surfaces fixed, in pure plunge and pure pitch at a number of test conditions is included. This provides a good indication of the type of actuator system required to generate the aerodynamic data resulting from pure plunging and pure pitching motion, in which much interest was expressed. The analysis makes use of previously obtained numerical results. Author (revised)

N94-12948# National Aerospace Lab., Tokyo (Japan). Aerodynamics Div.
NUMERICAL SIMULATION OF HYPERSONIC FLOW FOR THE DESIGN OF THE H-2 ORBITING PLANE (HOPE), PART 3 [HOPE NO GOKUCHOUONSOKURYUU SUUCHI SHIMYURESHON]
YUKIMITSU YAMAMOTO Jul. 1992 97 p In JAPANESE
Prepared in cooperation with NSDA, Tokyo, Japan
(ISSN 0389-4010)
(NAL-TR-1168-PT-3; JTN-93-80500-PT-3) Avail: CASI HC A05/MF A02

Three-dimensional upwind flux-split Navier-Stokes codes are applied to examine hypersonic flow around HOPE-01 (H-2 Orbiting Plane) configurations. Numerical results are compared with experimental data from the National Aerospace Lab (NAL) hypersonic wind and shock tunnel. In order to enlarge the applicability of Computational Fluid Dynamics (CFD) for a more practical design purpose, the effects of rudder and elevon deflections were numerically investigated. In addition, to study the aerodynamic and aerothermodynamic environments at the high Mach numbers expected in the HOPE flight trajectory, computations were conducted using a Mach number of 12.0 and 15.0. Aerothermodynamic heating distributions were compared in detail with Calspan's shock tunnel data and fairly good quantitative agreements were obtained. Real gas effects were also analyzed using a chemical non-equilibrium Navier-Stokes code which was developed by combining finite-rate chemical reactions to the currently used perfect gas flux-split code. A fully implicit Alternative Directional Implicit (ADI) scheme is employed to avoid the stiffness problem occurring in the time integration process. Typical real gas effects on aerodynamic characteristics are revealed. This work was conducted as joint research of NAL and the National Space Development Agency (NASDA). Author (NASDA)

N94-12951# National Aerospace Lab., Tokyo (Japan). Dynamic Wind Tunnel Test Group.
IDENTIFYING THE NAL SPACEPLANE AERODYNAMIC MODEL USING DYNAMIC WIND TUNNEL TESTS [KEBURU SHIJI DOUTEKI FUUDOU SHIKEN NIYORU NAL SUPESUPUREN NO KUURIKI MODERU DOUTEI]
MASAAKI YANAGIHARA Jul. 1992 45 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1171; JTN-93-80501) Avail: CASI HC A03/MF A01

An aerodynamic model identification technique utilized by the National Aerospace Laboratory (NAL) was applied to dynamic wind tunnel tests using a cable mounted model to extract aerodynamic parameters of the NAL Spaceplane. The estimated static parameters were evaluated by comparisons with static wind tunnel test results, whereas those for the dynamic parameters were evaluated by comparison with theoretically estimated values. In addition, mathematical flight simulations using both static and dynamic parameters were conducted for the total evaluation. The simulated results were subsequently compared with the wind tunnel test data, and satisfactory correlation was achieved, thereby, demonstrating the effectiveness of the dynamic tests. Author (NASDA)

N94-12989# Naval Surface Warfare Center, Dahlgren, VA.
IMPROVED AEROPREDICTION CODE. PART 1: SUMMARY OF NEW METHODS AND COMPARISON WITH EXPERIMENT
FRANK G. MOORE, THOMAS C. HYMER, and ROY M. MCINVILLE May 1993 156 p
(AD-A266015; NSWCDD/TR-93/91) Avail: CASI HC A08/MF A02

A new and improved version of the Naval Surface Warfare Center, Dahlgren Division aeroprediction code (AP93) was developed. The new code contains new technology that allows planar aerodynamics of axisymmetric solid rocket-type weapons to be computed with engineering accurately over the entire Mach number range and for angles of attack to 30 deg. New technology developed and included in the AP93 includes: a new engineering method to compute aeroheating information at a high Mach number; extension of the second-order shock-expansion theory to include real-gas effects, including several new pressure prediction techniques; an improved body-alone nonlinear normal-force method; new methods for computing nonlinear aerodynamics of wing alone, wing body, and body wing due to angle of attack, and wing body due to control deflection; and a new base-dmg database and improved empirical base-drag estimation technique. DTIC

N94-13076*# Tennessee Univ. Space Inst., Tullahoma. Center for Space Transportation and Applied Research.
A WALL INTERFERENCE ASSESSMENT/CORRECTION SYSTEM Semiannual Report No. 4, Jan. - Jun. 1993
CHING F. LO 1993 45 p
(Contract NAG2-733)
(NASA-CR-194174; NAS 1.26:194174) Avail: CASI HC A03/MF A01

A Wall Signature method originally developed by Hackett was selected to be adapted for the Ames 12-ft Wind Tunnel Wall Interference Assessment/Correction (WIAC) System in the project. This method uses limited measurements of the static pressure at the wall, in conjunction with the solid wall boundary condition, to determine the strength and distribution of singularities representing the test article. The singularities are used in turn for estimating wall interference at the model location. The lifting interference will be treated separately by representing in a horseshoe vortex system for the model's lifting effects. The development and implementation of a working prototype will be completed, delivered, and documented with a software manual. The WIAC code will be validated by conducting numerically simulated experiments rather than actual wind tunnel experiments. The simulations will be used to generate both free-air and confined wind-tunnel flow fields for each of the test articles over a range of test configurations. Specifically, the pressure signature at the test section wall will be computed for the tunnel case to provide the simulated 'measured' data. These data will serve as the input for the WIAC method - Wall Signature method. The performance of the WIAC method then may be evaluated by comparing the corrected parameters with those for the free-air simulation. The following two additional tasks are included in the supplement No. 1 to the basic Grant. On-line wall interference calculation: The developed wall signature method (modified Hackett's method) for Ames 12-ft Tunnel will be the pre-computed coefficients which facilitate the on-line calculation of wall interference; and support system effects estimation: The effects on the wall pressure measurements due

to the presence of the model support systems will be evaluated.
Author (revised)

N94-13172*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AERODYNAMICS OF A SPHERE AND AN OBLATE SPHEROID FOR MACH NUMBERS FROM 0.6 TO 10.5 INCLUDING SOME EFFECTS OF TEST CONDITIONS
M. LEROY SPEARMAN and DOROTHY O. BRASWELL Aug. 1993 26 p
(Contract RTOP 505-69-20-01)
(NASA-TM-109016; NAS 1.15:109016) Avail: CASI HC A03/MF A01

Wind-tunnel tests were made for spheres of various sizes over a range of Mach numbers and Reynolds numbers. The results indicated some conditions where the drag was affected by changes in the afterbody pressure due to a shock reflection from the tunnel wall. This effect disappeared when the Mach number was increased for a given sphere size or when the sphere size was decreased for a given Mach number. Drag measurements and Schlieren photographs are presented that show the possibility of obtaining inaccurate data when tests are made with a sphere too large for the test section size and Mach number. Tests were also made of an oblate spheroid. The results indicated a region at high Mach numbers where inherent positive static stability might occur with the oblate-face forward. The drag results are compared with those for a sphere as well as those for various other shapes. The drag results for the oblate spheroid and the sphere are also compared with some calculated results. Author

N94-13180*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
NUMERICAL STUDY OF THE EFFECTS OF ICING ON VISCOUS FLOW OVER WINGS Semiannual Progress Report, 1 Jan. - 30 Jun. 1993
L. N. SANKAR Jul. 1993 38 p
(Contract NAG3-768)
(NASA-CR-193306; NAS 1.26:193306) Avail: CASI HC A03/MF A01

The progress made during the period 1 Jan. - 30 Jun. 1993 on the numerical study of the effects of icing on viscous flow over wings is summarized. The tasks performed were development of 3-D boundary layer methods for accurate estimates of the velocity field and surface heat transfer rates in the vicinity of the leading edge ice shape; studies of the effects of icing on 3-D highlift system performance; and continued improvement and validation of the 3-D Navier-Stokes solver. Results are discussed.
CASI

N94-13260# Sandia National Labs., Albuquerque, NM.
PARACHUTE SYSTEM DESIGN, ANALYSIS, AND SIMULATION TOOL
W. D. SUNDBERG, D. D. MCBRIDE, K. W. GWINN, D. E. WAYE, and C. E. HAILEY 1992 11 p Presented at the 12th Royal Aeronautical Society/AIAA Aerodynamic Decelerator Systems Technical Conference, London, England, 10 May 1993
(Contract DE-AC04-76DP-00789)
(DE93-013755; SAND-92-1888C; CONF-930580-3; AIAA PAPER-93-1208) Avail: CASI HC A03/MF A01

For over twenty years designers at Sandia National Laboratories have developed various parachute simulation codes to model deployment, inflation, loading, trajectories, aircraft downwash, and line sail. In addition to these codes, material property data bases have been acquired. Recently we have initiated project to integrate these codes and data bases into a single software tool entitled SPARSYS (Sandia PARachute SYstem Simulation). We have constructed a graphical user interface as the driver and framework for SPARSYS. In this paper we present a status report on SPARSYS describing progress in developing and incorporating independent modules, in developing an integrated trajectory package, and in developing a materials data base including high-rate-of-strain data. DOE

N94-13266*# Stanford Univ., CA. Joint Inst. for Aeronautics and Acoustics.
THREE-DIMENSIONAL STRUCTURE OF STRAIGHT AND CURVED PLANE WAKES
JAMES H. WEYGANDT and RABINDRA D. MEHTA Sep. 1993 339 p
(Contract NCC2-55)
(NASA-CR-194420; NAS 1.26:194420; JIAA-TR-110) Avail: CASI HC A15/MF A03

Although the plane wake is marked by the formation of strong spanwise vortices, the initially two-dimensional Karman-like vortices soon develop a three-dimensional structure in the form of secondary streamwise vortices. So far, this streamwise vortex structure has been studied mostly through flow visualization and at relatively low Reynolds numbers. The primary objective of the present program was to investigate the origin and evolution of the three-dimensional structure of straight and curved plane wakes at relatively high Reynolds numbers (Re(sub b) = 28,000) through detailed measurements of the mean and turbulent properties at several streamwise locations. The experiments were conducted in three phases. In the first phase, the development of a straight plane wake was investigated. In the second phase, the effects of imposed streamwise curvature on the wake development were examined. The streamwise curvature was of constant radius and very mild in terms of the curvature ratio (b/(square root of R) is less than 2 percent). In both the first and second phases, the role of initial conditions was examined in wakes generated from both untripped (laminar) and tripped (turbulent) initial boundary layers. In the third phase, the effects of injecting streamwise vorticity and the effects of increased Reynolds number on the tripped wake structure and development were investigated.
Author (revised)

N94-13292*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
EXPLORATORY STUDY OF IN-PLANE STREAMLINE CURVATURE EFFECTS ON A TURBULENT BOUNDARY LAYER AT A MACH NUMBER OF 3 Final Technical Report, 27 Jan. 1989 - 26 Jan. 1990
SEYMOUR M. BOGDONOFF May 1991 4 p
(Contract NAG1-961)
(NASA-CR-193673; NAS 1.26:193673) Avail: CASI HC A01/MF A01

This report on a program to study in-plane streamline curvature effects in a turbulent boundary layer at a Mach number of 3. The original proposal, for a 3-year program to explore in-plane streamline curvature effects on a supersonic turbulent boundary layer using three-dimensional pressure fields generated by fins and wall geometry, ended after one year. The purpose of these tests was to compare these streamline curvature effects to the more classical two-dimensional curvature generated by wall shape and imposed pressure gradients, previously considered primarily in a plane normal to the floor. The studies were carried out in the Mach number of 3, 8 x 8 inch High Reynolds Number Supersonic Tunnel. The usual surface visualization and mean wall static pressures were supplemented by the use of many small high frequency wall static pressure gauges (Kulites) to get some indication of the amplification of boundary layer disturbances by the in-plane streamline curvature caused by the three-dimensional pressure fields imposed on the boundary layer.
Derived from text

N94-13340# National Aerospace Lab., Tokyo (Japan). Advanced Aircraft Research Group.
LOW-SPEED WIND TUNNEL TESTS ON FOUR TYPES OF JOINED-WING AIRCRAFT MODELS [HISHIGATA KETSUGOUYOKUKI 4 KEITAI NO TEISOKU FUUDOU JIKKEN]
AKIHITO IWASAKI, TOSHIMI FUJITA, HIROTOSHI FUJIEDA, and NAOTO TAKIZAWA Jul. 1992 24 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1167; JTN-93-80487) Avail: CASI HC A03/MF A01

Low-speed wind tunnel tests were conducted on four types of joined-wing aircraft models. Various ratios of horizontal tail to wing span were employed (40 percent, 60 percent, and 100 percent), and the leading-edge at the tip of horizontal tail was joined to the trailing-edge of the wing for three configurations. In addition, in one configuration, the tips of the horizontal tail and the wing were overlapped using the 100 percent ratio. The horizontal tail has minus 22 deg dihedral and minus 25 deg sweep angles (25 percent chord line). The main wing has respectively corresponding angles of 10 deg and 40 deg. The results indicated that the area and location of horizontal tail significantly effect the aerodynamic characteristics of the joined-wing aircraft. Author (NASDA)

N94-13341# National Aerospace Lab., Tokyo (Japan). Advanced Aircraft Research Group.

LOW-SPEED WIND TUNNEL TESTS ON A JOINED-WING AIRCRAFT MODEL WITH VARIOUS UPPER-FIN [HISHIGATA KETSUGOUYOKUKI (UEYOKU TSUKI) NO TEISOKU FUUDOU JIKKEN]

AKIHITO IWASAKI, TOSHIMI FUJITA, HIROTOSHI FUJIEDA, and NAOTO TAKIZAWA Jul. 1992 27 p In JAPANESE

(ISSN 0389-4010)

(NAL-TR-1169; JTN-93-80488) Avail: CASI HC A03/MF A01

Low-speed wind tunnel tests were conducted on a joined-wing aircraft model with various upper-fins (small wing-like surface fitted on the wing or the horizontal tail). The upper-fin was used to enhance direct side-force control capability. In this case, the upper-fin was equipped with a plain flap as a rudder. The effects of the upper-fin on the aerodynamic characteristics of a joined-wing aircraft are described. A 0.6 ratio of the rear to front wing span was selected as the best condition. Four different shaped upper-fins were installed at the three locations on each wing at 0.6 half span. Reynolds number based on the mean aerodynamic chord was from 6.5 to 6.7 x 10(exp 5). The angle of attack was varied from zero to 25 deg., and the side-slip angle from zero to 15 deg. The results indicated that the upper-fin acts like a 'boundary layer fence' and protects wing tip stall when the upper-fin is installed on the wing. On the other hand, the upper-fin produced local flow separation over the wing, and this flow separation caused asymmetric lateral and directional characteristics with side-slip angle. Author (NASDA)

N94-13342# National Aerospace Lab., Tokyo (Japan). Thermofluid Dynamics Div.

DEVELOPMENT OF A HIGH-SPEED MECHANICAL DRIVE SYSTEM FOR OSCILLATING AN ANNULAR BLADE ROW IN THE BENDING MODE [KOUSOKU KIKAISHIKI YOKURETSU MAGE SHINDOU KASHIN SOUCHI TO SONO TOKUSEI]

HIDESHI OINUMA and HIROSHI KOBAYASHI Jul. 1992 22 p In JAPANESE

(ISSN 0389-4010)

(NAL-TR-1170; JTN-93-80489) Avail: CASI HC A03/MF A01

A novel high-speed mechanical drive system was developed which enables controlled-oscillations to be produced in an annular blade row in the bending mode, thus, allowing solutions to be obtained for cascade flutter in turbomachinery. This system makes possible to take unsteady aerodynamic force measurements in the National Aerospace Laboratory (NAL) Annular Cascade Test Facility at the realistic, reduced frequency level of supersonic flutter in turbomachinery. Blade row oscillation tests demonstrated that the presented system can controllably-oscillate, at up to 200 Hz, all 16 blades composing the annular blade row at a constant amplitude and interblade phase angles. Both aerodynamically unstable and stable conditions of the annular blade row can be controllably-oscillated while operating in a supersonic flow field. Author (NASDA)

N94-13345# National Aerospace Lab., Tokyo (Japan). Airframe Div.

ESTIMATION OF CRITICAL VALUES AND VIBRATION CHARACTERISTICS ON SUPERSONIC DELTA WINGS. PART 2: LOCALLY-STATIONARY TIME SERIES ANALYSIS OF NONSTATIONARY RANDOM RESPONSES [CHOUONSOKU DERUTAYOKU NO SHINDOU TOKUSEI TO ANTEIGENKAI NO SUITEI: HITEIJOUNA FUKISOKU OUTOU NO KYOKUSHO TEIJOU JIKEIRETSU KAISEKI]

MASAKATSU MINEGISHI, YASUKATSU ANDOU, YUUJI MATSUZAKI, HIROSHI EJIRI, SEIZOU SAKAKIBARA, JUNICHI NODA, KIYOMICHI ISHIDA, HIDEO SEKINE, ATSUSHI TATE, and MITSUNORI WATANABE Sep. 1992 22 p In JAPANESE

(ISSN 0389-4010)

(NAL-TR-1179; JTN-93-80492) Avail: CASI HC A03/MF A01

A locally-stationary time series analysis of nonstationary random responses in delta wings under supersonic conditions is presented. Since the partially supported cantilever delta wings failed during supersonic blowdown wind tunnel tests employing the injection and rejection systems, a safety device was introduced to prevent such failures. This enabled wing response data to be obtained from a test blow in which the dynamic pressure was increased at a constant speed with the Mach number being fixed. Estimated results indicated that the wing's critical values could be determined by applying the locally-stationary autoregressive process. Author (NASDA)

N94-13369 Queens Univ., Kingston (Ontario). Dept. of Mechanical Engineering.

AN EXPERIMENTAL INVESTIGATION OF THE REDISTRIBUTION OF GAS STREAM TOTAL TEMPERATURE IN A HIGH TURNING ANGLE TRANSONIC PLANAR CASCADE Ph.D. Thesis

WILLIAM EDWARD CARSCALLEN Apr. 1990 170 p

(ISBN-0-315-60791-2; CTN-93-60734) Copyright Avail: Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC/MF

Early testing at the National Research Council of Canada's (NRC) Highly Loaded Turbine Test Rig revealed an apparent redistribution of the gas stream total temperature field as it passed through a transonic turbine nozzle. Furthermore, there appeared to be a change in area averaged total temperature across the nozzle row. In order to examine these observations, a transonic planar cascade of the exhauster type was constructed at NRC. Tests were carried out at pressure ratios giving nozzle isentropic exit Mach numbers ranging from low subsonic to low supersonic. Wedge probes were used to measure total temperature, total pressure, and flow angles downstream of the nozzle blades. Results of this detailed experimental investigation decisively indicated that the gas stream total temperature at the nozzle exit was highly redistributed. This total temperature separation or energy redistribution strongly depended on Mach number. A maximum temperature separation of 36.0 F occurred just prior to Mach number 1.0. The maximum negatively depressed values of the temperature change differ from those calculated by preliminary analysis and are not just a function of adiabatic wall temperature. An increase of area averaged temperature change was found and was attributed to heat transfer from the ambient surroundings to the planar cascade. Author (CISTI)

N94-13392# National Aerospace Lab., Tokyo (Japan). Flight Research Div.

ESTIMATION OF AIRCRAFT AERODYNAMIC DERIVATIVES WITH THE TOTAL LEAST SQUARES METHOD [TOTARURISUTO SUKUEA HOU WO MOCHIITA KOUKUUKI NO KUURIK I BIKEISUU NO SUITEI]

KAZUYA MASUI Apr. 1992 26 p In JAPANESE

(ISSN 0389-4010)

(NAL-TR-1150; JTN-93-80483) Avail: CASI HC A03/MF A01

This report describes the Total Least Squares (TLS) Method which estimates unknown linear equation coefficients assuming that both the explanatory variables and the objective variable are

affected by measurement errors. This method is one of the generalizations of the conventionally used Least Squares (LS) Method. The concept, algorithm, and characteristics of the TLS method are compared with those of the LS method. It is shown that the TLS method gives the unbiased coefficients and the correct standard deviations of them. In addition, an example of estimating aerodynamic derivatives from flight test data is presented.
Author (NASDA)

N94-13422*# MCAT Inst., San Jose, CA.
HIGH SPEED TRANSITION PREDICTION Final Report
GEDIMINIS GASPERAS Aug. 1993 20 p
(Contract NCC2-704)
(NASA-CR-194125; NAS 1.26:194125; MCAT-93-16) Avail: CASI HC A03/MF A01

The main objective of this work period was to develop, maintain and exercise state-of-the-art methods for transition prediction in supersonic flow fields. Basic state and stability codes, acquired during the last work period, were exercised and applied to calculate the properties of various flowfields. The development of a code for the prediction of transition location using a currently novel method (the PSE or Parabolized Stability Equation method), initiated during the last work period and continued during the present work period, was cancelled at mid-year for budgetary reasons. Other activities during this period included the presentation of a paper at the APS meeting in Tallahassee, Florida entitled 'Stability of Two-Dimensional Compressible Boundary Layers', as well as the initiation of a paper co-authored with H. Reed of the Arizona State University entitled 'Stability of Boundary Layers'.
Derived from text

N94-13454# National Aerospace Lab., Tokyo (Japan). Advanced Aircraft Research Group.
EXPERIMENTAL STUDIES OF VORTEX FLAPS AND VORTEX PLATES. PART 2: 1.15M SPAN 60 DEG DELTA WING
KENICHI RINOIE and JOHN L. STOLLERY (Cranfield Inst. of Tech., Bedford, England.) Oct. 1992 39 p
(ISSN 0389-4010)
(NAL-TR-1180T-PT-2; JTN-93-80502-PT-2) Avail: CASI HC A03/MF A01

Low-speed wind tunnel tests were carried out on several vortex flap and vortex plate configurations to assess their benefits. The force and surface pressure measurements were taken using a 1.15 m span, 60 deg delta wing model. Results indicate that the vortex flap deflection angle, which causes the flow to come almost smoothly onto the flap surface without any large separation, shows a much higher lift/drag ratio than the flap deflection angle which forms a leading-edge separation vortex over the flap surface. It was also found that there is no benefit in vortex flap deployment at incidences higher than the stall incidence. The performance of a vortex plate protruding from the leading-edge of the datum delta wing is shown to be comparable to that of the vortex flap. However, when the vortex plate is used with the vortex flap deflected, these tests showed no benefits. Author (NASDA)

N94-13463*# Colorado Univ., Boulder. Dept. of Aerospace Engineering Sciences.
ANALYSIS OF THE HARRIER FOREBODY/INLET DESIGN USING COMPUTATIONAL TECHNIQUES Final Report, 1 Mar. 1991 - 31 Aug. 1993
CHUEN-YEN CHOW 1993 3 p
(Contract NCC2-714)
(NASA-CR-193616; NAS 1.26:193616) Avail: CASI HC A01/MF A01

Under the support of this Cooperative Agreement, computations of transonic flow past the complex forebody/inlet configuration of the AV-8B Harrier II have been performed. The actual aircraft configuration was measured and its surface and surrounding domain were defined using computational structured grids. The thin-layer Navier-Stokes equations were used to model the flow along with the Chimera embedded multi-grid technique. A fully conservative, alternating direction implicit (ADI), approximately-factored, partially flux-split algorithm was employed to perform the computation. An existing code was altered to conform with the needs of the study, and some special engine face boundary conditions were developed. The algorithm incorporated the Chimera technique and an algebraic turbulence model in order to deal with the embedded multi-grids and viscous governing equations. Comparison with experimental data has yielded good agreement for the simplifications incorporated into the analysis. The aim of the present research was to provide a methodology for the numerical solution of complex, combined external/internal flows. This is the first time-dependent Navier-Stokes solution for a geometry in which the fuselage and inlet share a wall. The results indicate the methodology used here is a viable tool for transonic aircraft modeling. Author

N94-13528# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
ON THE USE OF THE METHOD OF MATCHED ASYMPTOTIC EXPANSIONS IN PROPELLER AERODYNAMICS AND ACOUSTICS
H. H. BROUWER 9 Aug. 1991 52 p Submitted for publication
(NLR-TP-91307-U; ETN-93-94337; AD-B169652L) Avail: CASI HC A04/MF A01

The applicability of the method of matched asymptotic expansions to both propeller aerodynamics and acoustics is investigated. The method is applied to a propeller with blades of high aspect ratio, in a uniform axial flow. The first two terms of the inner expansion and the first three terms of the outer expansion are considered. The matching yields an expression for the spanwise distribution of the downwash velocity. However, recasting the analytical expressions into an integral equation, similar to Pradtl lifting line equation for wings, yields results for both aerodynamic and acoustic quantities, which agree well with experimental results. The method, thus, constitutes a practical analysis method for conventional propellers. ESA

N94-13530# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
CLEBSCH VARIABLE MODEL FOR UNSTEADY, TRANSONIC FLOW; APPLICATION TO 2D AIRFOILS
J. WESTLAND 11 Oct. 1991 85 p
(Contract NIVR-01904N)
(NLR-TP-91387-U; ETN-93-94339) Copyright Avail: CASI HC A05/MF A01

A three dimensional model is derived from the unsteady Euler equations, in which shock generated entropy and vorticity are modeled using a Clebsch variable. This flow model is an extension of full potential theory and is capable of describing unsteady, inviscid, transonic flow with strong shock waves. Its implementation in the existing computer code TULIPS for the calculation of unsteady, transonic flow around a two dimensional airfoil by means of full potential theory is described. Results obtained show good agreement with results obtained from codes based on the Euler equations. ESA

N94-13531# National Aerospace Lab., Amsterdam (Netherlands). Informatics/Fluid Dynamics Div.
A ROBUST QUASI-SIMULTANEOUS INTERACTION METHOD FOR A FULL POTENTIAL FLOW WITH A BOUNDARY LAYER WITH APPLICATION TO WING/BODY CONFIGURATIONS
A. J. VANDERWEES and J. VANMUIJDEN 15 Oct. 1991 18 p
Presented at the 5th Symposium on Numerical and Physical Aspects of Aerodynamical Flows, Long Beach, CA, 13-15 Jan. 1992
(Contract NIVR-01802N)
(NLR-TP-91397-U; ETN-93-94340) Avail: CASI HC A03/MF A01

A progress report on the system MATRICS (Multicomponent Aircraft Transonic Inviscid Computation System), for the calculation of the three dimensional inviscid transonic potential flow about wing/body configurations, is given. At present, work is in progress to extend MATRICS to take viscous effects into account through coupling with a boundary layer solver. This solver, MATRICS-5, is based on robust calculation methods for the boundary layer, the outer wing flow, and their interaction. MATRICS-5 is intended for (inverse) design purposes. The boundary layer and wake are based on an integral formulation of the unsteady first order boundary layer equations, the inviscid method is the existing MATRICS potential flow solver, and the interaction algorithm is of the quasisimultaneous type. ESA

N94-13555 Virginia Polytechnic Inst. and State Univ., Blacksburg.
A TECHNIQUE FOR DIRECT MEASUREMENT OF SKIN FRICTION IN SUPERSONIC COMBUSTION FLOW Ph.D. Thesis
DIANNE JOAN DETURRIS 1992 162 p
Avail: Univ. Microfilms Order No. DA9310502

A technique has been developed to directly measure skin friction in the turbulent boundary layer of a three-dimensional supersonic combustion flow. A floating element cantilever beam configuration has been designed to detect two components of the small tangential shear forces created by the flow passing over the non-intrusive floating element. Although skin friction has been measured successfully in cold flow before, this gauge is uniquely designed for testing in high temperature, high heat flux environments. The application which specifically prompted the development of this technique was the propulsion system for the National Aero-Space Plane. An appreciable need exists to determine the skin friction inside the combustor of this scramjet engine, and the three-dimensional, supersonic, reacting flow field is difficult to predict numerically. Gauges were tested in a variety of supersonic combustion facilities, with each combustor requiring customization of the gauge design to the test conditions and geometry of the model wall. Maintaining constant temperature of the strain gages inside the sensor throughout the test cycle is of critical importance, due to their sensitivity to temperature changes. Over the course of the project, many parameters which may affect the measurement were identified and examined individually. Changes were adapted into the design when necessary, including tailoring the design to insure that the floating element temperature remains close to that of the surrounding wall. For this reason, a numerical heat transfer study was undertaken to check that the gauge could be adapted for new test conditions. The output from the gauge during supersonic combustion was found to be repeatable for the same nominal input conditions, and this repeatability was consistent from facility to facility. Results in two-dimensional, supersonic cold flow compare well with predicted flat plate values. Results indicate that C(sub f) is considerably higher in some cases than the corresponding value for a similar Reynolds number flow without combustion. The overall accuracy of the gauge is estimated to be +/- 10 percent. The gauge has made useful measurements in varying flow environments, and shown that its design is adaptable and durable. Author

N94-13556 Princeton Univ., NJ.
A THREE-DIMENSIONAL SUPERSONIC TURBULENT BOUNDARY LAYER GENERATED BY AN ISENTROPIC COMPRESSION Ph.D. Thesis
WOLFGANG KONRAD 1993 200 p
Avail: Univ. Microfilms Order No. DA9311224

An experimental study of a three-dimensional supersonic turbulent boundary layer generated by an isentropic compression is described. The incoming boundary layer was at Mach 2.9 and compressed by a 20 degree curved fin. The experimental data set comprises both mean and fluctuating data. Additionally, data from computations performed by Knight at Rutgers University were available for analysis. Surface flow visualizations, surface static pressures, flowfield surveys of Pitot pressure, yaw angle, and static pressure, and Preston tube measurements were included in the mean data. Hot-wire anemometry with normal and crossed-wires was used to obtain measurements of five of the six components of the Reynolds stress tensor ((-rho-bar)(v')(omego') being the only quantity not measured). The characteristics of the mean flowfield structure were revealed using both the experimental and the computed mean data. Three different flow regimes were identified: the small crossflow region, the upstream convergence region, and the downstream convergence region. The features of each region were discussed in detail. The turbulence behavior was investigated at one location in each of these identified flow regimes. The mean flowfield behavior was used to explain the turbulence behavior and differences to two-dimensional flows in similar pressure gradients were pointed out. A comparison of the turbulence behavior to that in an adverse pressure gradient with identical initial conditions indicates that the Reynolds shear stress (-rho-bar)(u'v')-bar is significantly reduced due to three-dimensionality and streamline curvature. The results show for the first time in supersonic flow the stabilizing effect of in-plane curvature. Further comparisons with available turbulence data in a 10 degree sharp fin interaction showed a generally similar behavior which was attributed to similar mean flowfield structure. Dissert. Abstr.

N94-13607*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
CALCULATION OF HYPERSONIC SHOCK STRUCTURE USING FLUX-SPLIT ALGORITHMS
W. M. EPPARD and B. GROSSMAN Jul. 1991 17 p
(Contract NAG1-776)
(NASA-CR-194296; NAS 1.26:194296; ICAM-91-07-04) Avail: CASI HC A03/MF A01

There exists an altitude regime in the atmosphere that is within the continuum domain, but wherein the conventional Navier-Stokes equations cease to be accurate. The altitude limits for this so called continuum transition regime depend on vehicle size and speed. Within this regime the thickness of the bow shock wave is no longer negligible when compared to the shock stand-off distance and the peak radiation intensity occurs within the shock wave structure itself. For this reason it is no longer valid to treat the shock wave as a discontinuous jump and it becomes necessary to compute through the shock wave itself. To accurately calculate hypersonic flowfields, the governing equations must be capable of yielding realistic profiles of flow variables throughout the structure of a hypersonic shock wave. The conventional form of the Navier-Stokes equations is restricted to flows with only small departures from translational equilibrium; it is for this reason they do not provide the capability to accurately predict hypersonic shock structure. Calculations in the continuum transition regime, therefore, require the use of governing equations other than Navier-Stokes. Several alternatives to Navier-Stokes are discussed; first for the case of a monatomic gas and then for the case of a diatomic gas where rotational energy must be included. Results are presented for normal shock calculations with argon and nitrogen. Author (revised)

N94-13621* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A FUTURE VIEW OF COMPUTATIONAL SCIENCE IN AIRCRAFT (Videotape)
Aug. 1989 Videotape: 9 min. 26 sec. playing time, in color, with sound
(NASA-TM-109284; NONP-VT-93-185300) Avail: CASI VHS A01/BETA A22

The accomplishments of LeRC in the field of computational fluid dynamics are presented. Author (revised)

N94-13705# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
A COMPARISON OF COMPUTATIONAL AND EXPERIMENTAL DATA FOR A SUBSCALE HIGH SPEED PROPULSIVE NOZZLE AT LOW MACH NUMBERS M.S. Thesis
YONGHEE HYUN Jun. 1993 164 p
(AD-A266543; AFIT/GAE/ENY/93J-02) Avail: CASI HC A08/MF A02

This computational study of a hypersonic sub-scale nozzle/cowl configuration compares numerical solutions with experimental data for nozzle performance at off design conditions (subsonic through supersonic Mach numbers). A combination of Van Leer and Roe flux-splitting algorithms was used to solve the flow field. The explicit formulation assumed laminar planar flow and the perfect gas

equation of state. A validation for the numerical algorithm was accomplished by comparing with experimental data for a variety of cases. Grid refinement, geometry, and operating conditions all influenced the comparison of the experimental and computational data. Generally, as the Mach number and nozzle pressure ratio increased, the consistency between the experimental results showed better agreement, although the computational investigation was performed on the basis of planar, laminar flow. For the different cowl configurations, the results for baseline and -5 degree cowl show a better agreement than the long and +5 degree cowl.
DTIC

N94-13795# Army Research Lab., Aberdeen Proving Ground, MD.
A COMPUTATIONAL STUDY OF THE BASE REGION FLOW FIELD FOR THE M865 PROJECTILE Final Report, Nov. 1990 - Jun. 1991
JUBARAJ SAHU Apr. 1993 33 p Supersedes BRL-IMR-955, Jan. 1991 *Original contains color illustrations*
(ARL-TR-109) Avail: CASI HC A03/MF A01

Recent firing tests for the M865 projectile have indicated that for reasons unknown, the tracer in the base cavity region does not remain visible during the entire flight. To assist in analyzing this problem, a computational study began to examine the base region flow field for this projectile including the base cavity. Flow computations for this projectile were performed at various supersonic Mach numbers, 2 less than M less than 5 and alpha = 0.0 degree using a time marching Navier-Stokes code. The computed results show sharp changes in the centerline pressure distributions in the base region near M = 3. This unexpected behavior may not be desirable and could be part of the problem. To minimize these pressure oscillations, several proposed configuration changes were made in the afterbody base cavity region and computations were performed for these modified configurations to analyze the effects on the flow field. One of these configurations with a new base cavity shape was found to improve the base region flow field. A modified version of this new base cavity was flight tested and the results revealed some improvement in the visibility of the tracer compared to the original configuration. Author (revised)

N94-14030*# MCAT Inst., San Jose, CA.
CNSFV CODE DEVELOPMENT, VIRTUAL ZONE NAVIER-STOKES COMPUTATIONS OF OSCILLATING CONTROL SURFACES AND COMPUTATIONAL SUPPORT OF THE LAMINAR FLOW SUPERSONIC WIND TUNNEL Final Report
GOETZ H. KLOPFER May 1993 30 p Original contains color illustrations
(Contract NCC2-616)
(NASA-CR-194259; NAS 1.26:194259; MCAT-93-14) Avail: CASI HC A03/MF A01; 2 functional color pages

The work performed during the past year on this cooperative agreement covered two major areas and two lesser ones. The two major items included further development and validation of the Compressible Navier-Stokes Finite Volume (CNSFV) code and providing computational support for the Laminar Flow Supersonic Wind Tunnel (LFSWT). The two lesser items involve a Navier-Stokes simulation of an oscillating control surface at transonic speeds and improving the basic algorithm used in the CNSFV code for faster convergence rates and more robustness. The work done in all four areas is in support of the High Speed Research Program at NASA Ames Research Center.
Author (revised)

N94-14031# Institute for Aerospace Research, Ottawa (Ontario). Applied Aerodynamics Lab.
FLOW-FIELD INTERFERENCE PRODUCED BY AN ASYMMETRICAL SUPPORT STRUT
M. E. BEYERS, H. J. CAI, and P. J. PENNA Jan. 1993 45 p
(IAR-AN-75; NCR-32157; CTN-93-60735) Avail: CASI HC A03/MF A01

The interference flow field associated with an asymmetrical strut-mounted aircraft model was studied visually and through floor pressure measurements in a low-speed wind tunnel. The object of the investigation was to elucidate the unsteady interference phenomena which are expected to prevail in oscillatory tests. The conditions under which direct support interference and coupled support/wall interference could occur were explored qualitatively. Static support interference was found to be significant at incidence angles below approximately 20 deg, and wall interference was found to be significant above this angle. Coupled support/wall interference is expected to be larger in pitch oscillation than in roll oscillation tests. This unsteady interference is expected to peak at intermediate incidence angles near 28 deg. These findings are generally applicable to test installations involving similarly sized models in closed, low-speed wind tunnels. Author (CISTI)

N94-14059# National Aerospace Lab., Tokyo (Japan). Advanced Aircraft Research Group.
EXPERIMENTAL STUDIES OF VORTEX FLAPS AND VORTEX PLATES. PART 1: *0.53 M SPAN 60 DEG DELTA WING*
KENICHI RINOIE Mar. 1992 18 p
(ISSN 0389-4010)
(DE93-767969; NAL-TR-1140T; JTN-93-80426) Avail: CASI HC A03/MF A01

Low-speed wind tunnel tests were conducted to investigate the flow around a leading-edge vortex flap at the maximum lift to drag (L/C) condition, and also to measure the performance of an inverted vortex flap and vortex plate. Associated force measurements and flow visualization tests were carried out on a 60 deg delta wing model. Results indicate that the maximum lift to drag ratio for any given flap deflection angle occurs when the flow smoothly comes onto the deflected vortex flap without forming a large leading-edge separation vortex on the flap surface. Use of a vortex plate was found to reduce the drag in comparison to the datum wing, a benefit due to some leading-edge suction acting on the forward facing region between the delta wing and the vortex plate. Author (NASDA)

N94-14061# National Aerospace Lab., Tokyo (Japan). Structural Mechanics Div.
NUMERICAL SIMULATION OF DYNAMIC STALL OF NACA0012 AIRFOIL OSCILLATING NEAR STATIC STALL ANGLE USING THE NAVIER-STOKES EQUATIONS
KOUJI ISOGAI Mar. 1992 25 p Original contains color illustrations
(ISSN 0389-4010)
(DE93-767970; NAL-TR-1141T; JTN-93-80427) Avail: CASI HC A03/MF A01

Numerical simulations were performed using the compressible Navier-Stokes equations to investigate the dynamic stall phenomena of the NACA0012 airfoil oscillating near the static stall angle. The Yee-Harten Total Variation Diminishing (TVD) scheme and the Baldwin-Lomax algebraic turbulence model were employed. The flow pattern, instantaneous pressure distribution, and behavior of the lift and pitching moment during dynamic stall were examined in detail. Computations showed that the major features of the dynamic stall phenomenon were qualitatively well reproduced, e.g., the formation of the leading-edge separation vortex and the behavior of the lift and pitching moment hysteresis loops. However, comparisons of the resultant pitching moment hysteresis loops with experimental data indicated that further research is necessary to obtain a rigorous quantitative prediction of the unsteady aerodynamic forces arising from the massively separated flows. Author (NASDA)

N94-14153# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
METHODOLOGY OF HYPERSONIC TESTING
1993 339 p Presented at VKI/AEDC Special Course Lecture Series, Rhode Saint Genese, Belgium, 22-26 Feb. 1993
(ISSN 0377-8312)
(VKI-LS-1993-03; D/1993/0238/409; ETN-93-94446) Copyright Avail: CASI HC A15/MF A03

An overview of the methods used in hypersonic testing and evaluation is presented and the principles behind those test techniques are explained. Topics covered include an introduction to hypersonic aerodynamics with descriptions of chemical and gas dynamic phenomena associated with hypersonic flight; categories and application of various hypersonic ground test facilities; characterization of facility flow fields; measurement techniques (both intrusive and non intrusive); hypersonic propulsion test principles and facilities; computational techniques and their integration into test programs; ground-test-to-flight data correlation methods; and test program planning. The Lecture Series begins at the introductory level and progressively increases in depth, culminating in a focus on special test and evaluation issues in hypersonics such as boundary layer transition, shock interactions, and electromagnetic wave testing.

ESA

N94-14154# Sverdrup Technology, Inc., Arnold AFS, TN.
HYPERSONIC OVERVIEW
VIRGIL K. SMITH, III *In* VKI, Methodology of Hypersonic Testing 23 p 1993 Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
Copyright Avail: CASI HC A03/MF A03

An introduction to the field of hypersonic testing methodology is given by describing the traditional and future hypersonic system mission requirements. The terminology and phenomenology which is characteristic of hypersonic flow fields, including both the fluid mechanics and physical chemistry characteristics, are addressed. An overview of the hypersonic Test and Evaluation (T and E) requirements, which include the T and E challenges of future systems, the corresponding T and E facilities challenges and shortfalls, and the enabling methodologies and options is given.

ESA

N94-14155# Calspan Corp., Arnold AFS, TN.
HYPERSONIC FLOW PHENOMENOLOGY
JAMES R. MAUS *In* VKI, Methodology of Hypersonic Testing 15 p 1993 Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
Copyright Avail: CASI HC A03/MF A03

A survey of some of the fundamental features of hypersonic flow is presented which introduces some of the purely fluid dynamic effects associated with high Mach numbers, as well as thermochemical effects inherent in high speed flows. Concepts such as Mach number independence and Newtonian theory are developed from simple gas dynamic relations. Boundary layer concepts are introduced, and the importance of the energy equation for predicting heating rates is discussed. The effect of entropy swallowing on the boundary layer development is addressed. Viscous interaction effects associated with the thick boundary layers of the high altitude flight regime are also introduced. Thermochemical effects arising due to elevated temperatures encountered in high speed flows are discussed. A method for calculating the equilibrium composition and thermodynamic properties of a reacting gas is described, and examples of the effects of chemical reactions on external and internal flows are presented. The phenomenological aspects of hypersonic flow are emphasized relying on a minimum of mathematical development.

ESA

N94-14166# Calspan Corp., Arnold AFS, TN.
HYPERSONIC FLOW FIELD MEASUREMENTS: INTRUSIVE
R. K. MATTHEWS *In* VKI, Methodology of Hypersonic Testing 13 p 1993 Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
Copyright Avail: CASI HC A03/MF A03

'Intrusive' flow field measurements, ones that require a probe or other device to be inserted into the flow, are discussed. In general, these intrusive techniques are currently viewed as inferior to the more popular nonintrusive techniques. However, it should be remembered that in general these intrusive techniques have evolved over several decades while the flow field experience of nonintrusive techniques is relatively limited. Included in the intrusive classification are pitot tubes, total temperature probes, Mach/angularity probes, static pressure devices, hot wire anemometers, and flow visualization methods (vapor screen, and oil flow techniques). Each of these methods is considered. Within limits, each of these techniques can provide very useful data for the aerodynamicist. ESA

N94-14167# Calspan Corp., Arnold AFS, TN.
HYPERSONIC FLOW-FIELD MEASUREMENTS: NONINTRUSIVE
W. D. WILLIAMS *In* VKI, Methodology of Hypersonic Testing 38 p 1993 Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
Copyright Avail: CASI HC A03/MF A03

'Nonintrusive' techniques of hypersonic flow field measurement that are currently available, their basic principles, and advantages and disadvantages, are reviewed. An assessment of the state of applicability of the techniques is provided. The techniques include: Rayleigh scattering, particle scattering, laser and lamp absorption, line reversal, electron beam fluorescence, Raman scattering, holographic interferometry, and laser/laser tagging. A methodology for diagnostics selection and application is presented, and problem areas with possible solutions are examined. Numerous references of both a general nature for review of the fundamentals required for a better understanding of the measurement principles and a specific nature to show the level of advancement of the techniques are provided. ESA

N94-14170# Calspan Corp., Arnold AFS, TN.
EXTRAPOLATION OF GROUND TEST DATA TO FLIGHT
JAMES R. MAUS *In* VKI, Methodology of Hypersonic Testing 16 p 1993 Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
Copyright Avail: CASI HC A03/MF A03

The differences revealed by initial space flights between preflight aerodynamic predictions and actual flight data, were investigated. For the Space Shuttle these differences were notable for longitudinal trim during high speed reentry. To investigate these differences, several computer codes were applied to a modified Space Shuttle Orbiter to determine aerodynamic parameters over a wide range of conditions. Computations were carried out for wind tunnel conditions and flight conditions to assess Mach number, real gas, and viscous effects on the reentry aerodynamics of the orbiter. Based on the computational fluid dynamics results and a semiempirical analysis of viscous effects, an aerodynamic model for the orbiter was developed to extrapolate wind tunnel data for the Space Shuttle Orbiter to flight conditions. ESA

N94-14208*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MIXING NOISE REDUCTION FOR RECTANGULAR SUPERSONIC JETS BY NOZZLE SHAPING AND INDUCED SCREECH MIXING
EDWARD J. RICE and GANESH RAMAN (Sverdrup Technology, Inc., Brook Park, OH.) Oct. 1993 12 p Proposed for presentation at the 15th AIAA Aeroacoustics Conference, Long Beach, CA, 25-27 Oct. 1993; sponsored by AIAA
(Contract NAS3-25266; RTOP 537-02-22)
(NASA-TM-106364; E-8165; NAS 1.15:106364; AIAA PAPER 93-4322) Avail: CASI HC A03/MF A01

Two methods of mixing noise modification were studied for supersonic jets flowing from rectangular nozzles with an aspect ratio of about five and a small dimension of about 1.4 cm. The first involves nozzle geometry variation using either single (unsymmetrical) or double bevelled (symmetrical) thirty degree cutbacks of the nozzle exit. Both converging (C) and converging-diverging (C-D) versions were tested. The double bevelled C-D nozzle produced a jet mixing noise reduction of about 4 dB compared to a standard rectangular C-D nozzle. In addition all bevelled nozzles produced an upstream shift in peak mixing noise which is conducive to improved attenuation when the nozzle is used in an acoustically treated duct. A large increase in high frequency noise also occurred near the plane of the nozzle exit. Because of near normal incidence, this noise can be easily attenuated with wall treatment. The second approach uses paddles

inserted on the edge of the two sides of the jet to induce screech and greatly enhance the jet mixing. Although screech and mixing noise levels are increased, the enhanced mixing moves the source locations upstream and may make an enclosed system more amenable to noise reduction using wall acoustic treatment.
Author

N94-14326*# Overset Methods, Inc., Vacaville, CA.
DOMAIN CONNECTIVITY AMONG SYSTEMS OF OVERSET GRIDS Progress Report
ROBERT L. MEAKIN 26 Jul. 1993 10 p
(Contract NCC2-783)
(NASA-CR-193390; NAS 1.26:193390) Avail: CASI HC A02/MF A01

This progress report describes research performed to achieve algorithmic improvements in the use of overset grids for the computation of unsteady flowfields about geometrically complex and moving component configurations. A hole-map computational method is detailed that reduces computational demand and corresponding demand on human resources. Results indicate that the method is both efficient and flexible for use in complex simulation cases. Tests were performed on shuttle orbiter/external tank, wing/store, and V-22 tilt-rotor configurations. The number of simulated points and the corresponding time on a SGI 4D-210 workstation are presented.
CASI

N94-14541*# Eloret Corp., Sunnyvale, CA.
AN EXPERIMENTAL STUDY OF A TURBULENT BOUNDARY LAYER IN THE TRAILING EDGE REGION OF A CURCULATION-CONTROL AIRFOIL Progress Report, 1 Oct. 1992 - 30 Jun. 1993
JEFF BROWN 12 Oct. 1993 6 p
(Contract NCC2-545)
(NASA-CR-194522; NAS 1.26:194522) Avail: CASI HC A02/MF A01

This report discusses progress made on NASA Cooperative Agreement NCC2-545, 'An Experimental Study of a Turbulent Boundary Layer in the Trailing-Edge Region of a Circulation-Control Airfoil,' during the period 1 Oct. 1992 - 30 Jun. 1993. The study, being conducted by Jeff Brown of the Eloret Institute, in conjunction with the Experimental Fluid Dynamics Branch at NASA Ames (Dennis Johnson, technical monitor), features 2-component laser Doppler velocimeter (LDV) measurements in the trailing edge and wake regions of a generic circulation-control airfoil model. The final experimental phase of the study will be carried out in the Ames High Reynolds Number Channel II (HRC2) transonic blow-down facility. During the 9-month period covered by this report, important data were acquired using the near-wall laser Doppler velocimeter (LDV) whose development has been described in previous reports. These data point strongly to the viability of this new technique for measuring the full Reynolds Stress Tensor in 3D flows.
Author (revised)

N94-14608# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
A GRID GENERATION PACKAGE FOR HIGH ASPECT RATIO WINGS
J. S. MATHUR and S. K. CHAKRABARTTY *In its* Proceedings of the Fluid Dynamics Symposium in Honour of Professor R. Narasimha on his 60th Birthday p 115-121 Jul. 1993
Avail: CASI HC A02/MF A03

A grid generation package has been developed to generate a quasi-three-dimensional grid of either O-H or C-H topology. Grid stacking has been implemented here to use two dimensional grid generation routines at different span stations, and then stack these together to get a three-dimensional grid. An algebraic grid generation routine for C-type grid with all the flexibilities of grid stretching and an elliptic grid generation routine with control functions for O-type grid have been used to generate two-dimensional grids. To demonstrate the method, a sample grid generated for the ONERA-M6 wing has been presented here.
Author

N94-14609# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
THE PHENOMENON OF VORTEX BREAKDOWN
VIDYADHAR Y. MUDKAVI *In its* Proceedings of the Fluid Dynamics Symposium in Honour of Professor R. Narasimha on his 60th Birthday p 123-135 Jul. 1993
Avail: CASI HC A03/MF A03

Vortex breakdown is an abrupt change of flow structure that occurs in swirling flows. More than 3 decades of research in this area has not shed light upon this very basic fluid dynamical phenomenon. The mechanism that leads to vortex breakdown is very poorly understood despite numerous theoretical and experimental investigations. There is still a need for a coherent theory. In this paper these issues are considered in the form of a review of current literature on the phenomenon of vortex breakdown. Some existing criteria to predict the breakdown are presented.
Author

N94-14612# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
HYPERSONIC VISCOUS FLOW COMPUTATIONS
S. K. SAXENA *In its* Proceedings of the Fluid Dynamics Symposium in Honour of Professor R. Narasimha on his 60th Birthday p 159-165 Jul. 1993
(Contract NAL PROJ. CF-1-121)
Avail: CASI HC A02/MF A03

A brief description of the work currently underway on hypersonic viscous flow computations, based on the solution of thin-layer Navier-Stokes equations employing upwind TVD schemes, is presented. Both van Leer and Roe schemes are considered. Some representative computational results presented indicate that these schemes are quite robust and can provide sharp description of the shocks. The importance of parallel computing on machines like Flosolver and the use of implicit techniques to accelerate the computations is emphasized. The future direction of hypersonic research is indicated.
Author

N94-14617# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
PANEL CODES FOR AERODYNAMIC ANALYSIS AT NAL
S. VISWANATHAN, C. L. NARAYANA, V. RAMESH, S. S. DESAI, and R. RANGARAJAN *In its* Proceedings of the Fluid Dynamics Symposium in Honour of Professor R. Narasimha on his 60th Birthday p 211-233 Jul. 1993
Avail: CASI HC A03/MF A03

The National Aerospace Laboratories' (NAL's) panel code capability buildup has been highlighted and several interesting applications are discussed to bring out the utility of panel methods in aerospace research and development.
Author

N94-14706# Royal Aerospace Establishment, Farnborough (England). Aerodynamics and Propulsion Dept.
INTRA-BLADE QUANTITATIVE TRANSONIC FLOW MEASUREMENTS AT THE DRA PYESTOCK ISENTROPIC LIGHT PISTON FACILITY USING PIV (PARTICLE IMAGE VELOCIMETRY)
K. S. CHANA, I. W. MATTHEWS, P. J. BRYANSTON-CROSS (Warwick Univ., Coventry, England.), and M. FUNES-GALLANZI (Warwick Univ., Coventry, England.) 15 Dec. 1992 16 p
Presented at the 11th International Symposium on Measuring Techniques for Transonic and Supersonic Flows in Cascades and Turbomachines, Munich, Germany, 14-15 Sep. 1992 Original contains color illustrations
(RAE-TM-AERO/PROP-21; BR316329; ETN-93-94497)
Copyright Avail: CASI HC A03/MF A01

Measurements made with the quantitative whole field flow visualization technique of Particle Image Velocimetry (PIV) in a transonic annular cascade are addressed. The measurements, which provided an instantaneous quantitative whole field visualization of unsteady region of flow, were compared with a full viscous prediction. The Isentropic Light Piston Facility used to make the measurements is described. The PIV techniques used are discussed along with the following: optical laser firing system;

Nd/YAG pulse laser; diffraction limited optics; beam propagation optics; PIV optical probe design; imaging system; data processing; and preprocessing and data analysis. ESA

N94-14710# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Military Aircraft Div.
SIMULATION OF HYPERSONIC, REACTING FLOW AROUND REENTRY BODIES: COMPARISONS OF NUMERICAL AND EXPERIMENTAL RESULTS
C. MUNDT, R. R. BOYCE (Australian National Univ., Canberra.), and E. H. HIRSCHEL Sep. 1992 18 p Presented at DGLR-Jahrestagung 1992, Bremen, Germany, 29 Sep. - 2 Oct. 1992
(MBB-LME-211-S-PUB-507; DGLR-92-03-108; ETN-93-94196) Copyright Avail: CASI HC A03/MF A01

Results of an ongoing validation project for hypersonic flow prediction, which involved both numerical methods and experimental facilities, are presented. The flow was simulated numerically by solving the Euler and the second order boundary layer equations. For the description of the thermodynamic and chemical behavior of the test gases, different models were used depending on the state of the flow around the test body. The experimental facility used was the free piston hypervelocity shock tunnel T3, capable of simulating the real gas chemical effects encountered in reentry. Techniques to retrieve information about the flows range from surface measurements through bulk flow visualizations to single point optical flow diagnostics. The general strategy for the comparison is described and the results obtained for different parameters and different test gases are compared critically. A hyperboloid is chosen to be the test body. The results of the comparison provide confidence in both the numerical method and the modeling of high temperature physical and chemical effects. ESA

N94-14774# Duke Univ., Durham, NC.
NEW VORTEX DYNAMICS METHODS FOR ROTOR FREE WAKE ANALYSIS Final Report, 15 May 1988 - 14 May 1991
DONALD B. BLISS May 1993 52 p
(Contract DAAL03-88-K-0062)
(AD-A266656; ARO-25747.1-EG) Avail: CASI HC A04/MF A01

This report summarizes recent work on rotorcraft aerodynamics involving novel methods for rotor free wake calculations. A new method called Analytical/Numerical Matching (ANM) was developed. ANM is a hybrid analytical and numerical method that achieves accurate results by combining a low resolution numerical solution with a high resolution analytical solution. Although originally developed for vortex dynamics, ANM has proven to be of a general nature. The application of ANM to the rotor wake problem provides accurate answers with a significant reduction in computation time. The use of ANM introduces the opportunity to develop new solution strategies, including Far-Field Linearization and Periodic Inversion. These methods afford the means to obtain accurate solutions Over the entire flight regime. Work involving applications of ANM has also led to a scheme that represents vortex filament dynamics by a hierarchy of nested problems of varying resolution joined by matching solutions. This approach, called ANM with Pyramiding (ANM/P), has reduced calculation times by more than a factor of twenty in some sample problems. DTIC

N94-14780*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INTERACTION OF TWO GLANCING, CROSSING SHOCK WAVES WITH A TURBULENT BOUNDARY-LAYER AT VARIOUS MACH NUMBERS
WARREN R. HINGST and KEVIN E. WILLIAMS (Washington Univ., Seattle.) Sep. 1991 97 p
(Contract RTOP 505-62-31)
(NASA-TM-103740; E-6566; NAS 1.15:103740) Avail: CASI HC A05/MF A02

A preliminary experimental investigation was conducted to study two crossing, glancing shock waves of equal strengths, interacting with the boundary-layer developed on a supersonic wind tunnel wall. This study was performed at several Mach numbers between 2.5 and 4.0. The shock waves were created by fins (shock generators), spanning the tunnel test section, that were set at angles varying from 4 to 12 degrees. The data acquired are wall static pressure measurements, and qualitative information in the form of oil flow and schlieren visualizations. The principle aim is two-fold. First, a fundamental understanding of the physics underlying this flow phenomena is desired. Also, a comprehensive data set is needed for computational fluid dynamic code validation. Results indicate that for small shock generator angles, the boundary-layer remains attached throughout the flow field. However, with increasing shock strengths (increasing generator angles), boundary layer separation does occur and becomes progressively more severe as the generator angles are increased further. The location of the separation, which starts well downstream of the shock crossing point, moves upstream as shock strengths are increased. At the highest generator angles, the separation appears to begin coincident with the generator leading edges and engulfs most of the area between the generators. This phenomena occurs very near the 'unstart' limit for the generators. The wall pressures at the lower generator angles are nominally consistent with the flow geometries (i.e. shock patterns) although significantly affected by the boundary-layer upstream influence. As separation occurs, the wall pressures exhibit a gradient that is mainly axial in direction in the vicinity of the separation. At the limiting conditions the wall pressure gradients are primarily in the axial direction throughout. Author (revised)

N94-14781# Flow Analysis, Inc., Brooklyn, NY.
FREE-WAKE COMPUTATION OF HELICOPTER ROTOR FLOWFIELD FOR GENERAL FLIGHT REGIMES Final Report, 1 Oct. 1989 - 30 Sep. 1992
KRISHNA RAMACHANDRAN, JOHN STEINHOFF, and WENREN YONGHU 30 Mar. 1993 79 p
(Contract DAAL03-89-C-0027)
(AD-A266692; ARO-25623.4-EG-S) Avail: CASI HC A05/MF A01

A CFD based computer code, HELIX 2 has been developed for computing helicopter rotor flowfield in hover and in forward flight. In order to predict the vibratory airloads in forward flight and the performance in hover the effect of shed wake has to be accurately accounted for. This has been accomplished by an unique vorticity embedding procedure. The wake is convected in a Lagrangian sense and does not suffer from numerical dissipation. The effect of this convected wake is included in the Eulerian using Clebsch representation. The unsteady full potential equation is solved in the Eulerian grid with the embedded vortical velocity accounting for the influence of wake. The wake evolves as a part of the solution. Dynamic grid modifications are performed at each time step to account for blade motion and deformation. These modifications are confined to regions near the blade using suitable blending functions. In addition a vorticity confinement method is developed which involves adding a term to the momentum conservation equation of fluid dynamics. This modification is very useful in the numerical solution of flow problems involving vortical regions. The Euler equations solved with this extra term can convect vortices without Numerical dissipation. DTIC

N94-14784# Auburn Univ., AL. Dept. of Mechanical Engineering.
A NEW TREATMENT OF PERIODIC SYSTEMS WITH APPLICATIONS TO HELICOPTER ROTOR BLADE DYNAMICS Final Report, 15 Sep. 1989 - 31 Mar. 1993
SUBBASH C. SINHA 28 May 1993 9 p
(Contract DAAL03-89-K-0172)
(AD-A266770; ARO-26061.15-EG) Avail: CASI HC A02/MF A01

A new solution technique for general periodic systems encountered in many mechanical systems including the helicopter rotor-blade dynamics has been developed. In this technique, the state transition matrices (STM) of periodic systems are obtained in terms of the shifted Chebyshev polynomials of first and second kind. Due to the excellent convergence properties of Chebyshev polynomials, the approach is found to be super efficient in terms of the CPU time with accuracy level comparable to any higher order numerical algorithms such as Runge-Kutta, Adams-Mouton, etc. The technique is suitable for both numerical and symbolic implementations. The method can be used in a variety of applications such as stability of linear and nonlinear periodic systems, response calculations of linear and nonlinear periodic systems, design of control systems for periodic systems, direct determination of periodic orbits of nonlinear systems and nonlinear analysis of periodic systems in stable, center and unstable manifolds. Case studies corresponding to each of these applications have been reported. Apart from the above mentioned utilities, the technique has resulted in a very practical procedure in obtaining the well-known Liapunov-Floquet (L-F) Transformation matrix which allows one to design a control system in the time-invariant domain. Currently, the research efforts are directed toward utilizing the L-F transformation matrix for various other problems such as order reduction, bifurcation analysis and nonlinear control design strategies for periodic systems. In the following, a short enumeration of the achievements of the project is presented. DTIC

N94-14799# Rensselaer Polytechnic Inst., Troy, NY.
CENTER OF EXCELLENCE IN ROTARY WING TECHNOLOGY Final Report
O. BAUCHAU, CRESPO M. DASILVA, M. DARLOW, P. HAJELA, and E. KREMPL 1 Apr. 1993 207 p
(Contract DAAL03-88-C-0004)
(AD-A266655; ARO-25462.13-EG-RW) Avail: CASI HC A10/MF A03

The activities of a Center of Excellence in Rotary Wing Technology at Rensselaer Polytechnic Institute under a second, continuation five year contract with the U.S. Army Research Office are reported here. The activities include the following: measures taken to revise and update comprehensive and in-depth curricula at advanced levels in rotorcraft technology; attract and retain outstanding young people in these programs; perform basic research at the leading edge of technology in structures, structural dynamics, unsteady aerodynamics, and aeroelasticity disciplines as applied to rotorcraft; and accomplishing technology transfer to the rotorcraft community beyond the Rensselaer campus. Descriptions, references, and statistics are provided to allow assessment of the extent to which these goals have been realized. DTIC

N94-14800# Technische Univ., Berlin (Germany). Inst. fuer Luft- und Raumfahrt.
DEVELOPMENT OF EXPERIMENTAL DEMONSTRATION PROCESSES FOR LAMINAR-TURBULENT FLOW STATES AT WING PROFILES IN FREE FLIGHT Final Report [ENTWICKLUNG EXPERIMENTELLER NACHWEISVERFAHREN FUER LAMINAR-TURBULENTE STROEMUNGSZUSTAENDE AN TRAGFLUEGELPROLIFEN IM FREIFLUG. ABSCHLUSSBERICHT]
P. MIROW and W. NITSCHE 1993 40 p In GERMAN
Sponsored by BMFT
(ILR-MITT-280(1993); ETN-93-94381) Avail: CASI HC A03/MF A01

Measurement techniques for industrial laminar wing experiments on a Grob 109B aircraft were developed and tested; two perturbation free surface measuring processes, piezoarray technique and CPM3 (Computational Preston tube Method), and an onboard supported data acquisition system are presented; CHM2 (Computational Hot-wire Method) was equally used for measuring wall shear stresses and torsional stress variations. CPM3 method was used for determination of local wall friction; power spectrum, time signals, and adaptation factors were obtained with piezoelectric foils, which proved to be very efficient for analysis of flow instabilities, but the method is found to be very expensive because of the necessity of multisensor arrays. It is concluded that a combination of both processes seems to be optimal for flight tests. ESA

N94-14847*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A NEW LAGRANGIAN METHOD FOR THREE-DIMENSIONAL STEADY SUPERSONIC FLOWS
CHING-YUEN LOH and MENG-SING LIOU Sep. 1993 39 p
(Contract RTOP 505-62-52)
(NASA-TM-106068; E-7673; NAS 1.15:106068) Avail: CASI HC A03/MF A01

In this report, the new Lagrangian method introduced by Loh and Hui is extended for three-dimensional, steady supersonic flow computation. The derivation of the conservation form and the solution of the local Riemann solver using the Godunov and the high-resolution TVD (total variation diminished) scheme is presented. This new approach is accurate and robust, capable of handling complicated geometry and interactions between discontinuous waves. Test problems show that the extended Lagrangian method retains all the advantages of the two-dimensional method (e.g., crisp resolution of a slip-surface (contact discontinuity) and automatic grid generation). In this report, we also suggest a novel three dimensional Riemann problem in which interesting and intricate flow features are present. Author

N94-14942# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.
THE EFFECT OF THE NOSE SHAPE AND WING LOCATION TOWARD THE WING VORTEX BREAKDOWN
FENG YANAN, XIA XUEJIAN, and LIU RIZHI 16 Jul. 1993 14 p Transl. into ENGLISH from Hangkong Xuebao (China), v. 11, no. 12, 1990 p 588-591
(AD-A267724; FASTC-ID(RS)T-0735-92) Avail: CASI HC A03/MF A01

The variation of the wing vortex breakdown vs. the angle of attack for a missile with a cruciform set of wings was investigated through experiments. The tests were carried out by conducting the flow pattern visualization in the water channel at BUAA. The model had two nose shapes - pointed and blunted nose. The wing was set at fore or aft location along the axis of the body. The experimental results indicate that for the configuration with the same nose, the location of the vortex breakdown for the wing with aft location is closer to the wing trailing edge than that of the wing with fore location. While for the configuration with the wing at an aft location, the wing vortex breakdown for the blunt nose is delayed compared to that for the pointed nose. DTIC

N94-14959# Colorado Univ., Boulder. Dept. of Aerospace Engineering Sciences.
UNSTEADY SEPARATED FLOWS: EMPIRICAL MODEL AND CONTROL Final Report, 1 Aug. 1988 - 31 Dec. 1992
MARVIN LUTTGES and MICHAEL ROBINSON 7 Jun. 1993 29 p
(Contract AF-AFOSR-0272-88)
(AD-A267282; AFOSR-93-0466TR) Avail: CASI HC A03/MF A01

Research examined the similarity behavior between forced unsteady separated flows elicited by airfoils and delta wings. For the first time, all of the existing unsteady separation data reported in open literature was assembled and contrasted directly. A vortex model which predicted vortex development and shedding characteristics from first principles was developed. Preliminary work was also initiated in using neural network techniques to model and predict these nonlinear unsteady flows. DTIC

N94-14963 Arizona Univ., Tucson. Dept. of Aerospace and Mechanical Engineering.
THE TURBULENT WALL JET Final Report, Nov. 1991 - 1992
I. WYGNANSKI and M. D. ZHOU 18 May 1993 7 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract AF-AFOSR-0176-88)
(AD-A267675; AFOSR-93-0485TR) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The flow of a wall jet embedded in an external stream or in a quiescent surrounding fluid was investigated experimentally. It was determined that the flow scales with the excess momentum injected into the stream and the viscosity of the fluid rather than the jet efflux velocity and the dimension of the nozzle. In the presence of an external stream, a velocity ratio parameter R = (Ui - U)/(Uj + U) had to be added in order to obtain a universal scaling of this flow. Low-amplitude external excitation of the wall jet resulted in a reduction of skin friction and drag. The only possible cause for this behavior observed is the enhancement of the two-dimensionality of the large eddies as expressed by spanwise coherence and correlation measurements. DTIC

N94-14973# Naval Postgraduate School, Monterey, CA.
LASER DOPPLER VELOCIMETRY MEASUREMENTS ACROSS A NORMAL SHOCK IN TRANSONIC FLOW M.S. Thesis
DAVID A. PERRETTA 25 Mar. 1993 117 p
(AD-A267240) Avail: CASI HC A06/MF A02

One-dimensional laser-Doppler velocimetry measurements were taken with standard optics in back scatter mode across a normal shock at a Mach number of 1.35. Back pressure on a blow-down supersonic tunnel was controlled to place a normal shock in a 4 by 4 inch test section and schlieren visualization techniques were used to verify and record shock position and behavior. Velocity surveys were taken across the shock, using various filtering techniques, in an attempt to quantify shock unsteadiness. Additional surveys were performed to further characterize the flow in the test section. The velocity surveys upstream and downstream of the shock compared favorably with pressure and temperature data and normal shock relations. Surveys across the shock indicated distinct and repeatable velocity patterns, and the measured location of the shock matched schlieren photographs. DTIC

N94-15105# Aeronautical Systems Div., Wright-Patterson AFB, OH.
AN UNCERTAINTY ANALYSIS OF INLET DYNAMIC FLOW DISTORTION USING AN ANALOG/DIGITAL HYBRID EDITING SYSTEM Final Report, Feb. 1991 - Dec. 1992
MARYANN ZELENAK Mar. 1993 337 p
(AD-A266924; ASC-TR-93-5005) Avail: CASI HC A15/MF A03

The objectives of this analysis were to establish precision and bias errors for an analog/digital hybrid computer system (DYNADEC) used in the dynamic data editing phase of inlet wind tunnel testing. An uncertainty analysis was initiated to evaluate the system using inlet data from the Aeronautical Systems Center (ASC)/Arnold Engineering Development Center (AEDC) Freejet Development program. Three test points from a subscale freejet test and three test points from a wind tunnel test of the same F-15 inlet model were selected to cover a wide range of test conditions and turbulence levels. Precision errors of the 40 total pressure probes at the location of the engine face were 1-2% of the 40 total pressure recovery magnitudes. Precision errors of the Pratt and Whitney K a2 distortion index, the parameter used to edit the data on DYNADEC, were also investigated. These results indicated that K a2 precision errors decreased with higher turbulence levels. Static bias errors were also computed by sending known signal through the DYNADEC system and measuring the output quantity. Static bias errors were much smaller in comparison to the precision error magnitudes and may be considered negligible. DTIC

N94-15655*# Eidetics International, Inc., Torrance, CA.
AERODYNAMIC CONTROL OF NASP-TYPE VEHICLES THROUGH VORTEX MANIPULATION. VOLUME 1: STATIC WATER TUNNEL TESTS
CARLOS J. SUAREZ, T. TERRY NG, LIH-YENN ONG, and GERALD N. MALCOLM Sep. 1993 88 p Sponsored by NASA, Washington
(Contract NAS2-13196)
(NASA-CR-177626-VOL-1; A-93138-VOL-1; NAS 1.26:177626-VOL-1) Avail: CASI HC A05/MF A01

Water tunnel tests were conducted on a NASP-type configuration to evaluate different pneumatic Forebody Vortex Control (FVC) methods. Flow visualization and yawing moment measurements were performed at angles of attack from 0 deg to 30 deg. The pneumatic techniques tested included jet and slot blowing. In general, blowing can be used efficiently to manipulate the forebody vortices at angles of attack greater than 20 deg. These vortices are naturally symmetric up to alpha = 25 deg and asymmetric between 25 deg and 30 deg angle of attack. Results indicate that tangential aft jet blowing is the most promising method for this configuration. Aft jet blowing produces a yawing moment towards the blowing side and the trends with blowing rate are well behaved. The size of the nozzle is not the dominant factor in the blowing process; the change in the blowing 'momentum,' i.e., the product of the mass flow rate and the velocity of the jet, appears to be the important parameter in the water tunnel (incompressible and unchoked flow at the nozzle exit). Forward jet blowing is very unpredictable and sensitive to mass flow rate changes. Slot blowing (with the exception of very low blowing rates) acts as a flow 'separator'; it promotes early separation on the blow side, producing a yawing moment toward the non-blowing side for the C(sub mu) range investigated. Author (revised)

N94-15657*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SUPPRESSION OF DYNAMIC STALL WITH A LEADING-EDGE SLAT ON A VR-7 AIRFOIL
K. W. MCALISTER and C. TUNG Mar. 1993 71 p
(Contract RTOP 505-61-51)
(NASA-TP-3357; ATCOM-TR-92-A-013; A-93006; NAS 1.60:3357)
Avail: CASI HC A04/MF A01

The VR-7 airfoil was experimentally studied with and without a leading-edge slat at fixed angles of attack from 0 deg to 30 deg at Re = 200,000 and for unsteady pitching motions described by alpha equals alpha(sub m) + 10 deg(sin(wt)). The models were two dimensional, and the test was performed in a water tunnel at Ames Research Center. The unsteady conditions ranged over Re equals 100,000 to 250,000, k equals 0.001 to 0.2, and alpha(sub m) = 10 deg to 20 deg. Unsteady lift, drag, and pitching-moment measurements were obtained along with fluorescent-dye flow visualizations. The addition of the slat was found to delay the static-drag and static-moment stall by about 5 degrees and to eliminate completely the development of a dynamic-stall vortex during unsteady motions that reached angles as high as 25 degrees. In all of the unsteady cases studied, the slat caused a significant reduction in the force and moment hysteresis amplitudes. The reduced frequency was found to have the greatest effect on the results, whereas the Reynolds number had little effect on the behavior of either the basic or the slatted airfoil. The slat caused a slight drag penalty at low angles of attack, but generally increased the lift/drag ratio when averaged over the full cycle of oscillation. Author (revised)

N94-15677*# Eidetics International, Inc., Torrance, CA.
AERODYNAMIC CONTROL OF NASP-TYPE VEHICLES THROUGH VORTEX MANIPULATION. VOLUME 2: STATIC WIND TUNNEL TESTS
CARLOS J. SUAREZ, BRIAN R. KRAMER, BROOKE C. SMITH, and GERALD N. MALCOLM Sep. 1993 144 p Sponsored by NASA, Washington
(Contract NAS2-13196)
(NASA-CR-177626-VOL-2; A-93138-VOL-2; NAS 1.26:177626-VOL-2) Avail: CASI HC A07/MF A02

Forebody Vortex Control (FVC) was explored in this research program for potential application to a NASP-type configuration. Wind tunnel tests were conducted to evaluate a number of jet blowing schemes. The configuration tested has a slender forebody and a 78 deg swept delta wing. Blowing jets were implemented on the leeward side of the forebody with small circular tubes tangential to the surface that could be directed aft, forward, or at angles in between. The effects of blowing are observed primarily in the yawing and rolling moments and are highly dependent on the jet configuration and the angle of attack. Results show that the baseline flow field, without blowing activated, is quite sensitive to the geometry differences of the various protruding jets, as well as being sensitive to the blowing, particularly in the angle of attack range where the forebody vortices are naturally asymmetric. The time lag of the flow field response to the initiation of blowing was also measured. The time response was very short, on the order of the time required for the flow disturbance to travel the distance from the nozzle to the specific airframe location of interest at the free stream velocity. Overall, results indicate that sizable yawing and rolling moments can be induced with modest blowing levels. However, direct application of this technique on a very slender forebody would require thorough wind tunnel testing to optimize the jet location and configuration. Author (revised)

N94-15678*# Eloret Corp., Sunnyvale, CA. Thermosciences Div.
PARTICLE KINETIC SIMULATION OF HIGH ALTITUDE HYPERVELOCITY FLIGHT Report, 1 Jan. - 31 Aug. 1993
BRIAN L. HAAS 12 Oct. 1993 58 p
(Contract NCC2-582)
(NASA-CR-194599; NAS 1.26:194599) Avail: CASI HC A04/MF A01

In this grant period, the focus has been on enhancement and application of the direct simulation Monte Carlo (DSMC) particle method for computing hypersonic flows of re-entry vehicles. Enhancement efforts dealt with modeling gas-gas interactions for thermal non-equilibrium relaxation processes and gas-surface interactions for prediction of vehicle surface temperatures. Both are important for application to problems of engineering interest. The code was employed in a parametric study to improve future applications, and in simulations of aeropass maneuvers in support of the Magellan mission. Detailed comparisons between continuum models for internal energy relaxation and DSMC models reveals that several discrepancies exist. These include definitions of relaxation parameters and the methodologies for implementing them in DSMC codes. These issues were clarified and all differences were rectified in a paper (Appendix A) submitted to Physics of Fluids A, featuring several key figures in the DSMC community as co-authors and B. Haas as first author. This material will be presented at the Fluid Dynamics meeting of the American Physical Society on November 21, 1993. The aerodynamics of space vehicles in highly rarefied flows are very sensitive to the vehicle surface temperatures. Rather than require prescribed temperature estimates for spacecraft as is typically done in DSMC methods, a new technique was developed which couples the dynamic surface heat transfer characteristics into the DSMC flow simulation code to compute surface temperatures directly. This model, when applied to thin planar bodies such as solar panels, was described in AIAA Paper No. 93-2765 (Appendix B) and was presented at the Thermophysics Conference in July 1993. The paper has been submitted to the Journal of Thermophysics and Heat Transfer. Application of the DSMC method to problems of practical interest requires a trade off between solution accuracy and computational expense and limitations. A parametric study was performed and reported in AIAA Paper No. 93-2806 (Appendix C) which assessed the accuracy penalties associated with simulations of varying grid resolution and flow domain size. The paper was also presented at the Thermophysics Conference and will be submitted to the journal shortly. Finally, the DSMC code was employed to assess the pitch, yaw, and roll aerodynamics of the Magellan spacecraft during entry into the Venus atmosphere at off-design attitudes. This work was in support of the Magellan aerobraking maneuver of May 25-Aug. 3, 1993. Furthermore, analysis of the roll characteristics of the configuration with canted solar panels was performed in support of the proposed 'Windmill' experiment. Results were reported in AIAA Paper No. 93-3676 (Appendix D) presented at the Atmospheric Flight Mechanics Conference in August 1993, and were submitted to Journal of Spacecraft and Rockets. Author

N94-15681*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WIND TUNNEL INVESTIGATION OF THREE AXISYMMETRIC COWLS OF DIFFERENT LENGTHS AT MACH NUMBERS FROM 0.60 TO 0.92
RICHARD J. RE and WILLIAM K. ABEYOUNIS Sep. 1993 285 p Sponsored by NASA, Washington
(Contract RTOP 535-03-10-01)
(NASA-TM-4488; L-17191; NAS 1.15:4488) Avail: CASI HC A13/MF A03

Pressure distributions on three inlets having different cowl lengths were obtained in the Langley 16-Foot Transonic Tunnel. The cowl diameter ratio (highlight diameter to maximum diameter) was 0.85 and the cowl length ratios (cowl length to maximum diameter) were 0.337, 0.439, and 0.547. The cowls had identical nondimensionalized (with respect to cowl length) external geometry and identical internal geometry. The internal contraction ratio (highlight area to throat area) was 1.250. The inlets had longitudinal rows of static pressure orifices on the top and bottom (external) surfaces and on the contraction (internal) and diffuser surfaces. The afterbody was cylindrical in shape, and its diameter was equal to the maximum diameter of the cowl. Depending on the cowl configuration and free-stream Mach number, the mass-flow ratio varied between 0.27 and 0.87 during the tests. Angle of attack varied from 0 to 4.1 deg at selected Mach numbers and mass-flow ratios, and the Reynolds number varied with the Mach number from 3.2x10(exp 6) to 4.2x10(exp 6) per foot. Author (revised)

N94-15696# Royal Aerospace Establishment, Farnborough (England). Aerodynamics and Propulsion Dept.
HEAT TRANSFER AND AERODYNAMICS OF A 3D DESIGN NOZZLE GUIDE VANE TESTED IN THE PYESTOCK ISENTROPIC LIGHT PISTON FACILITY
K. S. CHANA 17 Dec. 1992 15 p Presented at the AGARD 80th Symposium of the Propulsion and Energetics Panel on Heat Transfer and Cooling in Gas Turbines, Antalaya, Turkey, 12-16 Oct. 1992 Original contains color illustrations
(RAE-TM-AERO/PROP-19; BR316026; ETN-93-94495)
Copyright Avail: CASI HC A03/MF A01

The prediction of the heat transfer to the blade and endwalls in high pressure turbines, which is particularly important for an accurate assessment of turbine component life is addressed. On the endwalls, there are often complex three dimensional (3D) (secondary) flows present which make predictions of heat transfer particularly difficult. A detailed investigation of this area was carried out on a fully annular cascade of highly 3D nozzle guide vanes. Measurements were made on the vane and endwalls to determine heat transfer and aerodynamic characteristics. Testing was conducted in a short duration isentropic light piston test facility, at engine representative Reynolds number, Mach number, and gas to wall temperature ratio. Interpreted test data are compared with computations obtained at test conditions. ESA

N94-15720*# Eidetics International, Inc., Torrance, CA.
AERODYNAMIC CONTROL OF NASP-TYPE VEHICLES THROUGH VORTEX MANIPULATION, VOLUME 4
BROOKE C. SMITH, CARLOS J. SUAREZ, WILLIAM M. PORADA, and GERALD N. MALCOLM Sep. 1993 151 p Sponsored by NASA, Washington
(Contract NAS2-13196)
(NASA-CR-177626-VOL-4; A-93138; NAS 1.26:177626-VOL-4)
Avail: CASI HC A08/MF A02

Forebody Vortex Control (FVC) is an emerging technology that has received widespread and concentrated attention by many researchers for application on fighter aircraft to enhance aerodynamic controllability at high angles of attack. This research explores potential application of FVC to a NASP-type configuration. The configuration investigated is characterized by a slender, circular cross-section forebody and a 78 deg swept delta wing. A man-in-the-loop, six-degress-of-freedom, high-fidelity simulation was developed that demonstrates the implementation and advantages of pneumatic forebody vortex control. Static wind tunnel tests were used as the basis for the aerodynamic characteristics modeled in the simulation. Dynamic free-to-roll wind tunnel tests were analyzed and the wing rock motion investigated. A non-linear model of the dynamic effects of the bare airframe and the forebody vortex control system were developed that closely represented the observed behavior. Multiple state-of-the-art digital flight control systems were developed that included different utilizations of pneumatic vortex control. These were evaluated through manned simulation. Design parameters for a pneumatic forebody vortex control system were based on data collected regarding the use of blowing and the mass flow required during realistic flight maneuvers. Author (revised)

N94-15780*# Eidetics International, Inc., Torrance, CA.
AERODYNAMIC CONTROL OF NASP-TYPE VEHICLES THROUGH VORTEX MANIPULATION. VOLUME 3: WING ROCK EXPERIMENTS
CARLOS J. SUAREZ, BROOKE C. SMITH, BRIAN R. KRAMER, T. TERRY NG, LIH-YENN ONG, and GERALD N. MALCOLM Sep. 1993 130 p
(Contract NAS2-13196)
(NASA-CR-177626; A-93138; NAS 1.26:177626) Avail: CASI HC A07/MF A02

Free-to-roll tests were conducted in water and wind tunnels in an effort to investigate the mechanisms of wing rock on a NASP-type vehicle. The configuration tested consisted of a highly-slender forebody and a 78 deg swept delta wing. In the water tunnel test, extensive flow visualization was performed and roll angle histories were obtained. In the wind tunnel test, the roll angle, forces and moments, and limited forebody and wing surface pressures were measured during the wing rock motion. A limit cycle oscillation was observed for angles of attack between 22 deg and 30 deg. In general, the experiments confirmed that the main flow phenomena responsible for the wing-body-tail wing rock are the interactions between the forebody and the wing vortices. The variation of roll acceleration (determined from the second derivative of the roll angle time history) with roll angle clearly slowed the energy balance necessary to sustain the limit cycle oscillation. Different means of suppressing wing rock by controlling the forebody vortices using small blowing jets were also explored. Steady blowing was found to be capable of suppressing wing rock, but significant vortex asymmetrices are created, causing the model to stop at a non-zero roll angle. On the other hand, alternating pulsed blowing on the left and right sides of the fore body was demonstrated to be a potentially effective means of suppressing wing rock and eliminating large asymmetric moments at high angles of attack. Author (revised)

N94-15787# Stanford Univ., CA. Dept. of Aeronautics and Astronautics.
PARTICLE SIMULATION OF HYPERSONIC FLOW Final Report, 1 Apr. 1990 - 31 Mar. 1993
DONALD BAGANOFF 26 May 1993 40 p
(Contract AF-AFOSR-0232-90)
(AD-A267185; AFOSR-93-0457TR) Avail: CASI HC A03/MF A01

A particle code for simulating a rarefied hypersonic flow is developed which accounts for a multiple species gas in thermochemical nonequilibrium and which takes advantage of the parallel architecture of the Intel iPSC/860 supercomputer. Various tests were conducted using a generic blunt body consisting of a hemispherically blunted 60-degree half-angle cone at angle of attack. The different tests conducted show that the performance of the parallel code using 512 nodes exceeds by an order of magnitude the performance obtained for a highly vectorized code run on a single processor of the Cray YMP, that scaleup is found to be nearly linear with the number of processors used, that run time can be greatly reduced by employing a large number of particles, and that runs with 67.5 million particles can be carried out when employing the large memory of the Intel iPSC/860. Other results relate to different applications of the code for studying the near-continuum state of a gas near a cold solid boundary. DTIC

N94-15824# Dayton Univ., OH. Dept. of Chemistry.
CENTER FOR ROTORCRAFT EDUCATION AND RESEARCH PROGRESS REPORT, 1987 - 1992 Final Report, 1 Jan. 1988 - 31 Dec. 1992
INDERJIT CHOPRA Jun. 1993 133 p
(Contract DAAL03-88-C-0002)
(AD-A266760; ARO-25467.74-EG-RW) Avail: CASI HC A07/MF A02

Established in 1981, the Center for Rotorcraft Education and Research at the University of Maryland has achieved international recognition as a center of excellence in rotorcraft engineering based on the quality and quantity of its research output and advanced-degree recipients. In the process of growth, it has built an integrated team of rotorcraft dedicated research faculty and staff, a pipeline of high quality graduate students, and a group of specialized rotorcraft research facilities and instrumentation unmatched by any other university. The center carried out interdisciplinary research program built around four interrelated areas that advanced understanding and predictive capability in: Aerodynamics-unsteady aerodynamics, dynamic stall, and rotor/airframe interaction tests and analyses; Dynamics and Aeroelasticity-bearingless and composite rotor tests and analyses, and minimization of rotor/body vibrations by optimization techniques; Flight Dynamics and Control-control of the dynamic behavior of highly coupled rotor-fuselage configurations; and Structures and Materials-structural integrity, energy absorption, and modeling of composite blades. Author (revised)

N94-16471 Naval Postgraduate School, Monterey, CA.
A RAPID COMPUTATIONAL MODEL FOR ESTIMATING THE PERFORMANCE OF COMPLIANT AIRFOILS IN CASCADES Technical Report, Jan. - Jun. 1992
F. SISTO and M. AVILA 1 Jul. 1992 21 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A266275; NPS-AA-93-001) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

We consider the problem of designing the blades in a turbomachine to have a specific schedule of structural stiffness in order to achieve more favorable aerothermodynamic performance characteristics than is possible with rigid blades. This problem of 'aerothermodynamic tailoring' is extremely complex because of the need to couple the flow computation over a deformable surface with the structural dynamics computation. In this report an analysis is presented which accomplishes this objective by means of a two-dimensional incompressible potential flow model using vortex sheet representation of the blades. Details of the analysis and of the resulting computer program together with representative results are described. DTIC

N94-16510*# MCAT Inst., San Jose, CA.
COMPUTATION OF THE FLUID AND OPTICAL FIELDS ABOUT THE STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA) AND THE COUPLING OF FLUIDS, DYNAMICS, AND CONTROL LAWS ON PARALLEL COMPUTERS Final Report
CHRISTOPHER A. ATWOOD May 1993 185 p
(Contract NCC2-677)
(NASA-CR-193168; NAS 1.26:193168; MCAT-93-09) Avail: CASI HC A09/MF A02

The June 1992 to May 1993 grant NCC-2-677 provided for the continued demonstration of Computational Fluid Dynamics (CFD) as applied to the Stratospheric Observatory for Infrared Astronomy (SOFIA). While earlier grant years allowed validation of CFD through comparison against experiments, this year a new design proposal was evaluated. The new configuration would place the cavity aft of the wing, as opposed to the earlier baseline which was located immediately aft of the cockpit. This aft cavity placement allows for simplified structural and aircraft modification requirements, thus lowering the program cost of this national astronomy resource. Three appendices concerning this subject are presented.

N94-16511*# MCAT Inst., San Jose, CA.
SELECTED COMPUTATIONS OF TRANSONIC CAVITY FLOWS
CHRISTOPHER A. ATWOOD *In its* Computation of the Fluid and Optical Fields About the Stratospheric Observatory for Infrared Astronomy (SOFIA) and the Coupling of Fluids, Dynamics, and Control Laws on Parallel Computers 13 p May 1993 The 1993 ASME Fluids Engineering Conference of the Forum on Computational Aero- and Hydro-Acoustics held in Washington, DC, 20-24 Jun. 1993
Avail: CASI HC A03/MF A02

An efficient diagonal scheme implemented in an overset mesh framework has permitted the analysis of geometrically complex cavity flows via the Reynolds averaged Navier-Stokes equations. Use of rapid hyperbolic and algebraic grid methods has allowed simple specification of critical turbulent regions with an algebraic turbulence model. Comparisons between numerical and experimental results are made in two dimensions for the following problems: a backward-facing step; a resonating cavity; and two quieted cavity configurations. In three-dimensions the flow about three early concepts of the stratospheric Observatory For Infrared Astronomy (SOFIA) are compared to wind-tunnel data. Shedding frequencies of resolved shear layer structures are compared against experiment for the quieted cavities. The results demonstrate the progress of computational assessment of configuration safety and performance. Author (revised)

N94-16512*# MCAT Inst., San Jose, CA.
UNSTEADY FLUID AND OPTICAL SIMULATION OF TRANSONIC AERO-WINDOWS
CHRISTOPHER A. ATWOOD *In its* Computation of the Fluid and Optical Fields About the Stratospheric Observatory for Infrared Astronomy (SOFIA) and the Coupling of Fluids, Dynamics, and Control Laws on Parallel Computers 12 p May 1993 Conference of the AIAA 24th Fluid Dynamics, PlasmaDynamics, and Lasers held in Orlando, FL, 6-9 Jul. 1993
(AIAA PAPER 93-3017) Avail: CASI HC A03/MF A02

The time-varying fluid and optical fields of several cavity configurations have been computed on overset mesh systems using the Reynolds-averaged Navier-Stokes equations and geometric optics. Comparisons between numerical results and Airborne Optical Adjunct (AOA) flight data are made in two-dimensions for a quieted cavity geometry with two lip-blowing rates. In three-dimensions, two proposed aero-window locations for the Stratospheric Observatory For Infrared Astronomy (SOFIA) are discussed. The simulations indicate that convection of large shear layer structures across the aperture cause the blur circle diameter to be three times the diffraction-limited diameter in the near-infrared band. Author

N94-16513*# MCAT Inst., San Jose, CA.
COMPUTATION OF A CONTROLLED STORE SEPARATION FROM A CAVITY
CHRISTOPHER A. ATWOOD *In its* Computation of the Fluid and Optical Fields About the Stratospheric Observatory for Infrared Astronomy (SOFIA) and the Coupling of Fluids, Dynamics, and Control Laws on Parallel Computers 17 p May 1993 Proposed for presentation at the AIAA 32nd Aerospace Sciences Meeting and Exhibit, Reno, NV, 10-13 Jan. 1994
Avail: CASI HC A03/MF A02

Coupling of the Reynolds-averaged Navier-Stokes equations, rigid-body dynamics, and a pitch attitude control law is demonstrated in two- and three-dimensions. The application problem was the separation of a canard-controlled store from an open-flow rectangular cavity bay at a freestream Mach number of 1.2. The transient flowfield was computed using a diagonal scheme in an overset mesh framework, with the resultant aerodynamic loads used as the forcing functions in the nonlinear dynamics equations. The proportional and rate gyro sensitivities were computed a priori using pole placement techniques for the linearized dynamical equations. These fixed gain values were used in the controller for the nonlinear simulation. Reasonable comparison between the full and linearized equations for a perturbed two-dimensional missile was found. Also in two-dimensions, a controlled store was found to possess improved separation characteristics over a canard-fixed store. In three-dimensions, trajectory comparisons with wind-tunnel data for the canard-fixed case will be made. In addition, it will be determined if a canard-controlled store is an effective means of improving cavity store separation characteristics. Author (revised)

N94-16571*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FLOW ANALYSIS FOR THE NACELLE OF AN ADVANCED DUCTED PROPELLER AT HIGH ANGLE-OF-ATTACK AND AT CRUISE WITH BOUNDARY LAYER CONTROL
D. P. HWANG, D. R. BOLDMAN, and C. E. HUGHES Jan. 1994 9 p Proposed for presentation at the 32nd Aerospace Sciences Meeting and Exhibit, Reno, NV, 10-13 Jan. 1994; sponsored by AIAA
(Contract RTOP 535-03-10)
(NASA-TM-106371; AIAA PAPER 94-0391; E-8181; NAS 1.15:106371) Copyright Avail: CASI HC A02/MF A01

An axisymmetric panel code and a three dimensional Navier-Stokes code (used as an inviscid Euler code) were verified for low speed, high angle of attack flow conditions. A three dimensional Navier-Stokes code (used as an inviscid code), and an axisymmetric Navier-Stokes code (used as both viscous and inviscid code) were also assessed for high Mach number cruise conditions. The boundary layer calculations were made by using the results from the panel code or Euler calculation. The panel method can predict the internal surface pressure distributions very well if no shock exists. However, only Euler and Navier-Stokes calculations can provide a good prediction of the surface static pressure distribution including the pressure rise across the shock. Because of the high CPU time required for a three dimensional Navier-Stokes calculation, only the axisymmetric Navier-Stokes calculation was considered at cruise conditions. The use of suction and tangential blowing boundary layer control to eliminate the flow separation on the internal surface was demonstrated for low free stream Mach number and high angle of attack cases. The calculation also shows that transition from laminar flow to turbulent flow on the external cowl surface can be delayed by using suction boundary layer control at cruise flow conditions. The results were compared with experimental data where possible. Author

N94-16572*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECTS OF INTERNAL YAW-VECTORING DEVICES ON THE STATIC PERFORMANCE OF A PITCH-VECTORING NONAXISYMMETRIC CONVERGENT-DIVERGENT NOZZLE
SCOTT C. ASBURY Washington NASA. Washington Sep. 1993 109 p
(Contract RTOP 505-68-70-06)
(NASA-TP-3369; L-17229; NAS 1.60:3369) Avail: CASI HC A06/MF A02

An investigation was conducted in the static test facility of the Langley 16-Foot Transonic Tunnel to evaluate the internal performance of a nonaxisymmetric convergent divergent nozzle designed to have simultaneous pitch and yaw thrust vectoring capability. This concept utilized divergent flap deflection for thrust vectoring in the pitch plane and flow-turning deflectors installed within the divergent flaps for yaw thrust vectoring. Modifications consisting of reducing the sidewall length and deflecting the sidewall outboard were investigated as means to increase yaw-vectoring performance. This investigation studied the effects of multiaxis (pitch and yaw) thrust vectoring on nozzle internal performance characteristics. All tests were conducted with no external flow, and nozzle pressure ratio was varied from 2.0 to approximately 13.0. The results indicate that this nozzle concept can successfully generate multiaxis thrust vectoring. Deflection of the divergent flaps produced resultant pitch vector angles that, although dependent on nozzle pressure ratio, were nearly equal to the geometric pitch vector angle. Losses in resultant thrust due to pitch vectoring were small or negligible. The yaw deflectors produced resultant yaw vector angles up to 21 degrees that were controllable by varying yaw deflector rotation. However, yaw deflector rotation resulted in significant losses in thrust ratios and, in some cases, nozzle discharge coefficient. Either of the sidewall modifications generally reduced these losses and increased maximum resultant yaw vector angle. During multiaxis (simultaneous pitch and yaw) thrust vectoring, little or no cross coupling between the thrust vectoring processes was observed. Author (revised)

N94-16573*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

WIND TUNNEL INVESTIGATIONS OF FOREBODY STRAKES FOR YAW CONTROL ON F/A-18 MODEL AT SUBSONIC AND TRANSONIC SPEEDS

GARY E. ERICKSON and DANIEL G. MURRI Washington NASA. Washington Sep. 1993 101 p
(Contract RTOP 505-68-30-03)
(NASA-TP-3360; L-17197; NAS 1.60:3360) Avail: CASI HC A06/MF A02

Wind tunnel investigations have been conducted of forebody strakes for yaw control on 0.06-scale models of the F/A-18 aircraft at free-stream Mach numbers of 0.20 to 0.90. The testing was conducted in the 7- by 10-Foot Transonic Tunnel at the David Taylor Research Center and the Langley 7- by 10-Foot High-Speed Tunnel. The principal objectives of the testing were to determine the effects of the Mach number and the strake plan form on the strake yaw control effectiveness and the corresponding strake vortex induced flow field. The wind tunnel model configurations simulated an actuated conformal strake deployed for maximum yaw control at high angles of attack. The test data included six-component forces and moments on the complete model, surface static pressure distributions on the forebody and wing leading-edge extensions, and on-surface and off-surface flow visualizations. The results from these studies show that the strake produces large yaw control increments at high angles of attack that exceed the effect of conventional rudders at low angles of attack. The strake yaw control increments diminish with increasing Mach number but continue to exceed the effect of rudder deflection at angles of attack greater than 30 degrees. The character of the strake vortex induced flow field is similar at subsonic and transonic speeds. Cropping the strake planform to account for geometric and structural constraints on the F-18 aircraft has a small effect on the yaw control increments at subsonic speeds and no effect at transonic speeds. Author (revised)

N94-16574*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

WIND-TUNNEL INVESTIGATION OF AERODYNAMIC EFFICIENCY OF THREE PLANAR ELLIPTICAL WINGS WITH CURVATURE OF QUARTER-CHORD LINE

RAYMOND E. MINECK and PAUL M. H. W. VIJGEN (High Technology Corp., Hampton, VA.) Washington NASA. Washington Oct. 1993 80 p
(Contract RTOP 505-59-10-03)
(NASA-TP-3359; L-17185; NAS 1.60:3359) Avail: CASI HC A05/MF A01

Three planar, untwisted wings with the same elliptical chord distribution but with different curvatures of the quarter-chord line were tested in the Langley 8-Foot Transonic Pressure Tunnel (8-ft TPT) and the Langley 7- by 10-Foot High-Speed Tunnel (7 x 10 HST). A fourth wing with a rectangular planform and the same projected area and span was also tested. Force and moment measurements from the 8-ft TPT tests are presented for Mach numbers from 0.3 to 0.5 and angles of attack from -4 degrees to 7 degrees. Sketches of the oil-flow patterns on the upper surfaces of the wings and some force and moment measurements from the 7 x 10 HST tests are presented at a Mach number of 0.5. Increasing the curvature of the quarter-chord line makes the angle of zero lift more negative but has little effect on the drag coefficient at zero lift. The changes in lift-curve slope and in the Oswald efficiency factor with the change in curvature of the quarter-chord line (wingtip location) indicate that the elliptical wing with the unswept quarter-chord line has the lowest lifting efficiency and the elliptical wing with the unswept trailing edge has the highest lifting efficiency; the crescent-shaped planform wing has an efficiency in between. Author

N94-16583# Royal Aircraft Establishment, Farnborough (England).

DETERMINATION OF THE EFFECT OF THE WALLS OF A WIND-TUNNEL FROM THE PARAMETERS OF FLOW NEAR THEM [OPREDELENIE VLIYANIYA STENOK AERODINAMICHESKOI TRUBY PO PARAMETRAM POTOKA VBLIZI NIKH]

S. A. GLASKOV Jan. 1993 19 p Transl. into ENGLISH from Uchenye Zapiski TsAGI, XIX (Russia), no. 3, 1988 p 34-35 In RUSSIAN
(RAE-LIB-TRANS-2201; AD-A271384) Copyright Avail: CASI HC A03/MF A01

This paper describes a method based on the use of two flow variables measured at a boundary close to the tunnel wall to calculate wall interference. It is similar to earlier work in the West although the author was probably unaware of this work. Derived from text

N94-16798# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

HOPH BIFURCATION IN VISCOUS, LOW SPEED FLOWS ABOUT AN AIRFOIL WITH STRUCTURAL COUPLING Ph.D. Thesis

MARK J. LUTTON Mar. 1993 152 p
(AD-A266542; AFIT/DS/AA/93-1) Avail: CASI HC A08/MF A02

The locations of Hopf bifurcation points associated with the viscous, incompressible flow about a NACA 0012 airfoil with structural coupling are computed for very low Reynolds numbers (less than 2000). A semi-implicit, first-order-accurate time-integration algorithm is employed to solve the stream-function-vorticity form of the Navier-Stokes equations. The formulation models the inclusion of simple structural elements affixed to the airfoil and captures the resulting airfoil motion. The equations describing the airfoil motion are integrated in time using a fourth-order Runge-Kutta algorithm. The dissertation is divided into two parts. In part one, numerical experiments are performed in the laminar regime to determine if the structural model of the airfoil has an effect upon the location of the Hopf bifurcation point when compared with the fixed airfoil. Results are reported for a variety of structural characteristics including variations of torsional and linear spring constants, inertial properties, structural coupling, and structural damping. The structure of the solution space is explored by means of phase plots. In part two, the Baldwin-Lomax turbulence model is implemented to model turbulent flow. A numerical effort is made to predict the onset of unsteady flow. DTIC

N94-16913# Naval Postgraduate School, Monterey, CA.

DETERMINING THE EFFECT OF ENDWALL BOUNDARY LAYER SUCTION IN A LARGE SCALE SUBSONIC COMPRESSOR CASCADE M.S. Thesis

MATTHEW A. WEBBER 31 Mar. 1993 140 p
(AD-A267208) Avail: CASI HC A07/MF A02

An arrangement of suction slots was installed in the Naval Postgraduate School's subsonic cascade wind tunnel. The aim was to improve flow two dimensionality to enable flow separation of the installed controlled diffusion blades at high incidence. The slots were located 17.25 inches upstream of the test section. Pressure and laser Doppler velocimetry measurements were made, for a Reynolds number of 711000 and an inlet flow angle of 44.4 deg, upstream and downstream of the test section to determine the effects of varying suction. The set of baseline inlet flow field measurements was to be used for comparison purposes in future tunnel modifications. The results showed that the tunnel endwall boundary layers were asymmetric for the baseline configuration. Uniform suction was not achieved in both the pitchwise and spanwise directions. However, the axial velocity ratio was reduced by 1.9 percent and the blade loading increased slightly with increased suction. DTIC

N94-17074# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
COMPUTATIONAL AERODYNAMICS WITH ICING EFFECTS Ph.D. Thesis
THOMAS N. MOUCH May 1993 160 p
(AD-A267509; AFIT/CI/CIA-93-007D) Avail: CASI HC A08/MF A02

A quick, inexpensive technique has been developed for the analysis of a full aircraft configuration with iced surfaces. A comprehensive literature search of icing analysis methods is presented. Viscous effects for the flow field about an airfoil with an iced leading edge are accounted for in a thin-layer Navier-Stokes code (ARC2D). A panel code (PMARC) solves the flow field away from the body. The results of the airfoil analysis represent the near-field solutions and are used to modify the boundary conditions in the three-dimensional calculations with the panel code by matching the local circulation. This process is repeated until the total lift coefficient between successive iterations differs by less than a specified value. Comparison with viscous experimental data shows excellent results for lift coefficient and a strong improvement over the basic PMARC for drag and pitching moment coefficients. For the full configuration considered, with ice simulated on the horizontal tail, pitching moment data predicts a very sudden unstable pitch break above angle of attack = 8 deg. This tendency models the pitch tendency described in the literature for similar configurations with an iced horizontal tail. Thus, a quick method has been developed to handle a full configuration with viscous effects. DTIC

N94-17081*# MCAT Inst., San Jose, CA.
PROGRESS IN COMPUTATIONAL UNSTEADY AERODYNAMICS
SHIGERU OBAYASHI Nov. 1993 20 p
(Contract NCC2-605)
(NASA-CR-177630; A-94021; NAS 1.26:177630) Avail: CASI HC A03/MF A01

After vigorous development for over twenty years, Computational Fluid Dynamics (CFD) in the field of aerospace engineering has arrived at a turning point toward maturity. This paper discusses issues related to algorithm development for the Euler/Navier Stokes equations, code validation and recent applications of CFD for unsteady aerodynamics. Algorithm development is a fundamental element for a good CFD program. Code validation tries to bridge the reliability gap between CFD and experiment. Many of the recent applications also take a multidisciplinary approach, which is a future trend for CFD applications. As computers become more affordable, CFD is expected to be a better scientific and engineering tool. Author

N94-17221# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
AN EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF LEADING EDGE GEOMETRY ON THE DYNAMICS OF BLUNT FIN-INDUCED SHOCK WAVE TURBULENT BOUNDARY LAYER INTERACTION M.S. Thesis
KELLY KLEIFGES May 1993 99 p
(AD-A267656; AFIT/CI/CIA-93-093) Avail: CASI HC A05/MF A02

Fluctuating wall pressure measurements have been made on the centerline upstream of blunt fins in a Mach 5 flow. Standard time series analysis and conditional sampling algorithms have been used to examine the effects of leading edge sweep, leading edge shape, and fin root modifications on the RMS level and spectral content of fluctuating pressures. Results show that the fluctuating loads can be reduced significantly by appropriate modification of the fin leading edge. Leading edge sweep considerably reduces the mean and RMS pressure loading at the fin root, the extent of the region of unsteady separation shock motion (i.e. the intermittent region), and the separation length. The spectral content of pressure fluctuations in the intermittent region shifts to higher frequencies with leading edge sweep, while the spectral content of pressure fluctuations in the separated region is virtually unchanged by leading edge sweep. Of the different fin leading edge geometries which induce the same size interaction, the 'blunter' configurations produce smaller intermittent regions and larger separated regions. While the use of a strake at the fin leading edge root has virtually no effect, a swept hemicylindrically blunted root fillet reduces the centerline upstream influence and intermittent region length by 50% and reduces the mean and RMS pressure loading at the fin root by 75% and 95% respectively. DTIC

N94-17222# Air Force Inst. of Tech., Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.
NUMERICAL SOLUTION OF SUPG FINITE-ELEMENT METHOD FOR SUPERSONIC VISCOUS FLOW
GUO-QUN XU and GUO-FU ZHANG 20 Jul. 1993 22 p Transl. into ENGLISH from Lixue Xuebao (China), v. 23, no. 5, 1991 p 533-541
(AD-A267762; FASTC-ID(RS)T-0932-92) Avail: CASI HC A03/MF A01

A streamline upwind/Petrov-Galerkin (SUPG) weighted residual formalism was developed in the paper for the quasi-simplified Navier-Stokes equations. Numerical computations were made for Burger's equation, the nonviscous shock wave reflection problem, as well as supersonic laminar flow over a flat plate and compression corner flow by using the method. The results of the computations show that this method is accurate, convergent, and stable. DTIC

N94-17260*# Wichita State Univ., KS. National Inst. for Aviation.
SUPERSONIC FLOW VISUALIZATION OF A NACELLE IN CLOSE PROXIMITY TO A SIMULATED WING Final Technical Report
KASIM BIBER and DAVID R. ELLIS Jul. 1993 43 p
(Contract NASA ORDER A-24888-D)
(NASA-CR-194675; NAS 1.26:194675; NIAR-93-18) Avail: CASI HC A03/MF A01

A flow visualization study was made in the 9 x 9 inch supersonic wind tunnel at Wichita State University to examine shock and boundary layer flow interaction for a nacelle in close proximity to the lower surface of a simulated wing. The test matrix included variations of angle of attack from -2 degrees to +4 degrees, nacelle-wing gap from 0.5 to 3-nacelle inlet diameter (0.12 inch), and Reynolds number based on nacelle length (1.164 inch) from 1.16 x 10(exp 6) to 1.45 x 10(exp 6) at a nominal Mach number of 2. Schlieren pictures of wing and nacelle flowfield were recorded by a video camera during each tunnel run. Results show that the nacelle inlet shock wave remains attached to the inlet lip and its impingement does not significantly affect the wing boundary layer. At the nacelle trailing edge location, the wing boundary layer thickness is approximately one nacelle inlet diameter at alpha = 0 degrees and it decreases with increase of angle of attack. Author (revised)

N94-17274# Air Force Systems Command, Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.
EXPERIMENTAL STUDY OF VORTEX AND AERODYNAMIC CHARACTERISTICS OF STACK WINGS WITH SIDESLIP
BAO GUOHUA 20 Jul. 1993 15 p Transl. into ENGLISH from Kongqidonglixue Xuebao (China), v. 7, no. 2, Jun. 1989 p 215-219
(AD-A267722; FASTC-ID(RS)T-0034-93) Avail: CASI HC A03/MF A01

This paper reports on an experimental study of stack wings with small aspect ratio, and describes the variation of detached vortex system at the aircraft wing leading edge with different aspect ratios. The influence on aerodynamic characteristics due to vortex twisting and bursting is analyzed. As revealed in the study, sideslip delays the vortex twisting at the upstream side of the aircraft wing. The vortex bursts early. At the downward side, the phenomena are exactly in reverse. During sideslip, bursting of an asymmetrical vortex has an obvious influence on the aerodynamic characteristics. DTIC

N94-17284*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUBSONIC AERODYNAMIC CHARACTERISTICS OF THE HL-20 LIFTING-BODY CONFIGURATION
GEORGE M. WARE and CHRISTOPHER I. CRUZ Nov. 1993 29 p
(Contract RTOP 505-40-61-01)
(NASA-TM-4515; L-17261; NAS 1.15:4515) Avail: CASI HC A03/MF A01

The HL-20 is proposed as a possible future manned spacecraft. The configuration consists of a low-aspect-ratio body with a flat undersurface. Three fins (a small centerline fin and two outboard (tip) fins set at a dihedral angle of 50 deg) are mounted on the aft body. The control system consists of elevon surfaces on the outboard fins, a set of four body flaps on the upper and lower aft body, and an all-movable center fin. Both the elevons and body flaps were capable of trimming the model to angles of attack from -2 deg to above 20 deg. The maximum trimmed lift-drag ratio was 3.6. Replacing the flat-plate tip fins with airfoil tip fins increased the maximum trimmed lift-drag ratio to 4.2. The elevons were effective as a roll control, but they produced about as much yawing moment as rolling moment because of the tip-fin dihedral angle. The body flaps produced less rolling moment than the elevons and only small values of yawing moment. A limited investigation of the effect of varying tip-fin dihedral angle indicated that a dihedral angle of 50 deg was a reasonable compromise for longitudinal and lateral stability, longitudinal trim, and performance at subsonic speeds. Author (revised)

N94-17461 Wright Lab., Wright-Patterson AFB, OH.
AN EXPERIMENTAL STUDY OF FLUCTUATING WALL PRESSURES IN A HIGHLY SWEPT, SHARP FIN-INDUCED, MACH 5 SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTION Final Report, Aug. 1990 - May 1992
J. D. SCHMISSEUR Jan. 1993 158 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract AF PROJ. 2404)
(AD-A268394; WL-TR-93-3058) Avail: CASI HC A08

Fluctuating wall pressure measurements have been made beneath the shock wave/turbulent boundary layer interaction generated by a sharp, unswept fin at angle of attack. Tests were conducted at Mach 5 with a freestream unit Reynolds number of 47.88 x 106 /m. The boundary layer developed naturally on the tunnel floor under approximately adiabatic temperature conditions. From visual inspection and standard time series analysis of fluctuating wall pressure signals, it has been shown that the separation shock wave undergoes a translating, intermittent type motion for fin angles between 16 and 28 degrees. Both the mean wall pressures and higher order moments are quasi-conically symmetric when collapsed in a conical coordinate system. Finally, the maximum wall pressure standard deviation in the intermittent region has been shown to scale with the sweep of the interaction and not with the inviscid pressure rise as has been previously suggested in the literature. DTIC

N94-17558*# Sverdrup Technology, Inc., Brook Park, OH.
THIN-LAYER AND FULL NAVIER-STOKES CALCULATIONS FOR TURBULENT SUPERSONIC FLOW OVER A CONE AT AN ANGLE OF ATTACK Final Report
CRAWFORD F. SMITH and STEVE D. PODLESKI Nov. 1993 102 p
(Contract NAS3-25266; RTOP 533-02-35)
(NASA-CR-189103; E-8197; NAS 1.26:189103) Avail: CASI HC A06/MF A02

The proper use of a computational fluid dynamics code requires a good understanding of the particular code being applied. In this report the application of CFL3D, a thin-layer Navier-Stokes code, is compared with the results obtained from PARC3D, a full Navier-Stokes code. In order to gain an understanding of the use of this code, a simple problem was chosen in which several key features of the code could be exercised. The problem chosen is a cone in supersonic flow at an angle of attack. The issues of grid resolution, grid blocking, and multigridding with CFL3D are explored. The use of multigridding resulted in a significant reduction in the computational time required to solve the problem. Solutions obtained are compared with the results using the full Navier-Stokes equations solver PARC3D. The results obtained with the CFL3D code compared well with the PARC3D solutions. Author

N94-17574# Cincinnati Univ., OH. Dept. of Aerospace Engineering and Engineering Mechanics.
AN INVESTIGATION OF OBLIQUE SHOCK/BOUNDARY LAYER INTERACTION CONTROL Final Report, 1 Dec. 1990 - 31 Mar. 1993
A. HAMED 30 Jun. 1993 14 p
(Contract AF-AFOSR-0101-91)
(AD-A268106; AFOSR-93-0613TR) Avail: CASI HC A03/MF A01

The objective of this work is to provide a basic understanding of the flow in the shock boundary layer interactions and of the mechanisms of their control. A parametric investigation was conducted to determine the effect of bleed configuration on the flow in the interaction region of an incident oblique shock with a turbulent boundary layer. Results of the numerical flow simulations were obtained for different slot widths, depths and slat angles over a bleed mass flow range between zero and choked conditions. The bleed results reveal a complex structure of compression expansion wave system over the bleed port entrance, and different levels of flow operation inside the slot. Code development for the implicit numerical solution of the two dimensional compressible Navier-Stokes and K-Epsilon equations was completed. The code was used in the simulation of unsteady supersonic cavity flow and the results compared with experimental data. DTIC

N94-17580# California Inst. of Tech., Pasadena. Graduate Aeronautical Labs.
CHEMICAL REACTIONS IN TURBULENT MIXING FLOWS Final Report, 15 May - 30 Dec. 1992
PAUL E. DIMOTAKIS, JAMES E. BROADWELL, and ANTHONY LEONARD 30 Jun. 1993 9 p
(Contract AF-AFOSR-0304-90)
(AD-A268287; AFOSR-93-0568TR) Avail: CASI HC A02/MF A01

This is a supplement to the Final Annual Report for this Grant. It documents: (1) an upgrade/modification to the Supersonic Shear Layer (S3L) combustion facility, and (2) progress and developments in digital-image-data systems and acquisition, realized during the extension period, ending 30 June 1992. DTIC

N94-17609# Wright Lab., Wright-Patterson AFB, OH.
LASER VELOCIMETRY MEASUREMENTS OF VORTEX FLOWS ON A DELTA WING AT MACH 1.9 Final Report, Aug. 1990 - Sep. 1992
LINDA G. SMITH, MARK S. MAURICE, CHARLES TYLER, GEORGE L. SEIBERT, and C. D. MILLER Jan. 1993 115 p
(Contract AF PROJ. 2404)
(AD-A268596; WL-TR-93-3059) Avail: CASI HC A06/MF A02

Off-body flow visualizations and fluid velocity measurements are conducted in a supersonic vortex flow. Three-dimensional laser velocimetry measurements are made in the leeward flowfield over a simple sharp-edged delta wing with 75 degree sweep angle. Tests are conducted at Mach 1.9 and Reynolds number of 2.4 x 10(exp 6) based on model root chord. Measurements are made at 40% and 80% chord positions for 20 and 30 degree angles of attack and at 40% chord for 35 degrees. Mean velocities and turbulence intensities are measured on the five planes. Measurement accuracy is discussed in detail. The measurements define the location of the vortex core and provide the flowfield velocities surrounding the vortex. The difficulties inherent with seeding high velocity vortex flows are discussed. DTIC

N94-17639*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
USER'S MANUAL FOR THE LANGLEY RESEARCH CENTER 14- BY 22- FOOT SUBSONIC TUNNEL STATIC DATA ACQUISITION SYSTEM
NETTIE M. ORIE and P. FRANK QUINTO Nov. 1993 108 p

(Contract RTOP 535-03-10-02)
(NASA-TM-109027; NAS 1.15:109027) Avail: CASI HC A06/MF A02

The Static Data Acquisition System (SDAS) components primarily responsible for acquiring data at the 14- by 22-Foot Subsonic Tunnel are the NEFF 620/600 Data Acquisition Unit (DAU) and the PSI 780B electronically scanned pressure (ESP) measurement system. A 9250 Modcomp computer is used to process the signal, to do all aerodynamic calculation, and to control the output of data. All of the tasks required to support a wind tunnel investigation are menu driven. The purpose of this report is to acquaint users of this system with the wide range of capabilities that exist with the available hardware and software and provide them with the proper procedures to follow when setting up or running individual tests. Author

N94-17721 Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
WBNGRID, A PROGRAM FOR GENERATION OF C-H AND C-O TOPOLOGY GRIDS AROUND WING/BODY/NACELLE CONFIGURATIONS: USER'S GUIDE
SVEN G. HEDMAN and LARS G. TYSELL Jan. 1993 91 p
Sponsored by Foersvarets Materialverk, Stockholm, Sweden, and National Board for Industrial and Technical Development, Sweden
Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(FFA-TN-1992-09; ETN-93-94856) Avail: Issuing Activity (European Space Agency (ESA))

The principles of WBNGRID, a computer program for generation of C-H or C-O topology grids for the discretization of flow fields around configurations consisting of a wing alone or a wing with a fuselage and/or a nacelle, are described. WBNGRID is a development from an earlier grid generation progam MATGRID for wing fuselage combinations. In case the configuration contains a nacelle the grid is divided into two blocks. It is thought that primarily the grids will be used together with the full potential flow solver WBNFLOW which is a two block extension from the one block solver MATRICS (Multicomponent Aircraft Transonic Inviscid Computation System). The files required, some parameters, how to modify the input, and how to run the program are described. An example is also included as a test case. ESA

N94-17722 Aeronautical Research Inst. of Sweden, Stockholm.
A STUDY OF THE INFLUENCE OF A DELTA WING GEOMETRY ON THE INDUCED DRAG AT TRANSONIC SPEED (M=0.55) AND HIGH ANGLES OF ATTACK
GEORG DROUGGE Feb. 1993 23 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract FMV-82260-91-087-073-001; FMV-82260-92-060-073-001)
(FFA-TN-1992-14; ETN-93-94857) Avail: CASI HC A03

An investigation which concerns mainly the effect of variation of the leading edge geometry and droop for a delta wing with given planform is reported. The lift and the induced drag at M = 0.55 at high angles of attack are calculated with a Euler code. It is found that with the leading edge drooping angle increasing over the span and with the nose radius increasing from 0.1% at the root to 0.7% at the tip it was possible to obtain attached flow over the wing for alpha = 17 deg and alpha = 18 deg. This resulted in very high efficiency factors which means low induced drag which in turn, improves the maneuver performance. The effect of viscosity not included in the Euler equations is discussed. ESA

N94-17919# Aeronautical Research Inst. of Sweden, Stockholm.
CFD INVESTIGATIONS OF THE HYPERSONIC DOUBLE DELTA WING GRETA: SANGER PROJECT NO. 3.2
STEFAN WALLIN and TOR-ARNE GROENLAND 31 Mar. 1993 40 p Sponsored by Swedish Board for Space Activities, Solna
(FFA-TN-1992-42; ETN-93-94860) Avail: CASI HC A03/MF A01

The flow field over the double delta wing Greta with neutral flaps, was computed by solving the inviscid Euler equations and the laminar and turbulent Navier-Stokes equations at two Mach numbers, Mach 4 and 7. The Euler computations were made at three different angles of attack, alpha equals +10 deg, 0 deg, and -10 deg, while the Navier Stokes computations were made only at alpha equals +10 deg. The Computational Fluid Dynamics (CFD) were compared to measurements of the integrated forces and oil flow patterns. The flow field over the Greta vehicle is quite complex and is dominated by a strong bow shock and a strong primary vortex in the leeward side of the wing. At the high Mach number a cross flow shock is observed. The inviscid results show one strong vortex in the leeward side while the laminar results shows additional secondary vortices that introduce a couple of separation and reattachment lines. The turbulent flow solutions show a more viscous behavior, with thicker boundary layers and less distinct vortices and separation lines. The oil flow pattern from the wind tunnel experiments looks like something between the laminar and turbulent results. There is a reason to believe that the computational meshes have to be refined to get more accurate turbulent results. ESA

N94-17957# Institut National de Recherche d'Informatique et d'Automatique, Valbonne (France). Programme 6: Calcul Scientifique, Modelisation et Logiciels Numeriques.
SYNTHESIS OF THE WORKSHOP ON HYPERSONIC FLOWS FOR REENTRY PROBLEMS
REMI ABGRALL, JEAN-ANTOINE DESIDERI, MICHEL MALLET (Dassault-Breguet Aviation, Saint Cloud, France.), JACQUES PERIAUX (Dassault-Breguet Aviation, Saint Cloud, France.), PIERRE PERRIER (Dassault-Breguet Aviation, Saint Cloud, France.), and BRUNO STOUFFLET (Dassault-Breguet Aviation, Saint Cloud, France.) Jun. 1992 85 p Workshop held in Antibes, France, Jan. 1990 and Apr. 1991
(ISSN 0249-6399)
(INRIA-RR-1721; ETN-93-94431) Avail: CASI HC A05/MF A01

The organization of a workshop open to the international scientific community on hypersonic flows for reentry problems is addressed. This workshop was focused on the issues of validation of numerical methodologies for the computation of high Mach number flows, and gathered experts in scientific computing, fluid mechanics and experimentalists associated with the research and development Hermes program. This report presents a general synthesis of the motivations for this initiative, the development of the meetings, and the main conclusions drawn. ESA

N94-18275# Sandia National Labs., Albuquerque, NM.
ERROR PROPAGATION EQUATIONS AND TABLES FOR ESTIMATING THE UNCERTAINTY IN HIGH-SPEED WIND TUNNEL TEST RESULTS
E. L. CLARK Aug. 1993 100 p
(Contract DE-AC04-76DP-00789)
(DE93-018685; SAND-93-0208) Avail: CASI HC A05/MF A02

Error propagation equations, based on the Taylor series model, are derived for the nondimensional ratios and coefficients most often encountered in high-speed wind tunnel testing. These include pressure ratio and coefficient, static force and moment coefficients, dynamic stability coefficients, calibration Mach number, and Reynolds number. The error equations contain partial derivatives, denoted as sensitivity coefficients, which define the influence of free-stream Mach number, M(infinity), on various aerodynamic ratios. To facilitate use of the error equations, sensitivity coefficients are derived and evaluated for nine fundamental aerodynamic ratios, most of which relate free-stream test conditions (pressure, temperature, density, or velocity) to a reference condition. Tables of the ratios, R, absolute sensitivity coefficients, (partial derivative)R/(partial derivative)M(infinity), and relative sensitivity coefficients, (M(infinity)/R) ((partial derivative)R/(partial derivative)M(infinity)), are provided as functions of M(infinity). DOE

N94-18402# Naval Postgraduate School, Monterey, CA.
A COMPUTATIONAL AND EXPERIMENTAL INVESTIGATION OF INCOMPRESSIBLE OSCILLATORY AIRFOIL FLOW AND FLUTTER PROBLEMS M.S. Thesis
PETER J. RIESTER Jun. 1993 158 p
(AD-A268748) Avail: CASI HC A08/MF A02

In this thesis several incompressible oscillatory flow and flutter problems were investigated. First, a previously developed unsteady panel code was modified so that systematic comparisons with Theodorsen's classical theory could be accomplished. It was found that the panel code is in excellent agreement with the Theodorsen results. Second, the panel code was applied to the analysis of bending-torsion flutter. Again, general agreement with Theodorsen's flutter predictions was obtained. In the experimental part of the thesis, two flow visualization experiments were performed. First, the vortical flow patterns generated by an airfoil executing harmonic plunge oscillations were visualized. In the second experiment, the interference effects between a stationary airfoil and a small vane executing plunge oscillations were explored. DTIC

N94-18413# Maryland Univ., College Park. Dept. of Aerospace Engineering.
AERODYNAMIC CHARACTERISTICS OF A HELICOPTER ROTOR AIRFOIL AS AFFECTED BY SIMULATED BALLISTIC DAMAGE Final Report, Apr. - Dec. 1992
J. G. LEISHMAN Sep. 1993 60 p
(Contract DAAD05-92-C-0114; DA PROJ. 1L1-62618-AH-80)
(AD-A269206; ARL-CR-66) Avail: CASI HC A04/MF A01

Tests were made in a two-dimensional insert at the University of Maryland's Glenn L. Martin subsonic wind tunnel to examine the effects of simulated ballistic damage on the aerodynamic characteristics of a UH-60A Black Hawk helicopter main rotor blade section. Tests were conducted on the undamaged blade section, and on the same section with simulated ballistic damage comprising a circular hole with a surrounding portion of the skin removed, exposing the internal honeycomb structure. The structural lift, drag, and pitching moment were measured at small increments in angle of attack up through stall at Reynolds numbers of 10(exp 6) and 2 x 10(exp 6). In addition, tests were conducted over a full 360-degree range in angle of attack for a Reynolds number of 10(exp 6). The measurements were complemented by mini-tuft flow visualization on the upper wing section, particularly near the hole. DTIC

N94-18417# Middle East Technical Univ., Ankara (Turkey). Dept. of Aeronautical Engineering.
EXPERIMENTAL INVESTIGATION OF FLOW AROUND A MULTIELEMENT AIRFOIL
NAFIZ ALEMDAROGLU *In* AGARD, High-Lift System Aerodynamics 19 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

This paper presents the results of experimental investigations performed around a multielement airfoil and gives detailed information about the flow in and around the flap-well and slat cavity regions. Measurements are made using pitot probes, hotwire anemometer and laser Doppler velocimeter at a Reynolds number of 0.5 and 0.8x10(exp 6). The results obtained show the complex nature of the shear flows investigated and put into evidence the necessity of accurate modeling of these flows by numerical methods. Author (revised)

N94-18419# Dornier Luftfahrt G.m.b.H., Friedrichshafen (Germany).
CALCULATION OF MAXIMUM AND HIGH LIFT CHARACTERISTICS OF MULTI ELEMENT AEROFOILS
WILLY FRITZ *In* AGARD, High-Lift System Aerodynamics 12 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

The flow field around multi-element aerofoil sections possesses a high degree of complexity. Due to the strong interactions between wakes from the upstream elements and the upper surface boundary layers developing on the downstream elements, there are thick viscous layers present over the upper surface of the trailing edge flap. Large regions of separated flow can be present, even for conditions well below maximum lift. Finally, the flow around the leading edge slat can become locally supersonic, even for low freestream Mach numbers, due to the large suction levels induced in this region. The viscous-inviscid interaction methods, which are most widely in use for the prediction of multi-element aerofoil flows, are computationally very efficient, but unable to describe many of the complex flow features present. A more complete description of the physical phenomena can be achieved only by methods based on a solution of the Reynolds-averaged Navier-Stokes equations, in conjunction with a suitable turbulence model. The generation of a suitable computational grid then becomes a major problem. Within the present work, a method to generate suitable block structured grids around multi-element aerofoils has been developed. The Dornier 2-D block structured Navier-Stokes solver has been extended for grids with arbitrary block structure. After very encouraging results for a two-element high lift system at low angles of attack, in this work the method was applied for realistic two- and three-element high lift systems at high angles of attack. Derived from text

N94-18420# Technische Univ., Berlin (Germany). Inst. fuer Luft- und Raumfahrt.
NAVIER-STOKES COMPUTATIONS OF TURBULENT FLOW AROUND HIGH-LIFT CONFIGURATIONS
P. BARTSCH, W. NITSCHE, and M. BRITSCH *In* AGARD, High-Lift System Aerodynamics 10 p Sep. 1993
Copyright Avail: CASI HC A02/MF A04

This paper presents Navier-Stokes calculations of the turbulent flow around two different high-lift configurations, for which experimental data exist. In the calculations, the flow field is considered as of steady-state and two-dimensional. Because of the low Mach numbers, the fluid is treated as incompressible. The solution procedure uses a finite volume method in order to solve the Reynolds-averaged Navier-Stokes equations. The effects of turbulence on the mean flow field are described by the k-epsilon turbulence model. The computational mesh is systematically refined in order to assess numerical solution errors. The results presented in this paper include surface pressure distributions as well as mean velocities and turbulence quantities. If possible, the calculations are compared to experimental data. Author

N94-18421*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EFFICIENT SIMULATION OF INCOMPRESSIBLE VISCOUS FLOW OVER MULTI-ELEMENT AIRFOILS
STUART E. ROGERS, N. LYN WILTBERGER, and DOCHAN KWAK *In* AGARD, High-Lift System Aerodynamics 9 p Sep. 1993
Copyright Avail: CASI HC A02/MF A04

The incompressible, viscous, turbulent flow over single and multi-element airfoils is numerically simulated in an efficient manner by solving the incompressible Navier-Stokes equations. The solution algorithm employs the method of pseudo compressibility and utilizes an upwind differencing scheme for the convective fluxes, and an implicit line-relaxation scheme. The motivation for this work includes interest in studying high-lift take-off and landing configurations of various aircraft. In particular, accurate computation of lift and drag at various angles of attack up to stall is desired. Two different turbulence models are tested in computing the flow over an NACA 4412 airfoil; an accurate prediction of stall is obtained. The approach used for multi-element airfoils involves the use of multiple zones of structured grids fitted to each element. Two different approaches are compared; a patched system of grids, and an overlaid Chimera system of grids. Computational results are presented for two-element, three-element, and four-element airfoil configurations. Excellent agreement with experimental surface pressure coefficients is seen. The code converges in less than 200 iterations, requiring on the order of one minute of CPU time on a CRAY YMP per element in the airfoil configuration. Author (revised)

N94-18422*# McDonnell Aircraft Co., Saint Louis, MO.
NAVIER-STOKES CALCULATIONS ON MULTI-ELEMENT AIRFOILS USING A CHIMERA-BASED SOLVER
DONALD W. JASPER, SHREEKANT AGRAWAL, and BRIAN A. ROBINSON *In* AGARD, High-Lift System Aerodynamics 11 p Sep. 1993 Sponsored by NASA. Ames Research Center and Cray Research, Inc.
Copyright Avail: CASI HC A03/MF A04

A study of Navier-Stokes calculations of flows about multielement airfoils using a chimera grid approach is presented. The chimera approach utilizes structured, overlapped grids which allow great flexibility of grid arrangement and simplifies grid generation. Calculations are made for two-, three-, and four-element airfoils, and modeling of the effect of gap distance between elements is demonstrated for a two element case. Solutions are obtained using the thin-layer form of the Reynolds averaged Navier-Stokes equations with turbulence closure provided by the Baldwin-Lomax algebraic model or the Baldwin-Barth one equation model. The Baldwin-Barth turbulence model is shown to provide better agreement with experimental data and to dramatically improve convergence rates for some cases. Recently developed, improved farfield boundary conditions are incorporated into the solver for greater efficiency. Computed results show good comparison with experimental data which include aerodynamic forces, surface pressures, and boundary layer velocity profiles.
Author

N94-18423# Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.
NUMERICAL SOLUTION OF THE NAVIER-STOKES EQUATIONS FOR HIGH-LIFT CONFIGURATIONS ON STRUCTURED COMPOSITE GRIDS
T. E. NELSON, D. W. ZINGG, and G. W. JOHNSTON *In* AGARD, High-Lift System Aerodynamics 14 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

A numerical method is presented for the solution of the compressible Reynolds-averaged, thin-layer Navier-Stokes equations on structured composite grids as applied to high-lift configurations. The method is an adaptation of an implicit approximate factorization algorithm for block structured composite grids. Interfaces between blocks are treated by overlapping the grids and taking one layer of points from neighboring blocks. Turbulence is treated using the Baldwin-Barth one-equation turbulence model. High-lift applications presented for comparison with wind tunnel data include: a NACA 4412 airfoil with NACA 4415 flap, a GA(W)-1 airfoil with a 29 percent chord flap at 30 degree flap angle and two gap settings, and a GA(W)-1 airfoil with 15 percent chord slat and 29 percent chord flap. Good agreement with experimental data is obtained for cases with fully attached flow or small regions of separated flow. For cases with extensive regions of flow separation, the thickness and extent of the separated regions are underpredicted. Author

N94-18424*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HIGH REYNOLDS NUMBER CONFIGURATION DEVELOPMENT OF A HIGH-LIFT AIRFOIL
WALTER O. VALAREZO (Douglas Aircraft Co., Inc., Long Beach, CA.), CHET J. DOMINIK (Douglas Aircraft Co., Inc., Long Beach, CA.), ROBERT J. MCGHEE, and WESLEY L. GOODMAN *In* AGARD, High-Lift System Aerodynamics 8 p Sep. 1993
Copyright Avail: CASI HC A02/MF A04

An experimental program has been conducted to assess performance of a transport multielement airfoil at flight Reynolds numbers. The studies were performed at chord Reynolds numbers as high as 16 million in the NASA Langley Low Turbulence Pressure Tunnel. Sidewall boundary-layer control to enforce flow two dimensionality was provided via an endplate suction system. The basic airfoil was an 11.55 percent thick supercritical airfoil representative of the stall critical station of a new-generation transport aircraft wing. The multielement airfoil was configured as a three-element airfoil with slat and flap chord ratios of 14.48 percent and 30 percent respectively. Testing focused on the development of landing configurations with high maximum lift capability and the assessment of Reynolds and Mach number effects. Also assessed were high-lift performance effects due to devices such as drooped spoilers and trailing-edge wedges. The present experimental studies revealed significant effects on high-lift airfoil performance due to Reynolds and Mach number variations and favorable lift increments at approach angles of attack due to the use of drooped spoilers or trailing-edge wedges. However, no substantial improvements in maximum lift capability were identified. A recently developed high performance single-segment flap was also tested and results indicated considerable improvements in lift and drag performance over existing airfoils. Additionally, it was found that this new flap shape at its optimum rigging was less sensitive to Reynolds number variations than previous designs.
Author

N94-18425# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
A VISCOUS-INVISCID SOLVER FOR HIGH-LIFT INCOMPRESSIBLE FLOWS OVER MULTI-ELEMENT AIRFOILS AT DEEP SEPARATION CONDITIONS [UNE METHODE D'INTERACTION VISQUEUX NON-VISQUEUX POUR ECOULEMENTS INCOMPRESSIBLES HYPERSUSTENTES SUR PROFILS MULTI-CORPS EN REGIME DE DECOLLEMENT PROFOND]
J. C. LEBALLEUR and M. NERON *In* AGARD, High-Lift System Aerodynamics 12 p Sep. 1993 In FRENCH
Copyright Avail: CASI HC A03/MF A04

A viscous-inviscid interaction numerical method for incompressible flows over multi-element airfoils, which is an extension of the numerical method previously suggested for compressible attached or separated or even stalled flows over airfoils, is presented. The robust algorithms of the method are capable now to converge well for attached flows or massively separated flows, such as induced by slope discontinuities of airfoils or slats, or such as induced by stall. The viscous-inviscid approach introduces a self-adaptative viscous grid in both normal and streamwise directions along the displacement surfaces, with everywhere a streamwise grid-resolution of the same order as the separating boundary layer thicknesses, even at slat apexes, which is believed to eliminate any aleatory effect of numerical viscosity. The method is validated with respect to ONERA experiments, on the three-element RA16SC1 high-lift device, with the severe AMD slat-geometry. A realistic non-uniqueness of the separated flow solutions has been exhibited by the calculation method. A satisfactory agreement between theory and experiment is obtained, with the suggested 2-equation turbulence model.
Author (revised)

N94-18426# National Aerospace Lab., Amsterdam (Netherlands).
HIGH-LIFT SYSTEM ANALYSIS METHOD USING UNSTRUCTURED MESHES
K. DECOCK *In* AGARD, High-Lift System Aerodynamics 20 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

A 2D high-lift configuration analysis method is described. The flow model used is based on the Euler equations, discretized on unstructured meshes. The generation of the unstructured meshes is based on the principle of successive grid adaptation with respect to the geometry. This approach makes later extension towards fully integrated grid adaptation with respect to the solution straightforward. The main characteristics of the Euler solver are upwind flux-difference splitting of the convective part of the Euler equations (second-order accurate discretization in space) and four stage Runge Kutta local time stepping. Results obtained with this analysis method are shown for the NACA0012 airfoil and three-element airfoils. Conclusions are drawn. Author

N94-18427# Manchester Coll. of Science and Technology (England). Dept. of Mechanical Engineering.
PREDICTION OF THE HIGH-LIFT PERFORMANCE OF MULTI-ELEMENT AEROFOILS USING AN UNSTRUCTURED NAVIER-STOKES SOLVER
LESLIE J. JOHNSTON and LUCA STOLCIS *In* AGARD, High-Lift System Aerodynamics 18 p Sep. 1993
(Contract CEC-SC1/900369)
Copyright Avail: CASI HC A03/MF A04

A detailed description is presented of a computational method to predict the aerodynamic performance of mechanical high-lift systems. The Reynolds-averaged Navier-Stokes equations applicable to compressible, two-dimensional mean flow are solved using a cell-centered, finite-volume spatial discretization and an explicit multi-stage to time march to steady-state solutions. The governing mean-flow equations are solved in conjunction with a two-equation, high-Reynolds number k-epsilon turbulence model, this level of turbulence model sophistication being considered as the minimum required to enable an adequate resolution of the complex flow physics. The geometric complexity associated with practical multi-element airfoil configurations is addressed by adopting unconstructed computational grids. Results for the RAE 2822 transonic single-airfoil section are presented, comparing two near-wall treatments for the turbulence-transport equations. Thereafter, a detailed evaluation is presented of the predictive capability of the method, in its current form, by comparison with experimental data for the low-speed, high-lift NLR 7301 airfoil/trailing-edge flap configuration. Results are also presented for the SKF 1.1 airfoil/manoeuver flap configuration over a range of transonic flow conditions, from fully-subcritical flow to supercritical flow with shock-induced separation. The level of agreement between predictions and experiment is encouraging for the cases considered. However, it is concluded that improved modeling of the complex flow physics is required, with the lack of response of the current k-epsilon turbulence model to streamline curvature being a significant limitation on quantitative accuracy around maximum lift conditions. Similarly, procedures to automatically adapt the computational grid to the flow solution would improve predictions over the extended range of conditions associated with the practical operation of a mechanical high-lift system. Author (revised)

N94-18428# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. for Design Aerodynamics.
NUMERICAL CALCULATIONS OF HIGH LIFT FLOWS USING STRUCTURED AND UNSTRUCTURED METHODS
R. BAILEY, J. M. A. LONGO, R. RADESPIEL, A. RONZHEIMER, A. DEMIER, N. KROLL, and C.-C. ROSSOW *In* AGARD, High-Lift System Aerodynamics 13 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

At the DLR Institute for Design Aerodynamics current research in the area of high lift aerodynamics is directed towards the development of a computational analysis capability for high lift systems. The Navier-Stokes equations are solved with a multigrid method based on central spatial differencing and Runge-Kutta time stepping. Two particular problems are addressed in this paper. The first concerns the calculation of maximum lift for a single airfoil and a clean wing configuration. The accuracy of the basic structured flow solver is investigated by comparing the results with experimental data for two test problems and several flow conditions. Emphasis is placed on the sensitivity of the computed solution associated with turbulence modeling. The second aspect dealt with in the present paper concerns the extension of the numerical method to multi-element airfoils. Both, the block-structured and the unstructured grid approach are investigated in order to explore their specific merits and limitations. Detailed comparisons of the structured and unstructured approach are presented for low Reynolds number laminar viscous flows around a single airfoil, and for the inviscid flow around a multi-element airfoil. Author

N94-18429# Grumman Aerospace Corp., Bethpage, NY.
NAVIER-STOKES SIMULATION OF FLOW FIELD AROUND A BLOWN-FLAP HIGH-LIFT SYSTEM
R. CHOW, K. CHU, and G. CARPENTER *In* AGARD, High-Lift System Aerodynamics 10 p Sep. 1993
Copyright Avail: CASI HC A02/MF A04

Solution of the Reynolds averaged Navier-Stokes equations is obtained to simulate the flow field around a 13 percent thickness supercritical airfoil slat/blown-flap high-lift system. A stacked-C mesh topology is used in conjunction with the slat and the flap trailing edge streamlines and adapted to accurately locate the strong viscous flow regions. A previously modified PARC2D implicit ADI solver is employed whereby the multiply connected boundary value problem can be treated with a single computation zone. A modeled injection boundary condition was demonstrated to connect transient flap wake vortices downstream of the computational domain. The converged surface pressures and the values of the lift coefficient are compared with the wind tunnel data at M(infinity) = 0.17, Re = 3.4 M for momentum injection coefficients of C(mu) = 0.01 and C(mu) = 0.04, respectively. Author (revised)

N94-18430# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
THE GARTEUR HIGH LIFT RESEARCH PROGRAMME
J. J. THIBERT *In* AGARD, High-Lift System Aerodynamics 21 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

An extensive European wind tunnel research program on high lift systems has been carried out in the past few years within the framework of a GARTEUR Action Group. To provide a relevant and realistic case, permission was given by British Aerospace to use a section from the A-310 wing from which a 2D airfoil could be derived. A Deutsche Airbus 3D half model of the A-310 aircraft has been used for the 3D test and an airfoil representative of the 59 percent span section has been used for the 2D test. The wind tunnel test program carried out in the major European low speed wind tunnels (ONERA F1 in France, NLR HST and LST in Netherlands, RAE 5 m in UK) was complemented by a full scale flight test supported by Airbus Industries. A wide range of Reynolds numbers and Mach numbers has been covered by the test and a very comprehensive, well integrated and accurate body of data has been generated by this research program. After presenting GARTEUR the paper deals with the Reynolds number and the Mach number effects as well as the correlations between 2D and 3D data and between wind tunnel and flight test results. Author

N94-18433# Boeing Commercial Airplane Co., Seattle, WA.
VISCOUS PHENOMENA AFFECTING HIGH-LIFT SYSTEMS AND SUGGESTIONS FOR FUTURE CFD DEVELOPMENT
P. T. MEREDITH *In* AGARD, High-Lift System Aerodynamics 8 p Sep. 1993
Copyright Avail: CASI HC A02/MF A04

This paper describes a number of viscous phenomena which affect the aerodynamic performance of high-lift systems typical of commercial jet transports. The nature of these phenomena suggest a course of action regarding the continuing development of computational fluid dynamics (CFD): in addition to the ongoing work of grid generation and algorithm development, increased attention to fundamental fluid mechanics is called for. Author

N94-18434# Defence Research Agency, Farnborough (England).
A STUDY OF THE USE OF HALF-MODELS IN HIGH-LIFT WIND-TUNNEL TESTING
P. B. EARNSHAW, A. R. GREEN, B. C. HARDY, and A. H. JELLY *In* AGARD, High-Lift System Aerodynamics 9 p Sep. 1993
Copyright Avail: CASI HC A02/MF A04

An experimental investigation into the use of half-model testing techniques specifically aimed at high-lift testing has been carried out in the 5 Metre Pressurized Wind Tunnel at the DRA, Farnborough. The aim of the program was to provide an assessment of the extent to which the measured characteristics of a high-lift model might be compromised by, in particular, the existence of a boundary layer on the reflection plane and how any penalties might be minimized. The results suggest that, provided care is taken with experimental technique, good agreement is possible on stall incidence as well as the absolute values of lift, drag and pitching moment. Author

N94-18435*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

IN-FLIGHT PRESSURE DISTRIBUTIONS AND SKIN-FRICTION MEASUREMENTS ON A SUBSONIC TRANSPORT HIGH-LIFT WING SECTION

LONG P. YIP, PAUL M. H. W. VIJGEN (High Technology Corp., Hampton, VA.), JAY D. HARDIN (Lockheed Engineering and Sciences Co., Hampton, VA.), and C. P. VANDAM (California Univ., Davis.) *In* AGARD, High-Lift System Aerodynamics 19 p Sep. 1993

(Contract NAS1-19299; NAS1-19000; NCC1-163)

Copyright Avail: CASI HC A03/MF A04

Flight experiments are being conducted as part of a multiphased subsonic transport high-lift research program for correlation with wind-tunnel and computational results. The NASA Langley Transport Systems Research Vehicle (B737-100 aircraft) is used to obtain in-flight flow characteristics at full-scale Reynolds numbers to contribute to the understanding of 3-D high-lift, multi-element flows including attachment-line transition and relaminarization, confluent boundary-layer development, and flow separation characteristics. Flight test results of pressure distributions and skin friction measurements were obtained for a full-chord wing section including the slat, main-wing, and triple-slotted, Fowler flap elements. Test conditions included a range of flap deflections, chord Reynolds numbers (10 to 21 million), and Mach numbers (0.16 to 0.40). Pressure distributions were obtained at 144 chordwise locations of a wing section (53-percent wing span) using thin pressure belts over the slat, main-wing, and flap elements. Flow characteristics observed in the chordwise pressure distributions included leading-edge regions of high subsonic flows, leading-edge attachment-line locations, slat and main-wing cove-flow separation and reattachment, and trailing-edge flap separation. In addition to the pressure distributions, limited skin-friction measurements were made using Preston-tube probes. Preston-tube measurements on the slat upper surface suggested relaminarization of the turbulent flow introduced by the pressure belt on the slat leading-edge surface when the slat attachment line was laminar. Computational analysis of the in-flight pressure measurements using two-dimensional, viscous multielement methods modified with simple-sweep theory showed reasonable agreement. However, overprediction of the pressures on the flap elements suggests a need for better detailed measurements and improved modeling of confluent boundary layers as well as inclusion of three-dimensional viscous effects in the analysis. Author

N94-18437# Institut fuer Theoretische Stroemungsmechanik, Goettingen (Germany).

A FAST COMPUTING METHOD FOR THE FLOW OVER HIGH-LIFT WINGS

K. JACOB *In* AGARD, High-Lift System Aerodynamics 12 p Sep. 1993

Copyright Avail: CASI HC A03/MF A04

A quasi 3-dimensional method for analyzing the viscous steady subsonic flow over wings with flaps for high lift is briefly presented. The total iterative procedure combines a 3-dimensional inviscid lifting surface theory with a 2-dimensional surface-singularity method for analyzing multi-element airfoils in a curved basic flow field. This method also includes boundary layer calculations and a model for rear separation. Also, small compressibility effects are accounted for by simple corrections, and ground effects are included by means of the reflected image technique. First attempts to validate the method by a few theory-experiment comparisons are reported. The results are encouraging but more experimental data are needed for a thorough validation. The computing time requirements of the method are modest. Author

N94-18438# California State Univ., Long Beach. Dept. of Aerospace Engineering.

CALCULATION OF MULTIELEMENT AIRFOILS AND WINGS AT HIGH LIFT

TUNCER CEBECI *In* AGARD, High-Lift System Aerodynamics 15 p Sep. 1993

Copyright Avail: CASI HC A03/MF A04

A calculation method based on an interactive boundary-layer approach to multi-element airfoils and wings is described. For two-dimensional flows, the method is applied to three types of airfoil configurations with and without flap wells in order to demonstrate its applicability and accuracy to general high-lift configurations. This method, extensively tested for single airfoils as a function of shape, angle of attack, and Reynolds number, is shown here to apply equally well to multi-element airfoils. The calculation method is also applied to a wing and wing/flap configuration in order to demonstrate its promise for addressing three-dimensional flows. Preliminary results indicate that with further development, the method, as for multi-element airfoils, will also become a practical, accurate and efficient tool for multi-element wings. Author

N94-18439# Politecnico di Milano (Italy). Dipt. di Ingegneria Aerospaziale.

WAKE STRUCTURE AND AERODYNAMIC BEHAVIOR OF HIGH LIFT AIRCRAFT CONFIGURATIONS DURING UNSTEADY MANEUVERS IN GROUND EFFECT

A. BARON and M. BOFFADOSSI *In* AGARD, High-Lift System Aerodynamics 15 p Sep. 1993

Copyright Avail: CASI HC A03/MF A04

A nonlinear unsteady vortex lattice scheme is used and flight dynamics equations are solved in order to predict the structure of the wakes and the instantaneous distribution of the aerodynamic loads on high-lift aircraft configurations, during general unsteady take-off maneuvers in ground effect. The numerical scheme here presented can treat an arbitrary number of mutually interfering lifting and moving control surfaces having arbitrary planform and camber. Wakes can be released in the flowfield from any of the sharp edges of the lifting surfaces, depending on their planform, aspect ratio and angle of attack, while the effects of the fuselage are ignored in the present formulation. Turbulent diffusion of the cores of the Rankine vortex filaments is regarded as a preeminent factor in a correct simulation of the development of unsteady interfering wakes. A vortex core diffusion model is used capable to deal even with the severe roll-up of the mutually interfering wakes developing close and impinging on the ground. Typical applications of the unsteady vortex lattice scheme are presented, aimed at illustrating the capabilities of the code. Author

N94-18440# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

VISCOUS-INVISCID CALCULATION OF HIGH-LIFT SEPARATED COMPRESSIBLE FLOWS OVER AIRFOILS AND WINGS [CALCUL PAR INTERACTION VISQUEUX NON-VISQUEUX DES ECOULEMENTS COMPRESSIBLES FORTEMENT DECOLLES AUX GRANDES PORTANCES SUR PROFILS D'AILES ET VOILURES]

J. C. LEBALLEUR *In* AGARD, High-Lift System Aerodynamics 18 p Sep. 1993 In FRENCH Sponsored by Ministry of Defence

Copyright Avail: CASI HC A03/MF A04

The viscous-inviscid interaction transonic numerical method previously defined by the author for computing attached or separated flows over airfoils, including the deeply stalled flows, is extended into a new three-dimensional method for strongly separated flows over wings at high-lift and compressible speeds. The numerical nonlinearly implicit boundary layer technique (direct/inverse), the turbulent models, the grid generation and grid-adaption, the coupling and wake-equilibration algorithms, the inviscid full-potential schemes, are extended in three dimension, with approximation on the viscous equations (2.75D-local). New theoretical results are given on the singularities and characteristic cones of the fully three-dimensional boundary layer in inverse mode.

A new 'Massive-separation 2.75D' extension of the 'Semi-inverse' algorithm of Le Balleur for coupling is given and detailed, together with its stability theory. Results are shown for 2D-stall, and for 3D separated flows over rectangular or swept wings, with satisfactory agreement between theory and experiment. A self-adaptation technique of the grid to the viscous effects is displayed. The results demonstrate that the viscous-inviscid interaction methods give a full access to the calculation of three-dimensional separation. Author (revised)

N94-18553*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A COMPARATIVE STUDY OF TURBULENCE MODELS IN PREDICTING HYPERSONIC INLET FLOWS
KAMLESH KAPOOR *In its* Workshop on Computational Turbulence Modeling 9 p 1993
Avail: CASI HC A02/MF A04

A computational study has been conducted to evaluate the performance of various turbulence models. The NASA P8 inlet, which represents cruise condition of a typical hypersonic air-breathing vehicle, was selected as a test case for the study; the PARC2D code, which solves the full two dimensional Reynolds-averaged Navier-Stokes equations, was used. Results are presented for a total of six versions of zero- and two-equation turbulence models. Zero-equation models tested are the Baldwin-Lomax model, the Thomas model, and a combination of the two. Two-equation models tested are low-Reynolds number models (the Chien model and the Speziale model) and a high-Reynolds number model (the Launder and Spalding model). Derived from text

N94-18571 Naval Postgraduate School, Monterey, CA.
TWO-DIMENSIONAL BOUNDARY SURFACES FOR AXI-SYMMETRIC EXTERNAL TRANSONIC FLOWS M.S. Thesis
WALEED ISA AL-HASHEL Mar. 1993 69 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A269678) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Investigation of two-dimensional transonic flows is extended to axisymmetric problems. This is of considerable practical interest, for example, with regard to missiles or aircraft engines which approximate much more closely bodies of revolution than two-dimensional bodies. The main concern with axisymmetric flows lies not only with the complexity of the governing nonlinear partial differential equation which is mixed of elliptic-hyperbolic type but also with the lack of a general method for accurately solving this type of equation. We solve the nonlinear transonic equation using the separation of variables technique, which yields two nonlinear ordinary differential equations. The x-dependence can be integrated numerically, and the solution for the r-dependence can be obtained using the expansion method originated by Van Dyke. This works well with only three terms in the expansion. The sonic solution of these equations is obtained analytically since both equations are simple enough to be integrated for this case (M(sub infinity) = 1.0) The small parameter (1-M(sub infinity)(exp 2)) plays an important role in specifying the shape of the boundary surfaces for external axisymmetric steady flow of interest for design. A Navier-Stokes solver was used to compute the inviscid flow to confirm our results in the region over the surface where the small perturbations apply. DTIC

N94-18964* National Aeronautics and Space Administration, Washington, DC.
AIRFLOW RESEARCH (Videotape)
Dec. 1985 Videotape: 3 min. 5 sec. playing time, in color, with sound
(NASA-TM-109372; NONP-VT-94-198219) Avail: CASI VHS A01/BETA A22

This is an overview of research being done in laminar flow at Ames Dryden Flight Research Center and Langley Research Center. Airflow research at Ames Dryden has resulted in a special wing covering that will artificially induce laminar flow on the wing surface; this specially adapted wing is shown being tested in different flying conditions. This video also features research done at Langley in producing a chemical covering for wings that will make visible natural laminar flow and turbulent airflow patterns as they occur. Langley researchers explain possible use of this technology in supersonic flight. CASI

N94-19119*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
INTERFEROMETRIC INVESTIGATIONS OF COMPRESSIBLE DYNAMIC STALL OVER A TRANSIENTLY PITCHING AIRFOIL
M. S. CHANDRASEKHARA (Naval Postgraduate School, Monterey, CA.), L. W. CARR, and M. C. WILDER (MCAT Inst., San Jose, CA.) 14 Jan. 1993 18 p Presented at the 31st Aerospace Sciences Meeting and Exhibit, Reno, NV, 11-14 Jan. 1993; sponsored by AIAA See also A93-22628
(Contract MIPR-92-0004; ARO-MIPR-130-92)
(NASA-TM-109380; AIAA PAPER 93-0211; AD-268794; NAS 1.15:109380) Avail: CASI HC A03/MF A01

The dynamic stall flow field over NACA 0012 airfoil pitching transiently from 0 - 60 at a constant rate under compressible flow conditions has been studied using the real-time technique of point diffraction interferometry. This investigation using nonintrusive diagnostics provides a quantitative description of the overall flow field, including the finer details of dynamic stall vortex formation, growth and the concomitant changes in the pressure distribution. Analysis of several hundred interferograms obtained for a range of flow conditions shows that the peak leading edge suction pressure coefficient that stall is nearly constant for a given free stream Mach number at all nondimensional pitch rates. Also, this value is below that seen in steady flow at static stall for the same Mach number, indicating that dynamic effects significantly effect the separation behavior. Further, for a given Mach number, the dynamic stall vortex seems to form rapidly at nearly the same angle of attack for all pitch rates studied. As the vortex is shed, it induces an anti-clockwise trailing edge vortex, which grows in a manner similar to that of a starting vortex. The measured peak suction pressure coefficient drops as the free stream Mach number increases. For free stream Mach numbers above 0.4, small multiple shocks appear near the leading edge. DTIC

N94-19388*# North Carolina State Univ., Raleigh. Dept. of Mechanical and Aerospace Engineering.
SEMI-SPAN MODEL TESTING IN THE NATIONAL TRANSONIC FACILITY Annual Status Report
NDAONA CHOKANI and WILLIAM E. MILHOLEN, II Oct. 1993 16 p
(Contract NCC1-169)
(NASA-CR-194479; NAS 1.26:194479) Avail: CASI HC A03/MF A01

A semi-span testing technique has been proposed for the NASA Langley Research Center's National Transonic Facility (NTF). Semi-span testing has several advantages including (1) larger model size, giving increased Reynolds number capability; (2) improved model fidelity, allowing ease of flap and slat positioning which ultimately improves data quality; and (3) reduced construction costs compared with a full-span model. In addition, the increased model size inherently allows for increased model strength, reducing aeroelastic effects at the high dynamic pressure levels necessary to simulate flight Reynolds numbers. The Energy Efficient Transport (EET) full-span model has been modified to become the EET semi-span model. The full-span EET model was tested extensively at both NASA LRC and NASA Ames Research Center. The available full-span data will be useful in validating the semi-span test strategy in the NTF. In spite of the advantages discussed above, the use of a semi-span model does introduce additional challenges which must be addressed in the testing procedure. To minimize the influence of the sidewall boundary layer on the flow over the semi-span model, the model must be off-set from the sidewall. The objective is to remove the semi-span model from the sidewall boundary layer by use of a stand-off geometry. When this is done however, the symmetry along the centerline of the full-span model is lost when the semi-span model is mounted on the wind tunnel sidewall. In addition, the large semi-span model will impose a significant pressure loading on the sidewall boundary layer, which may cause separation. Even under flow conditions where the sidewall boundary layer remains attached, the sidewall boundary layer may adversely effect the flow over the semi-span model. Also, the increased model size and sidewall mounting requires a modified wall correction strategy. With these issues in mind, the semi-span model has been well instrumented with surface pressure taps to obtain data on the expected complex flow field in the near wall region. This status report summarizes the progress to date on developing the semi-span geometry definition suitable for generating structured grids for the computational research. In addition, the progress on evaluating three state-of-the-art Navier-Stokes codes is presented. Derived from text

N94-19433*# California Polytechnic State Univ., San Luis Obispo. Aeronautical Engineering Dept.
NUMERICAL PREDICTION OF TRANSITION OF THE F-16 WING AT SUPERSONIC SPEEDS Final Report
RUSSELL M. CUMMINGS and JOSEPH A. GARCIA Sep. 1993 52 p
(Contract NCC2-754; NGT-70228)
(NASA-CR-194407; NAS 1.26:194407) Avail: CASI HC A04/MF A01

A parametric study is being conducted as an effort to numerically predict the extent of natural laminar flow (NLF) on finite swept wings at supersonic speeds. This study is one aspect of a High Speed Research Program (HSRP) to gain an understanding of the technical requirements for high-speed aircraft flight. The parameters that are being addressed in this study are Reynolds number, angle of attack, and leading-edge wing sweep. These parameters were analyzed through the use of an advanced Computational Fluid Dynamics (CFD) flow solver, specifically the ARC 3-D Compressible Navier-Stokes (CNS) flow solver. From the CNS code, pressure coefficients (Cp) are obtained for the various cases. These Cp's are then used to compute the boundary-layer profiles through the use of the 'Kaups and Cebeci' compressible 2-D boundary layer code. Finally, the boundary-layer parameters are processed into a 3-D compressible boundary layer stability code (COSAL) to predict transition. The parametric study then consisted of four geometries which addressed the effects of sweep, and three angles of attack from zero to ten degrees to yield a total of 12 cases. The above process was substantially automated through a procedure that was developed by the work conducted under this study. This automation procedure then yields a 3-D graphical measure of the extent of laminar flow by predicting the transition location of laminar to turbulent flow.
Derived from text

N94-19484*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SUPERSONIC JETS FROM BEVELLED RECTANGULAR NOZZLES
EDWARD J. RICE and GANESH RAMAN (Sverdrup Technology, Inc., Brook Park, OH.) Nov. 1993 9 p Proposed for presentation at the Winter Annual Meeting of the ASME Symposium on Flow Acoustics Interaction and Fluid Control, New Orleans, LA, 28 Nov. - 3 Dec. 1993; sponsored by ASME
(Contract NAS3-25266; RTOP 537-02-22)
(NASA-TM-106403; E-8239; NAS 1.15:106403; REPT-93-WA/NCA-26) Avail: CASI HC A02/MF A01

The influence of nozzle exit geometry on jet mixing and noise production was studied experimentally for a series of rectangular nozzles operating at supersonic jet velocities. Both converging (C) and converging-diverging (C-D) nozzles were built with asymmetrical (single bevel) and symmetrical (double bevel) exit chambers and with conventional straight exits for comparison. About a four decibel reduction of peak mixing noise was observed for the double bevelled C-D nozzle operated at design pressure ratio. All bevelled geometries provided screech noise reduction for under-expanded jets and an upstream mixing noise directivity shift which would be beneficial for improved acoustic treatment performance of a shrouded system. Author

N94-19524 Institut Franco-Allemand de Recherches, Saint-Louis (France).
NUMERICAL INVESTIGATION OF THE INCOMPRESSIBLE FLOW AROUND A WING WITH A FIXED SPOILER [NUMERISCHE UNTERSUCHUNG DER INKOMPRESSIBLEN STROEMUNG UM EINEN TRAGFLUEGEL MIT FESTEM SPOILER]
W. CZICHOWSKY 20 Aug. 1991 99 p In GERMAN
(ISL-R-109/91; ETN-93-95121) Copyright Avail: Issuing Activity (Fachinformationszentrum Karlsruhe, 7514 Eggenstein-Leopoldshafen 2, Germany)

A differential method for the numerical solution of Navier-Stokes equations for calculation of time dependent incompressible flow around a wing is presented. The method was based on Chaplygin equation and vortex transport equation with the psi-omega formalism. A coordinates system, numerically established and body fitted, was chosen. The solution of finite stream equations was iteratively obtained for each time step with the successive overrelaxation method. The flow around a wing without incidence, with a spoiler with an angle of 40 deg, and without a spoiler was analyzed. Numerical results give flow structure, pressure distribution, and force coefficients as a function of time for Reynolds numbers equal to 100, 500, 1000, and 5000. ESA

N94-19621*# Old Dominion Univ., Norfolk, VA. Dept. of Aerospace Engineering.
NAVIER-STOKES, DYNAMICS AND AEROELASTIC COMPUTATIONS FOR VORTICAL FLOWS, BUFFET AND FLUTTER APPLICATIONS Progress Report, 1 Oct. 1992 - 30 Sep. 1993
OSAMA A. KANDIL Sep. 1993 75 p
(Contract NAG1-648)
(NASA-CR-194520; NAS 1.26:194520) Avail: CASI HC A04/MF A01

Research on Navier-Stokes, dynamics, and aeroelastic computations for vortical flows, buffet, and flutter applications was performed. Progress during the period from 1 Oct. 1992 to 30 Sep. 1993 is included. Papers on the following topics are included: vertical tail buffet in vortex breakdown flows; simulation of tail buffet using delta wing-vertical tail configuration; shock-vortex interaction over a 65-degree delta wing in transonic flow; supersonic vortex breakdown over a delta wing in transonic flow; and prediction and control of slender wing rock. CASI

N94-19667# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
ADAS IMPLEMENTATION OF A PANEL METHOD FOR THE PREDICTION OF AERODYNAMIC LOADS
P. M. HEYMA Jun. 1993 57 p Original contains color illustrations
(LR-723; ETN-93-95027) Avail: CASI HC A04/MF A01

New developments and extensions to the Aircraft Design and Analysis System (ADAS) are discussed. ADAS semi automatically generates a finite element model suitable for structural analysis and optimization. Major structural components can be defined. The aircraft loads are determined by aerodynamic forces. For aerodynamic loads, a simplified lift distribution was used. To improve the prediction of the aerodynamic loads, the panelcode O215 is implemented. This panel method computes the potential flow around complex arbitrary configurations. The program requires a quadrilateral panel surface discritization. The same ADAS finite element model was used for the structural as well as the aerodynamic calculations. The panel program O215, the coordinate system setup, the panel partitioning, the way lifting parts are modeled and the system of integral equations are reported. The ADAS Finite Element (FE)-model and the usefulness of the structural mesh for aerodynamic calculations are discussed. The use of a structural mesh for aerodynamic calculations is validated. New subprograms added to the ADAS system are described and some results for a typical transport aircraft are presented. ESA

N94-19963# Air Force Inst. of Tech., Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.
EXPERIMENTAL STUDY ON INTERFERENCE AERODYNAMICS OF CLOSE-COUPLED CANARD CONFIGURATION
YAO-BIN GUO 20 Jul. 1993 19 p Transl. into ENGLISH from Hangkong Xuebao (China), v. 11, no. 12, 1990 p 528-533
(AD-A267760; FASTC-ID(RS)T-0730-92) Avail: CASI HC A03/MF A01

By using the canard-wing balance and the whole aircraft aerodynamic balance, which can measure the aerodynamic forces of the canard-wing part, experimental studies were conducted on interference aerodynamic forces on a canard-configuration model that can be assembled and disassembled. It was discovered that the interferences are destructive between the canard wing and the main wing when alpha is less than 20 deg, causing a reduction in the lift. When alpha is greater than 32 deg, the interferences turn increasingly beneficial. When alpha = 32 deg, the interference lift increases to 24 percent of total lift. If the main wing is a swept-forward wing, the aerodynamic properties of the canard configuration are better. Author

N94-20014*# Eloret Corp., Sunnyvale, CA.
EXPERIMENTAL INVESTIGATION OF NOZZLE/PLUME AERODYNAMICS AT HYPERSONIC SPEEDS Progress Research Report, 1 Dec. 1992 - 30 Jun. 1993
DAVID W. BOGDANOFF and JEAN-LUC CAMBIER 30 Jun. 1993 32 p
(Contract NCC2-487)
(NASA-CR-194628; NAS 1.26:194628) Avail: CASI HC A03/MF A01

Work continued on the improvement of 16-Inch Shock Tunnel. This comprised studies of ways of improving driver gas ignition, an improved driver gas mixing system, an axial translation system for the driver tube, improved diaphragm materials (carbon steel vs. stainless steel), a copper liner for the part of the driven tube near the nozzle, the use of a buffer gas between the driver and driven gases, the use of N2O in the driven tube, the use of a converging driven tube, operation of the facility as a non-reflected shock tunnel and expansion tube, operation with heated hydrogen or helium driver gas, the use of detonations in the driver and the construction of an enlarged test section. Maintenance and developmental work continued on the scramjet combustor continued. New software which greatly speeds up data analysis has been written and brought on line. In particular, software which provides very rapid generation of model surface heat flux profiles has been brought on line. A considerable amount of theoretical work was performed in connection with upgrading the 16 Inch Shock Tunnel Facility. A one-dimensional Godunov code for very high velocities and any equation of state is intended to add viscous effects in studying the operation of the Shock Tunnel and also of two-stage light gas guns. Derived from text

N94-20043# Florida Atlantic Univ., Boca Raton.
THE FLUID MECHANICS OF VORTEX CUTTING BY A BLADE Final Report, 1 Aug. 1992 - 31 Jul. 1993
JEFFREY S. MARSHALL 25 Sep. 1993 31 p
(Contract DAAL03-92-G-0277)
(AD-A270932; ARO-30168.5-EG-YIP) Avail: CASI HC A03/MF A01

A study of the nonlinear response of a vortex to the approach of, and cutting by, a blade traveling in the plane normal to the vortex axis has been performed. Two different types of vortex forces on the blade are distinguished. For large values of the ratio of blade thickness T to vortex ambient core radius sigma(0), the force on the blade is primarily due to decreased pressure near the blade leading edge due to bending of the vortex about the blade. For values of T/sigma(0) of 0(1) or less, the vortex does not bend substantially during interaction with the blade and instead the blade passes through, or 'cuts', the vortex. In this case, the force on the blade is primarily due to formation of a vortex shock which propagates on the vortex away from the blade, and the subsequent difference in vortex core radius on opposite sides of the blade due to the vortex shock. This study was conducted based on analytical, computational and experimental studies, the results of which compared well in the regimes in which each are valid. DTIC

N94-20136*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL AND COMPUTATIONAL RESULTS FROM A LARGE LOW-SPEED CENTRIFUGAL IMPELLER
M. D. HATHAWAY (Army Research Lab., Cleveland, OH.), R. M. CHRISS, J. R. WOOD, and A. J. STRAZISAR Dec. 1993 12 p Presented at the 82nd Meeting of the AGARD Propulsion and Energetics Panel, Technology Requirements for Small Gas Turbine Engines, Montreal, Ontario, 4-6 October, 1993; sponsored by the Advisory Group for Aerospace Research and Development
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TM-106421; E-8258; NAS 1.15:106421; ARL-TR-331)
Avail: CASI HC A03/MF A01

An experimental and computational investigation of the NASA Low-Speed Centrifugal Compressor (LSCC) flow field has been conducted using laser anemometry and Dawes' 3D viscous code. The experimental configuration consists of a backswept impeller followed by a vaneless diffuser. Measurements of the three-dimensional velocity field were acquired at several measurement planes through the compressor. The measurements describe both the throughflow and secondary velocity field along each measurement plane and in several cases provide details of the flow within the blade boundary layers. The experimental and computational results provide a clear understanding of the development of the throughflow momentum wake which is characteristic of centrifugal compressors. Author

03

AIR TRANSPORTATION AND SAFETY

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

A94-10514
HELICOPTER ROTOR BLADE INJURY - A PERSISTENT SAFETY HAZARD IN THE U.S. ARMY
JOHN S. CROWLEY and SHANNON L. GEYER (U.S. Army, Aeromedical Research Lab., Fort Rucker, AL) Aviation, Space, and Environmental Medicine (ISSN 0095-6562) vol. 64, no. 9 Sept. 1993 p. 854-858. refs
Copyright

Rotor blade injuries are an inherent hazard of helicopter operations. To determine the recent incidence of rotor blade injuries in the U.S. Army, a review of accident records (1972-1991) was conducted. Crash-related injuries were not included. During the study period, there were 24 blade strike injuries (12 involving the main rotor), 11 (46 percent) of which were fatal. Comparison with previous reports indicates a lower rotor blade injury rate in the last decade than in any previous period. The head was injured most frequently (65 percent), followed by the chest (17 percent) and abdomen (7 percent). Protective helmets helped to reduce injury in several instances. Flight crew comprised 49 percent of the victims, passengers 29 percent, ground crew 14 percent, and bystanders 8 percent. Helicopter crews must maintain situational awareness when around turning blades professional training alone does not guarantee protection from rotor blade injury.
Author (revised)

A94-10719*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NASA WAKE VORTEX RESEARCH
H. P. STOUGH, III, GEORGE C. GREENE, ERIC C. STEWART, ROBERT A. STUEVER, FRANK L. JORDAN, JR., ROBERT A. RIVERS, and DAN D. VICROY (NASA, Langley Research Center,

Hampton, VA) Aug. 1993 12 p. AIAA, Aircraft Design, Systems and Operations Meeting, Monterey, CA, Aug. 11-13, 1993 refs
(AIAA PAPER 93-4004) Copyright

NASA is conducting research that will enable safe improvements in the capacity of the nation's air transportation system. The wake-vortex hazard is a factor in establishing the minimum safe spacing between aircraft during landing and takeoff operations and, thus, impacts airport capacity. The ability to accurately model the wake hazard and determine safe separation distances for a wide range of aircraft and operational scenarios may provide the basis for significant increases in airport capacity. Current and planned NASA research is described which is focused on increasing airport capacity by safely reducing wake-hazard-imposed aircraft separations through advances in a number of technologies including vortex motion and decay prediction, vortex encounter modeling, wake-vortex hazard characterization, and in situ flow sensing.
Author (revised)

A94-11356
USE OF COMPUTER GRAPHIC SIMULATION FOR ANALYSIS OF A WIND SHEAR ACCIDENT - A CASE STUDY OF DELTA FLIGHT 191
ROY W. KRIEGER (Adler, Kaplan & Begy, Chicago, IL) *In* The use of simulation in aircraft accident prevention and investigation; Proceedings of the Conference, London, United Kingdom, Nov. 11, 12, 1992 London Royal Aeronautical Society 1992 p. 1.1-1.13. refs
Copyright

Much of the data for the crash of Delta 191 at Dallas/Ft. Worth Airport following a microburst encounter was highly technical and required correlation among numerous sources. The National Track Analysis Program view of the accident presented an overall description of events leading to the crash, including the relevant flight path and relevant meteorology, and allowed a three-dimensional reconstruction of the meteorological environment presented to the flight crew. Computer graphics thus based presented a compelling account of the failure of the flight crew to recognize numerous indications of an impending microburst.
AIAA

A94-11361
THE ROLE OF SIMULATION IN ACCIDENT INVESTIGATION AT THE NTSB - A CASE STUDY
JOHN C. CLARK and JOHN K. LAUBER (National Transportation Safety Board, Washington) *In* The use of simulation in aircraft accident prevention and investigation; Proceedings of the Conference, London, United Kingdom, Nov. 11, 12, 1992 London Royal Aeronautical Society 1992 p. 6.1-6.12.
Copyright

On March 3, 1991, a B-737-291 crashed while approaching Colorado Springs airport. A formal flight path study was conducted on the basis of a four-degree-of-freedom model for six different interpretations of the accident. This has been complemented by the aircraft manufacturer's engineering simulation studies, 'wind rotor' (tornado) modeling studies, and flight control system studies. No definitive findings concerning the cause of this accident have been obtained.
AIAA

A94-11365
THE USE OF A GENERIC NON-LINEAR SIMULATION ENVIRONMENT FOR ACCIDENT INVESTIGATION
P. W. L. PAYNE (British Aerospace Defence, Ltd., Military Aircraft Div., Farnborough, United Kingdom) *In* The use of simulation in aircraft accident prevention and investigation; Proceedings of the Conference, London, United Kingdom, Nov. 11, 12, 1992 London Royal Aeronautical Society 1992 p. 10.1-10.10.
Copyright

In order to accurately model the flight path of an aircraft, a nonlinear simulation model must possess sufficient flexibility so that most aircraft configurations and changes in state can be modeled. A description and an examination of such a simulation tool are presented. The nonlinear flight trajectory case study treated involves the flight behavior of a Sea Harrier following pilot ejection. An animated representation of the aircraft is driven by the output from the nonlinear simulation to show aircraft response from a user-defined perspective.
AIAA

A94-11366
THE USE OF SIMULATION IN RAF AIRCRAFT ACCIDENT INVESTIGATION
W. J. RAMSEY (RAF, Inspectorate of Flight Safety, London, United Kingdom) *In* The use of simulation in aircraft accident prevention and investigation; Proceedings of the Conference, London, United Kingdom, Nov. 11, 12, 1992 London Royal Aeronautical Society 1992 p. 11.1-11.4.
Copyright

Despite the widespread installation of accident data recorders (ADRs) in modern combat aircraft, the flight simulator is often used to recreate the last minutes of an accident sortie when the ADR has malfunctioned. The use of graphic computer imagery is being increasingly used to produce in-cockpit displays from raw ADR data, in the case of crash investigations. It may ultimately be possible to load a flight simulator with a program taken from an accident ADR and automatically fly a crash profile with board-of-inquiry members in the cockpit.
AIAA

A94-11968
THE AUTONOMOUS AIRPLANE CONCEPT
W. H. SYBLON (American Airlines, Inc., Dallas, TX) Oct. 1992 9 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992
(SAE PAPER 921918) Copyright

By 1995, as much as half of the world's commercial aircraft fleet will be equipped with flight management systems (FMSs) encompassing inertial reference units, dual flight-management computers, and map displays. After defining the current capabilities of FMSs, attention is given to the levels of performance achievable by such systems in the wake of their incorporation of Global Navigation Satellite System (GNSS) capabilities. A projection is made of the accuracy of an FMS/GNSS landing approach.
AIAA

A94-11969
ETOPS AND SERVICE READY STANDARDS AND PROCESSES
DAVID E. SAYRE and LARS Q. ANDERSON (Boeing Co., Seattle, WA) Oct. 1992 9 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992
(SAE PAPER 921919) Copyright

A review of the current extended-range twin-engine operations (ETOPS) and the modifications to the standards and processes that led to its successful operational record has contributed to the feasibility of developing an airplane and preparing an operator for ETOPS at entry into service. The airplane and engine manufacturers and component suppliers have continued to expand on these modified standards and processes in their design, build, test and support programs to meet regulatory authority ETOPS requirements and to facilitate the development of regulatory authority criteria for substantiating ETOPS capability prior to entry into service. Airlines, in conjunction with the manufacturers, have also developed improved processes that meet regulatory authority requirements for preparing an operator to integrate a new airplane into its existing ETOPS programs at entry into service. Implementation of these new or modified standards and processes will provide an airplane with ETOPS capability and improve its service readiness and support products.

A94-12083
THE CONTRIBUTION OF THE EH101 TO IMPROVING PUBLIC TRANSPORT HELICOPTER SAFETY LEVELS
A. J. WILSON (Westland Helicopters, Ltd., Yeovil, United Kingdom) Sep. 1992 26 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

An account is given of the correlation between safety targets set out for EH101 helicopter performance and associated airworthiness requirements. Attention is given to the unique difficulties faced by helicopters in meeting market perceptions of requisite safety levels for engine systems, transmissions, main rotors, flight controls, structures, and electrical subsystems. An account is given of the reliance of airworthiness-implicated accident rates. AIAA

A94-12116
BIRD STRIKE HAZARDS TO HELICOPTERS
L. S. BUURMA and A. DEKKER (Royal Netherlands Air Force, The Hague) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

A review of NATO statistics on bird strike frequencies and bird weights has uncovered an overall rate of 5.4 birdstrikes/10,000 flying hours for ten helicopter types. On this basis, the probability of serious damage is estimated to exceed 10 exp -6. Attention is drawn to the persistently different figures for bird strike frequency associated with the various helicopter types, and explanations for such differences are sought; differences in flight altitude typical of design missions for the various helicopters are invoked. AIAA

N94-10766# Federal Aviation Administration, Atlanta, GA.
PROCEEDINGS OF THE INTERNATIONAL CONFERENCE FOR THE PROMOTION OF ADVANCED FIRE RESISTANT AIRCRAFT INTERIOR MATERIALS
RICHARD G. HILL, THOR EKLUND, CONSTANTINE P. SARKOS, and APRIL HORNER, comp. (Galaxy Scientific Corp., Pleasantville, NJ.) Mar. 1993 372 p Conference held in Atlantic City, NJ, 9-11 Feb. 1993
(DOT/FAA/CT-93/3) Avail: CASI HC A16/MF A03

This publication contains the proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials held in Atlantic City, New Jersey, 9-11 Feb. 1993. Presentations were made in the following areas: advanced fire resistant materials, advanced technology, test methods and modeling, and future needs and requirements.

N94-10771# Gill (M. C.) Corp., El Monte, CA. Research and Development.
A REPAIR PATCHING SYSTEM FOR AIRCRAFT CARGO LINERS
DOUGLAS F. SMITH and MELVIN R. KANTZ *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 49-54 Mar. 1993
Avail: CASI HC A02/MF A03

With the FAA's mandate that cargo liner repair patches must meet flame penetration requirements described in FAR 25, Appendix F, Part 3, several new repair systems were introduced to the airlines to meet this demanding application. Previously available patches consisted of liner material with a pressure sensitive adhesive. While easy to use, the adhesive could not withstand temperatures to 1800 F, as required by the flame penetration test. Consequently, the patch fell from the liner, allowing the flame to penetrate the damaged area. The currently available repair systems were developed to meet the flame penetration requirements; however, the patches are difficult and time-consuming to apply. Moreover, they are expensive. A new patching system was developed which can be applied in less than 5 minutes, depending on the extent of the damage. This system is designated Gillpatch 2 and meets all flammability and flame penetration resistance tests described in FAR 25.855. The patch and adhesive combinations will be available in kits for rapid, on-the-spot repairs. The installation criteria and technical approach to solving the repair patch needs of the airlines and maintenance stations are described. Author (revised)

N94-10772# Allied-Signal Corp., Morristown, NJ.
PRIMASET (TM): A SAFER MATERIAL FOR AIRCRAFT INTERIOR APPLICATIONS
SAJAL DAS *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 55-65 Mar. 1993
Avail: CASI HC A03/MF A03

Aircraft interior designers favor plastics for their low weight, decorative effect, and functional strength. However, many plastics tend to emit smoke and toxic gases when they burn. Organic compounds such as hydrogen cyanide, hydrochloric acid, sulfur dioxide, carbon monoxide, and various oxides of nitrogen can be part of the lethal gaseous cocktail that modern laminates produce on combustion. Following a number of highly publicized accidents in which fatalities were primarily caused by fire on the ground, the Federal Aviation Administration (FAA) has moved to upgrade the fire performance of aircraft interiors, focusing on flammability. Faced with public horror and outrage over the years, airworthiness authorities have sought to make cabin interiors safer in fire. The underlying philosophy is simple: all concerned accept that, once established, a fire is likely to destroy the aircraft, but if the fire can be contained for a brief period, the occupants will be given time to evacuate. The realistic brief period has been determined to be two to five minutes in most of the Fire, Smoke, and Toxicity (FST) tests. A new non-volatile cure thermoset (Primaset) resin and some of its inherently good FST characteristics are discussed. In addition, a comparative study of cure characteristics of phenolic-triazine (PT) resin and phenol-formaldehyde (PF) resin is discussed. Author (revised)

N94-10782# Darchem Engineering, Stillington (England).
AN INVESTIGATION INTO AIRCRAFT FUSELAGE FIRE HARDENING
CLIFF T. M. HALL and MARK SNELL *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 191-205 Mar. 1993
Sponsored by Civil Aviation Authority
Avail: CASI HC A03/MF A03

The current investigation into the development of a new test facility which can reproduce in a controlled manner the fire conditions that would be experienced by an aircraft fuselage following a fuel spillage incident is outlined. The early investigation work has led to the definition of a fire source based upon previous test work in the aircraft industry and industrial pool fires in general. This definition was then used to design a test facility which was built and commissioned. It can create a reproducible thermal insult of up to 1150 C and 210 Kw/m(sup 2). The commissioning program is now complete, however, one particular aspect proved to be of great interest. That is the increased burnthrough rate due to soot deposition during the first few seconds of a pool fire. This phenomena will prove to be very critical as the ultimate aim of the project is to enhance the burnthrough capabilities of aircraft fuselages. The program will look at the determination of burnthrough times of existing fuselages before moving onto investigating the burnthrough capabilities of both improved materials and systems. Author (revised)

N94-10797# Federal Aviation Administration, Atlanta, GA. Materials Fire Safety.
THE FUTURE OF AIRCRAFT CABIN FIRE SAFETY
RICHARD G. HILL and NICK J. POVEY (Civil Aviation Authority, Gatwick, England.) *In its* Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 365-369 Mar. 1993
Avail: CASI HC A01/MF A03

The Fire Safety Branch at the Technical Center in Atlantic City, New Jersey, is the Federal Aviation Administration's (FAA) Research and Development (R&D) organization responsible for providing data to the regulatory organizations within the FAA for their use in developing, modifying, and/or interpreting rules and regulations pertaining to aircraft fire safety. The Fire Safety Branch has developed many of the fire safety standards adopted by civil aviation authorities throughout the world and is presently involved in R&D for future improvements. The Safety Regulation Group of the United Kingdom Civil Aviation Authority (CAA) initiates and funds research which is conducted by agencies external to the Authority. The research is 'Project Managed' by CAA staff working as a team involving technical experts, certification and regulatory specialists, and a project manager. There are programs of work in which the CAA together with other Authorities jointly manage complementary studies, an example is the research into Cabin Water Spray Systems which has involved the CAA, FAA, Transport

Canada, DGAC of France, and the European Commission. In the future, it is expected that CAA research activities will increasingly involve other European Joint Aviation Authorities (JAA) as partners and become integrated into a JAA-wide program of research.
Author (revised)

N94-11044# National Transportation Safety Board, Washington, DC.
AIRCRAFT ACCIDENT/INCIDENT SUMMARY REPORT: LOSS OF CONTROL. BUSINESS EXPRESS, INC., BEECHCRAFT 1900C N811BE NEAR BLOCK ISLAND, RHODE ISLAND, DECEMBER 28, 1991
27 Apr. 1993 77 p
(PB93-910405; NTSB/AAR-93/01/SUM) Avail: CASI HC A05/MF A01
The crash of N811BE into the Rhode Island Sound is explained. The safety issues discussed include the use of flight simulators rather than airplanes for training, the adequacy of FAA surveillance of Part 135 pilot training, and the adequacy of management oversight of pilot training for Part 135 commuter operators.
Author (revised)

N94-11333# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Munich (Germany). Aircraft Div.
IN-FLIGHT AIRCRAFT STRUCTURE HEALTH MONITORING BASED ON SMART STRUCTURES TECHNOLOGY
C. BOLLER and R. DILGER *In* AGARD, Smart Structures for Aircraft and Spacecraft 19 p Apr. 1993
Copyright Avail: CASI HC A03/MF A04
Aircraft are known to be highly complex systems requiring an extensive amount of monitoring because of their safety criticality. To reduce direct operating or life cycle cost a lot of effort was spent on automated monitoring systems. On-board loads monitoring systems for aircraft as well as built in test equipment in avionics systems are already available nowadays. On-board loads monitoring systems however do not monitor damage in-situ and on-board. This still has to be performed on-ground by manual nondestructive testing (NDT) inspection. Smart structures technology is a means which can support development towards automated in-situ monitoring of damage even on-board the aircraft. The paper starts with a brief view on aircraft maintenance cost, describes existing aircraft health and usage monitoring systems as well as NDT procedures, and explains how these procedures could be combined to a smart system using smart materials and structures technology. A strategy is proposed how gradual introduction of smart structures technology into structure health monitoring systems can make this new technology beneficial for aircraft operators in short term. Author (revised)

N94-11334# British Aerospace Aircraft Group, Kingston-upon-Thames (England).
STRUCTURAL HEALTH MONITORING USING EMBEDDED FIBRE OPTIC SENSORS
P. A. TUTTON and F. M. UNDERWOOD *In* AGARD, Smart Structures for Aircraft and Spacecraft 10 p Apr. 1993
Copyright Avail: CASI HC A02/MF A04
Structural health monitoring on military aircraft is currently carried out via strain gauges attached to the surface of the aircraft structure. A parametric system based exclusively on flight parameters is being developed for use on EFA. Both of these systems monitor the airframe fatigue life. With the emergence of Smart Structures technology, a new method of structural health monitoring is feasible that has perceived advantages over the current technology. How fiber optics embedded within a composite laminate can be used to monitor strains within the aircraft structure, and hence its fatigue life is described. Embedded fiber optics can be used to monitor sustained damage - battle or low velocity impact damage, give a full flight history and, with diagnostic capability, unconditioned maintenance would be available.
Author (revised)

N94-12384# Federal Aviation Administration, Atlantic City, NJ.
PROCEEDINGS OF THE INTERNATIONAL CONFERENCE FOR THE PROMOTION OF ADVANCED FIRE RESISTANT AIRCRAFT INTERIOR MATERIALS
11 Feb. 1993 293 p Conference held in Atlantic City, NJ, 9-11 Feb. 1993
(AD-A266057; DOT/FAA/93/3) Avail: CASI HC A13/MF A03
This publication contains the proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials held in Atlantic City, New Jersey, 9-11 Feb. 1993. Presentations were made in the following areas: advanced fire resistant materials, advanced technology, test methods and modeling, and future needs and requirements. DTIC

N94-12397# Federal Aviation Administration, Washington, DC.
FAA AIR TRAFFIC ACTIVITY Statistical Report, 1 Oct. 1991 - 30 Sep. 1992
NANCY TREMBLEY 1992 252 p
(AD-A266043) Avail: CASI HC A12/MF A03
This FAA publication furnishes terminal and en route air traffic activity information of the National Airspace System. The data were reported by the FAA-operated Airport Traffic Control Towers (ATCT's), Air Route Traffic Control Centers (ARTCC's), Flight Service Stations, Approach Control Facilities, and FAA-contracted ATCT's. These reports are used as a guide in determining the need for larger or additional facilities, upgraded equipment at particular facilities, and possible increases in personnel at existing facilities. DTIC

N94-12575# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
ANALYTICAL METHOD FOR WATER VAPOR COLLECTION AND ANALYSIS IN AIRCRAFT CABIN FIRES
LOUISE C. SPEITEL Aug. 1993 22 p
(DOT/FAA/CT-TN93/33) Avail: CASI HC A03/MF A01
The purpose of this work is to develop a method of quantifying water vapor in the presence of a complex mixture of airborne combustion products, to verify that this method is relatively free of interferences, and to demonstrate the applicability of this method to measure water vapor as a function-of-time in an aircraft cabin fire with and without water spray. This data was used to access whether there is an additional thermal inhalation hazard from the water vapor generated by water mist suppression of aircraft cabin fires. Author

N94-13247*# Ohio State Univ., Columbus. Dept. of Industrial and Systems Engineering.
COGNITIVE ENGINEERING IN AEROSPACE APPLICATION: PILOT INTERACTION WITH COCKPIT AUTOMATION
NADINE R. SARTER and DAVID D. WOODS Aug. 1993 71 p
(Contract NCC2-592)
(NASA-CR-177617; A-93108; NAS 1.26:177617) Avail: CASI HC A04/MF A01
Because of recent incidents involving glass-cockpit aircraft, there is growing concern with cockpit automation and its potential effects on pilot performance. However, little is known about the nature and causes of problems that arise in pilot-automation interaction. The results of two studies that provide converging, complementary data on pilots' difficulties with understanding and operating one of the core systems of cockpit automation, the Flight Management System (FMS) is reported. A survey asking pilots to describe specific incidents with the FMS and observations of pilots undergoing transition training to a glass cockpit aircraft served as vehicles to gather a corpus on the nature and variety of FMS-related problems. The results of both studies indicate that pilots become proficient in standard FMS operations through ground training and subsequent line experience. But even with considerable line experience, they still have difficulties tracking FMS status and behavior in certain flight contexts, and they show gaps in their understanding of the functional structure of the system. The results suggest that design-related factors such as opaque interfaces contribute to these difficulties which can affect pilots' situation awareness. The results of this research are relevant for both the

design of cockpit automation and the development of training curricula specifically tailored to the needs of glass cockpits.
Author (revised)

N94-13424*# Innovative Dynamics, Ithaca, NY.
SMART SKIN TECHNOLOGY DEVELOPMENT FOR MEASURING ICE ACCRETION, STALL, AND HIGH AOA AIRCRAFT PERFORMANCE. PART 1: CAPACITIVE ICE DETECTOR DEVELOPMENT Final Technical Report
DANIEL A. PRUZAN, ATEEN A. KHATKHATE, JOSEPH J. GERARDI, and GAIL A. HICKMAN 23 Apr. 1993 86 p Revised
(Contract NAS3-25966; SBIR-03.01-0533)
(NASA-CR-194252; NAS 1.26:194252; REPT-93D-03-0423-PT-1)
Avail: CASI HC A05/MF A01

A reliable way to detect and measure ice accretion during flight is required to reduce the hazards of icing currently threatening present day aircraft. Many of the sensors used for this purpose are invasive (probe) sensors which must be placed in areas of the airframe where ice does not naturally form. Due to the difference in capture efficiency of the exposed surface, difficulties result in correlating the ice accretion on the probe to what is happening on a number of vastly different airfoil sections. Most flush mounted sensors in use must be integrated into the aircraft surface by cutting or drilling the aircraft surface. An alternate type of ice detector which is based on a NASA patent is currently being investigated at Innovative Dynamics, Inc. (IDI). Results of the investigation into the performance of different capacitive type sensor designs, both rigid as well as elastic, are presented.
Author (revised)

N94-13534# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
OPTIMAL LATERAL ESCAPE MANEUVERS FOR MICROBURST ENCOUNTERS DURING FINAL APPROACH
H. G. VISSER Jul. 1992 44 p
(LR-691; ETN-93-94416) Avail: CASI HC A03/MF A01

The control and optimization of lateral escape trajectories in a microburst wind field for an aircraft on final approach is discussed. The performance index being minimized is the peak value of altitude drop. The characteristics of open loop extremal solutions for different locations of the microburst were calculated. If a sufficiently large bank angle limit is specified and the center of the microburst is not too far offset from the centerline extension of the approach runway, typically three trajectories can be found that satisfy the first order necessary conditions of optimality. The results bear out that trajectories that feature lateral maneuvering to turn the aircraft away from the microburst center, offer a significant improvement in the escape capability of the aircraft in comparison to a trajectory that passes through the center. In contrast to nonturning escape maneuvers, lateral escape maneuvers often exhibit an initial climb, rather than a descent. It is conjectured that this behavior is a result of optimal energy management. Efforts to develop a closed loop (feedback) guidance scheme that closely approximates the open loop trajectories are described. ESA

N94-13543 British Columbia Univ., Vancouver. Faculty of Commerce and Business Administration.
THE INTERNATIONAL REGULATION OF AIR TRANSPORT: CHANGING REGIMES AND PRICE EFFECTS Ph.D. Thesis
MARTIN ELLIOT DRESNER Jul. 1989 340 p
(ISBN-0-315-55958-6; CTN-93-60728) Copyright Avail: Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC/MF

Regulatory changes in the international air transport industry are traced from World War II to the present. A modified version of hegemonic stability theory was formulated and applied to the industry to explain the developments. Additional domestic political and market structural variables were introduced to arrive at a more comprehensive model of regime change. The comprehensive model added significantly to the explanation of regime developments. Finally, the model was used to predict future developments in the industry. It was predicted that there was still political credit to be gained from air services liberalization in developed areas of the world and that regulations in these areas are likely to be liberalized. A model was also developed to explain price differences on international air routes. Major assumptions were that airlines competing on liberalized air routes engaged in Bertrand pricing behavior, while carriers on non-liberal routes colluded to set prices. Several empirical versions of the model were used to test for price effects that arose from liberal agreements. The liberal agreements were found to contribute to lower discount fares significantly but not necessarily to lower normal fares. The findings were consistent with the use of greater price discrimination under the liberal bilateral agreements.
Author (CISTI)

N94-14008# Bundesanstalt fuer Flugsicherung, Frankfurt am Main (Germany).
ACTIVITIES REPORT OF THE FEDERAL ADMINISTRATION FOR FLIGHT SAFETY (GERMANY) Annual Report, 1991 [JAHRESBERICHT '91 DER BUNDESANSTALT FUER FLUGSICHERUNG]
1992 53 p In GERMAN
(ETN-93-94208) Copyright Avail: CASI HC A04/MF A01

Statistical information, technological advances and measures taken by German administration in the flight safety area are presented. The role of cooperation between transportation and defense departments was outlined. Air traffic service routes were created or modified in order to remedy to traffic increase. Standard flight safety processes were introduced at former East Germany. airports. Safety management services for Netherlands, Belgium and Federal Republic of Germany decided the integration of their existing air traffic control system in a common project for optimization of radar information use, by means of radar data interchange network. Safety improvements, obtained with instrument and microwave ranging systems and modifications in information and data transfer facilities were reported. Design phase of a monopulse secondary radar subsystem in the framework of the radar modernization program was achieved by introducing critical design review concept. An integration test between sensor data processor and radar message conversion and distribution equipment was performed. Feasibility of a short term conflict alert system was examined and the American en route automated radar tracking system was chosen. A departure coordination system for reduction of coordination cost between toward and approach control and area control center workstations was implemented at the Frankfurt airport. A weather data and information visualization system with light waveguide transmission was implemented at new Munich airport. Statistical information about air traffic in Germany is given. ESA

N94-14186# Federal Aviation Administration, Atlantic City, NJ.
WIDEBODY CABIN WATER SPRAY OPTIMIZATION TESTS
TIMOTHY R. MARKER Aug. 1993 47 p Original contains color illustrations
(DOT/FAA/CT-TN93/29) Avail: CASI HC A03/MF A01

Nine full-scale tests were conducted in a modified DC-10 test article as part of an aircraft cabin water spray optimization study. The purpose of the study was to test several spray configurations by varying the orientation of the nozzles, the flow rate, and the quantity of water sprayed, while keeping the fire conditions constant, in an attempt to minimize the amount of water required to effectively suppress a postcrash aircraft fire and improve occupant survivability. The tests were used to validate optimization tests previously conducted in the narrowbody 707 test article. The initial test series employed a full-zone spray system, extending across the width of the fuselage, consisting of 7 zones, each containing 12 nozzles. A thermocouple was centrally mounted at ceiling height in each of the 8 foot long zones, allowing for the activation of a particular zone when the temperature reached a pre-determined value. A second series of tests were run in which the original zones were divided in half, producing 5 zones on either side of the fuselage centerline for a total of 10. Each of the 10 zones contained 6 nozzles. The survival time was extended between 41 and 103 seconds, depending on zone configuration, discharge activation temperature, and cabin location. Author

N94-14292# Lawrence Livermore National Lab., CA.
A MODEL FOR FUEL FIRE DURATION AND APPLICATION TO THE B-1B BOMBER
D. E. MAGNOLI 15 Dec. 1992 67 p
(Contract W-7405-ENG-48)
(DE93-013000; UCRL-ID-112576) Avail: CASI HC A04/MF A01 (US Sales Only)

A current national priority is ensuring that nuclear weapons remain safe (i.e., that they have a very low probability of plutonium dispersal) even when exposed to abnormal environments. In order to be able to quantify the probability of plutonium release, it is imperative to understand the abnormal environments to which weapons might be subjected. One type of abnormal environment arises from an accidental fuel fire. This report deals with the environment created by exposure to fire and represents an initial effort to quantify fire durations and to describe fire duration statistically. Section 1 of the report documents the model developed to describe the duration of fuel fires on aircraft, where the source of the fuel is leaking fuel tanks. Section 2 examines the question of spreading to determine under what conditions a fire due to a leak in one fuel tank will spread to another. A later report will describe a first-cut effort to correlate the fires examined here with a temperature distribution. DOE

N94-14744*# Decision Systems, Inc., Los Altos, CA.
THE INFLUENCE OF ATC MESSAGE LENGTH AND TIMING ON PILOT COMMUNICATION
DANIEL MORROW and MICHELLE RODVOLD (San Jose State Univ., CA.) Aug. 1993 24 p
(Contract NAS2-13210)
(NASA-CR-177621; A-93115; NAS 1.26:177621) Avail: CASI HC A03/MF A01

Pilot-controller communication is critical to safe and efficient flight. It is often a challenging component of piloting, which is reflected in the number of incidents and accidents involving miscommunication. Our previous field study identified communication problems that disrupt routine communication between pilots and controllers. The present part-task simulation study followed up the field results with a more controlled investigation of communication problems. Pilots flew a simulation in which they were frequently vectored by Air Traffic Control (ATC), requiring intensive communication with the controller. While flying, pilots also performed a secondary visual monitoring task. We examined the influence of message length (one message with four commands vs. two messages with two commands each) and noncommunication workload on communication accuracy and length. Longer ATC messages appeared to overload pilot working memory, resulting in more incorrect or partial readbacks, as well as more requests to repeat the message. The timing between the two short messages also influenced communication. The second message interfered with memory for or response to the first short message when it was delivered too soon after the first message. Performing the secondary monitoring task did not influence communication. Instead, communication reduced monitoring accuracy. Author

N94-15125# Rijksluchtvaartdienst, Schiphol (Netherlands).
AVIATION INSPECTION PROSPECTS [TOEKOMSTVERWACHTING RLD, LUCHTVAARTINSPECTIE]
H. N. WOLLESWINKEL *In* NAL, Symposium on the Future of Aeronautics in the Netherlands 22 p 1991 In DUTCH
Avail: CASI HC A03/MF A02

The main tasks of aviation inspection, namely guaranteeing safety and minimizing the environment effects of civil aviation as well as the expectations, are discussed. The activities and methods are strongly changing due to increasing internationalization and environment consciousness. The establishment and application of international rules are outlined. ESA

N94-15336* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NASA IMAGES 6 (Videotape)
Jan. 1988 Videotape: 28 min. 30 sec. playing time, in color, with sound
(NASA-TM-109437; NONP-VT-93-190234) Avail: CASI VHS A01/BETA A22

The videotape is comprised of clips regarding aircraft safety and development through NASA research at its various centers. CASI

N94-15542# Aeronautical Research Labs., Melbourne (Australia).
AIRCRAFT ACCIDENT INVESTIGATION AT ARL: THE FIRST 50 YEARS General Document
J. L. KEPERT Mar. 1993 107 p
(AD-A267086; ARL-GD-37; DODA-AR-007-134) Avail: CASI HC A06/MF A02

Early Australian experience with the investigation of aircraft accidents is covered briefly as a prelude to the foundation of the Aeronautical Research Laboratory. With its foundation, a more scientific approach was possible. ARL was quickly involved with accident investigation, an activity which has been maintained throughout its fifty year history. This report examines ARL experiences during those fifty years with the idea of providing some useful guidelines for the next half-century. DTIC

N94-15550*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ALTITUDE DEVIATIONS: BREAKDOWNS OF AN ERROR-TOLERANT SYSTEM
EVERETT A. PALMER, EDWIN L. HUTCHINS (California Univ., San Diego.), RICHARD D. RITTER, and INGE VANCLEEMPUT (Wellesley Coll., MA.) Oct. 1993 44 p Sponsored by NASA and FAA, Washington
(Contract RTOP 505-64-13)
(NASA-TM-108788; A-93119; NAS 1.15:108788) Avail: CASI HC A03/MF A01

Pilot reports of aviation incidents to the Aviation Safety Reporting System (ASRS) provide a window on the problems occurring in today's airline cockpits. The narratives of 10 pilot reports of errors made in the automation-assisted altitude-change task are used to illustrate some of the issues of pilots interacting with automatic systems. These narratives are then used to construct a description of the cockpit as an information processing system. The analysis concentrates on the error-tolerant properties of the system and on how breakdowns can occasionally occur. An error-tolerant system can detect and correct its internal processing errors. The cockpit system consists of two or three pilots supported by autoflight, flight-management, and alerting systems. These humans and machines have distributed access to clearance information and perform redundant processing of information. Errors can be detected as deviations from either expected behavior or as deviations from expected information. Breakdowns in this system can occur when the checking and cross-checking tasks that give the system its error-tolerant properties are not performed because of distractions or other task demands. Recommendations based on the analysis for improving the error tolerance of the cockpit system are given. Author (revised)

N94-15637# Army Aeromedical Research Lab., Fort Rucker, AL.
BASIC PRINCIPLES OF HELICOPTER CRASHWORTHINESS Final Report
DENNIS F. SHANAHAN Feb. 1993 36 p
(Contract DA PROJ. 3M1-62787-A-878)
(AD-A267099; USAARL-93-15) Avail: CASI HC A03/MF A01

Crashworthiness can be defined as the ability of an aircraft and its internal systems to protect occupants from injury in the event of a crash. In general, injury in aircraft crashes can be considered to arise from three distinct sources: (1) excessive acceleration forces; (2) direct trauma from contact with hard surfaces; and (3) exposure to environmental factors such as fire, smoke, water, and chemicals resulting in burns, drowning, or asphyxiation. Consequently, effective crashworthiness designs must consider all possible sources of injury and eliminate or mitigate as many as practical for a given design impact limit. This involves considerations of the following: (1) strength of the container (cockpit and cabin); (2) the adequacy of seats and restraint systems; (3) energy attenuation; (4) elimination of injurious objects in occupants local environment; and (5) post-crash factors, principally fire prevention and adequacy of escape routes. The U.S. Army UH-60 Black Hawk and AH-64 Apache helicopters were the first helicopters built to modern crashworthiness specifications. This paper uses data gained from the investigation of crashes of these helicopters to illustrate basic crashworthiness principles and to demonstrate their effectiveness when systematically incorporated into helicopter designs. DTIC

N94-16464# National Transportation Safety Board, Washington, DC.
NATIONAL TRANSPORTATION SAFETY BOARD ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA, US GENERAL AVIATION, CALENDAR YEAR 1989
1993 88 p
(PB93-160687; NTSB/ARG-93/01) Avail: CASI HC A05/MF A01

The report presents a statistical compilation and review of general aviation accidents which occurred in 1989 in the United States, its territories and possessions, and in international waters. The accidents reported are all those involving U.S. registered aircraft not conducting operations under 14 CFR 121, 14 CFR 125, 14 CFR 127, or 14 CFR 135. The report is divided into five sections: All Accidents; Fatal Accidents; Serious Injury Accidents; Property Damage Accidents and Midair Collision Accidents. Several tables present accident parameters for 1989 accidents only, and each section includes tabulations which present comparative statistics for 1989 and for the five-year period 1984-1988. NTIS

N94-16520*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DEVELOPMENT OF A PROPOSED INTERNATIONAL STANDARD FOR CERTIFICATION OF AIRCRAFT TO HIGH INTENSITY RADIATED FIELDS (HIRF)
NOEL B. SARGENT Oct. 1993 7 p Proposed for presentation at the 1994 International Pacific Air and Space Technology Conference, Singapore, China, 14-18 Feb. 1994; sponsored by SIAE and SAE
(Contract RTOP 940-30-09-21)
(NASA-TM-106357; E-8141; NAS 1.15:106357) Avail: CASI HC A02/MF A01

Avionic systems performing critical functions in modern aircraft are potentially susceptible to the hazards of electromagnetic radiation from ground and airborne transmitters. The Federal Aviation Administration (FAA) requested that the Society of Automotive Engineers (SAE) coordinate the development of procedures and guidance material which can be used during the aircraft certification process to ensure adequate protection against high intensity radiated fields (HIRF). This paper addresses both the technical challenge of drafting a certification procedure and guidance standard as well as the management process used by the SAE subcommittee AE4R to converge a diverse range of opinions by its international membership in the shortest possible time. Author (revised)

N94-17262# Wichita State Univ., KS. National Inst. for Aviation Research.
THE AIRLINE QUALITY REPORT 1993
BRENT D. BOWEN (Nebraska Univ., Omaha.) and DEAN E. HEADLY 1993 48 p
(NIAR-93-11) Avail: CASI HC A03/MF A01

The Airline Quality Rating was developed and first announced in early 1991 as an objective method of comparing airline performance on combined multiple factors important to consumers. The Airline Quality Rating 1993 (NIAR Report 93-11) is a summary of month-by-month quality ratings for the nine major domestic U.S. airlines operating during 1992. Using the Airline Quality Rating (AQR) system and monthly performance data for each airline for the calendar year of 1992, individual and comparative ratings are reported. This research monograph contains a brief summary of the AQR methodology, detailed data and charts that track comparative quality for major domestic airlines across the 12 month period of 1992, and results reflecting industry averages. Also, comparative Airline Quality Rating data for 1991 is included to provide a longer term view of quality in the industry. Author (revised)

N94-17471# National Transportation Safety Board, Washington, DC.
ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA. US AIR CARRIER OPERATIONS, CALENDAR YEAR 1990
4 Oct. 1993 74 p
(PB94-102787; NTSB/ARC-93/02) Avail: CASI HC A04/MF A01

This publication presents the record of aviation accidents involving revenue operations of U.S. Air Carriers including Commuter Air Carriers and On Demand Air Taxis for calendar year 1990. The report is divided into three major sections according to the federal regulations under which the flight was conducted - 14 CFR 121, 125, 127, Scheduled 14 CFR 135, or Nonscheduled 14 CFR 135. In each section of the report tables are presented to describe the losses and characteristics of 1990 accidents to enable comparison with prior years. Author

N94-17586 Federal Aviation Administration, Washington, DC. Office of Civil Aviation Security.
CRIMINAL ACTS AGAINST CIVIL AVIATION, FISCAL YEAR 1992
1992 90 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A268014) Avail: CASI HC A05

Civil aviation overall continued to be the object of numerous criminal acts in 1992, but, in those instances where attacks resulted from factors other than personal motivation, the factors tended to be regional, rather than global, in nature. Accordingly, the geographical distribution of incidents varied widely: from a high of 34 in Europe to a low of 4 in North America. Most criminal acts against civil aviation in Asia were the result of internal ethnic or religious confrontations. These included rocket attacks against airports and aircraft by Afghan guerrillas as well as violence against Air India offices in both Bangladesh and Pakistan by Muslims protesting Hindus' destruction of the mosque in Ayodhya, India. For the first year since 1986, there were no projectile attacks against Narita Airport in Japan, the site of attacks and protests since before its construction even began in 1969. Although contractors and politicians associated with the airport continue to be the targets of leftist radicals, Narita Airport has been eclipsed as an issue by the military, the monarchy, and what the leftists term Japanese economic imperialism. The most significant aviation incident in Asia, the hijacking of a Vietnam Airlines aircraft by a former South Vietnamese Air Force pilot living in the U.S., may not bode well for the future as Vietnamese expatriates attempt to frustrate moves by both U.S. companies and the U.S. government to do business with the regime in Hanoi. DTIC

N94-17733 National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
FEASIBILITY OF A WIND-ELLIPSE CRITERION IN A VORTEX ADVISORY SYSTEM FOR SCHIPHOL AIRPORT
F. R. POLAK 7 Oct. 1991 24 p Presented at FAA International Wake Vortex Symposium, 29-31 Oct. 1991 Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(NLR-TP-91384-U; ETN-93-94782) Avail: Issuing Activity (European Space Agency (ESA))

The feasibility of a wind-ellipse criterion in a possible future Vortex Advisory System (VAS) for Schiphol Airport (the Netherlands), based on an extensive data collection and analysis concerning 11 months in 1980 and 1981, is investigated. A VAS must enable air traffic control to determine in real time whether or not the large separations during the approach of smaller aircraft behind heavy aircraft have to be applied. A VAS in its simplest form will show the air traffic controller, by means of a red/green indicator, whether the wind vector is inside the ellipse (red light) or outside the ellipse (green light). ESA

N94-18490 Federal Aviation Administration, Washington, DC.
AIRPORT ACTIVITY STATISTICS OF CERTIFICATED ROUTE AIR CARRIERS, 1992 Report, period ending 31 Dec. 1992
31 Dec. 1992 373 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A269042; FAA-APO-93-8) Avail: CASI HC A16

There are some major changes in this publication due to the new T-100 data collection system for U.S. air carriers which began 1 Jan. 1990. The format has been changed to comply with the regulations of 14 CFR 241.19.6 that restrict public disclosure of T-100 detail and summary international data. Non-U.S. airport data does not appear. Data is no longer broken out by domestic or international operations at airports, only system operations are shown. This edition presents the volume of revenue passenger, freight, and mail traffic handled by the nation's large certificated air carriers at each airport served by these scheduled airlines during the 12 months ending 31 Dec. 1992. In addition, a presentation of aircraft departures is shown including detail by aircraft type for total departures performed in scheduled, nonscheduled, and all services. Large certificated air carriers hold Certificates of Public Convenience and Necessity issued by the Department of Transportation (DOT) authorizing the performance of air transportation. Large certificated air carriers operate aircraft with seating capacity of more than 60 seats or a maximum payload capacity of more than 18,000 pounds. Data for charter only, commuter, intra-state, and foreign-flag air carriers are not included in this publication. DTIC

N94-18822# Applied Research Associates, Inc., Lakewood, CO.
AIRCRAFT FIRE SENTRY. VOLUME 1: SUMMARY Final Report, 17 Aug. 1990 - 17 Aug. 1992
R. M. MUGELE, P. T. DZWILEWSKI, and J. T. CILKE Jan. 1993 61 p
(Contract F08635-88-C-0067)
(AD-A270087; AFCESA/ESL-TR-92-63-VOL-1) Avail: CASI HC A04/MF A01

This report summarizes the development of an Aircraft Fire Sentry (AFS) system. The AFS is designed to automatically detect a fire in the cargo bay of large cargo aircraft, provide an audio and visual alarm locally, and remotely notify the nearest fire department by radio frequency link. The basic design philosophy in developing the AFS was to use commercially available fire detection hardware and radio transmitters/receivers. The finished assembly is to be lightweight and portable. The AFS is to be deployed onboard parked aircraft and left to sense fire stimulus for up to 60 continuous hours in the self-powered mode. A prototype model was designed, built, and tested for performance and reliability. DTIC

N94-18823# Applied Research Associates, Inc., Lakewood, CO.
AIRCRAFT FIRE SENTRY. VOLUME 2: APPENDICES A, B, C AND D Final Report, 17 Aug. 1990 - 17 Aug. 1992
R. M. MUGELE, P. T. DZWILEWSKI, and J. T. CILKE Jan. 1993 380 p
(Contract F08635-88-C-0067)
(AD-A270088; AFCESA/ESL-TR-92-63-VOL-2) Avail: CASI HC A17/MF A03

This report summarizes the development of an Aircraft Fire Sentry (AFS) system. The AFS is designed to automatically detect a fire in the cargo bay of large cargo aircraft, provide an audio and visual alarm locally, and remotely notify the nearest fire department by radio frequency link. The basic design philosophy in developing the AFS was to use commercially available fire detection hardware and radio transmitters/receivers. The finished assembly is to be lightweight and portable. The AFS is to be deployed onboard parked aircraft and left to sense fire stimulus for up to 60 continuous hours in the self-powered mode. A prototype model was designed, built, and tested for performance and reliability. DTIC

N94-18844*# Computer Technology Associates, Inc., Pleasantville, NJ.
DENVER TMA ASSESSMENT
KELLY HARWOOD and BEVERLY SANFORD Oct. 1993 79 p
(Contract DTFA03-89-C-00023)
(NASA-CR-4554; A-94009; NAS 1.26:4554) Avail: CASI HC A05/MF A01

This report describes the assessment of the Traffic Management Advisor (TMA) conducted at the Denver Center and TRACON, January 11-February 5, 1993. The assessment addressed the effectiveness of TMA for supporting various traffic management activities. At the Center, traffic management coordinators (TMC's) shadowed traffic operations, using TMA to make metering time and internal release decisions. At the TRACON, TMC's accessed TMA in an advisory mode for different planning activities such as staffing, distributing the traffic load, and changing the airport acceptance rate. These different opportunities for assessing TMA provide insight into TMA as a potential communication aid and planning tool. Findings from this assessment indicate that TMA can be used to support traffic management planning and decisions. TMC's at the center were able to use information provided by TMA to determine metering times as well as internal release times. At the TRACON, TMA supported decisions on airport configuration, airport acceptance rate, load distribution, proactive coordination with the center, and staffing. While findings of TMA use are generally positive, it must be kept in mind that this assessment is a snapshot in time. Not all TMA capabilities were assessed, nor were TMC's fully trained and knowledgeable on all features. Feature use will continue to evolve and strategies emerge as the TMC's gain experience with TMA over a variety of traffic situations and their understanding of TMA capabilities broadens with continued training. Author

N94-19352# National Transportation Safety Board, Washington, DC.
AIRCRAFT ACCIDENT REPORT: MIDAIR COLLISION, MITSUBISHI MU-2B-60, N74FB, AND PIPER PA-32-301, N82419, GREENWOOD MUNICIPAL AIRPORT, GREENWOOD, INDIANA, 11 SEPTEMBER 1992
13 Sep. 1993 84 p
(PB93-910406; NTSB/AAR-93/05) Avail: CASI HC A05/MF A01

The midair collision of an MU-2 aircraft with a PA-32 aircraft about 2 miles northeast of the Greenwood Municipal Airport, Greenwood, Indiana, on 11 Sep. 1992 is explained. Safety issues focused on the deficiencies in the see-and-avoid concept as a primary means of collision avoidance, and the failure of pilots to fully utilize the air traffic control system by obtaining instrument flight rules clearances before takeoff. Recommendations concerning these issues were made to the Federal Aviation Administration, the National Business Aircraft Association, the National Association of Flight Instructors, the Experimental Aircraft Association, and the Aircraft Owners and Pilots Association. Author (revised)

N94-19661# Massachusetts Inst. of Tech., Lexington.
ESTIMATION OF WAKE VORTEX ADVECTION AND DECAY USING METEOROLOGICAL SENSORS AND AIRCRAFT DATA
KETHRYN M. BUTLER 28 Sep. 1993 35 p
(Contract DTFA01-91-Z-02036)
(AD-A270763; ATC-201; DOT/FAA/RD-93/16) Avail: CASI HC A03/MF A01

The lift-generated wake vortices trailing behind an aircraft present a danger to aircraft following the same or nearby path. The degree of hazard to the following aircraft depends on the nature of the wake encountered in its flight path and on the ability of the aircraft to counter its effects. This report describes the current state of understanding of the factors that influence the motion and dissipation of wake vortices. The relationships of these factors to parameters that are measurable through meteorological sensors and from a priori knowledge of the vortex generating aircraft characteristics are discussed as an aid to structuring development plans for the creation of wake vortex advisory products by the Integrated Terminal Weather System (ITWS) and by special wake vortex sensors. DTIC

N94-19876 *Naval Air Warfare Center, Indianapolis, IN. Aircraft Div.*
GROUND PROXIMITY WARNING SYSTEM VOICE WARNING UNIT REQUIREMENTS STUDY Final Report
DAVID L. WAMPLER 30 Aug. 1993 24 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A270541; NAWCADIND-TR-2481) Avail: CASI HC A03
This report provides a record of the engineering considerations driving the establishment of initial Ground Proximity Warning System (GPWS) Voice Warning Unit (VWU) requirements. The work was stopped before sections 4, 5, and 6 of appendix A could be completed. DTIC

N94-20189# Wichita State Univ., KS. National Inst. for Aviation Research.
AVIATION SAFETY RESEARCH AT THE NATIONAL INSTITUTE FOR AVIATION RESEARCH, WICHITA STATE UNIVERSITY
WILLIAM H. WENTZ, JR., DAVID ELLIS, and STEVE HOOPER 1993 33 p
(NIAR-93-4) Avail: CASI HC A03/MF A01
In this National Institute for Aviation Research (NIAR) report to the FAA, goals included automatic target tracking to extract head motion during crash tests. Associated tasks included a crash analysis of aircraft seats and an analysis of commuter seat-type structures in a crash environment to study energy absorbing mechanics of seat structures subject to emergency landing conditions. One task was to evaluate and enhance the biodynamic analysis of the occupant responses for evaluation of aircraft crash safety. Another task was the bonded/fusion repair of aircraft structures to qualify a procedure for the assessment and repair of metallic and composite structures. The effects of mechanical paint removal on surface morphology and fatigue behavior of composite materials was studied. A test method was developed for the assessment of the integrity of bonded joints and composite materials; addressed features include cyclic loading and freeze/thaw moisture conditioning. With regards to regional/commuter aircraft flight loads, robotic assistance to aircraft inspection was studied and a robot was developed. Human factors in the cockpit were studied to improve the understanding of single pilot terminal area operations, with emphasis on flight guidance displays. There was also a task toward standardization of design procedures for turbine rotor containment. Proposals are included in the report with their goals, approach, and status. CASI

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A94-10331
THE POTENTIAL OF A NONSOLICITED POSITION REPORT [LES POTENTIALITES DU REPORT NON SOLLICITE DE POSITION]
ALBERT JANEX (Thomson-CSF, Paris, France) Navigation (Paris) (ISSN 0028-1530) vol. 41, no. 163 July 1993 p. 316-322. In FRENCH Inst. Francais de Navigation, Colloque sur la Navigation de Precision, Ouistreham, France, Oct. 21, 22, 1992 refs
Copyright
The availability of very acurate navigation systems with global coverage is of great interest to many users. Less obvious applications can be foreseen, derived from position reporting. In this concept, every user periodically transmits a message containing at least its position on a common channel, and listen to similar messages transmitted by others. Anyone can consequently locate on a map the position of all other user. In aeronautical navigation, this 'pseudo-radar' has been named ADS (Automatic Dependant *Surveillance) It allows an efficient Air Traffic Control in non* instrumented areas. For maritime use, Thomson-CSF proposed on that same concept a collision avoidance system which can be adapted to the needs of a coastal VTMS (Vessel Traffic Management Services). A Swedish company proposes that same system to control the surface movements on an airport, and by extension, in surrounding airspace. Applications can also be foreseen in transport by road, railway and wa terwa ys.

A94-10332
EUROCONTROL AND THE IMPLEMENTATION OF WGS 84 FOR THE PURPOSES OF NAVIGATION FOR CIVIL AVIATION [EUROCONTROL ET LA MISE EN OEUVRE DU WGS 84 AUX FINS DE NAVIGATION POUR L'AVIATION CIVILE]
R. RAWLINGS, J. STOREY, and A. WATT (EUROCONTROL, Brussels, Belgium) Navigation (Paris) (ISSN 0028-1530) vol. 41, no. 163 July 1993 p. 343-353. In FRENCH EURNAV, Report, London, United Kingdom, Nov. 17-19, 1992
Copyright
In March 1989 the ICAO accepted Recommendation 3.2/1 of the Special Committee on Future Air Navigation Systems (FANS) concerning the adoption of the WGS 84 geodetic reference system. The ICAO then requested that the Eurocontrol Agency act as the coordinating body for the introduction of WGS 84 in the European region for the States of the European Civil Aviation Conference (ECAC). This paper outlines some of Eurocontrol's experiences in this area, with emphasis on developments since 1989. Particular attention is given to the WGS 84 Implementation Workshop organized by Eurocontrol, and the program to be followed for the implementation of WGS 84 in the ECAC States which is based on the findings of the Workshop. Several items discussed here will be included in proposals for a WGS 84 Implementation Program to be submitted to the Agency's Committee of Management. AIAA

A94-10750
CONFLICT RECOGNITION IN THE ONBOARD COLLISION PROTECTION SYSTEM ACAS II [DIE KONFLIKTERKENNUNG BEIM BORDKOLLISIONSSCHUTZSYSTEM ACAS II]
D. KUEGLER (Braunschweig, Technische Univ., Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X) vol. 17, no. 4 Aug. 1993 p. 270-278. In GERMAN refs
Copyright
The essential aspects of conflict recognition aboard an aircraft are analyzed. The international collision protection system ACAS II is used as the basis of a discussion of mechanisms which are applicable to slant range data, altitude information, and temporal variations. AIAA

A94-11717
AIRLINE PERSPECTIVE ON DATA LINK
PAUL R. RYAN (American Airlines, Inc., Dallas, TX) *In* Enhanced situation awareness technology for retrofit and advanced cockpit design; Proceedings of the SAE Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Warrendale, PA Society of Automotive Engineers, Inc. 1992 p. 105-110.
(SAE PAPER 922001) Copyright
The development of an international standard data link network for processing air traffic system tactical and control messages is discussed from the airlines' perspective. Such a network will provide both airlines and the FAA with the operational benefits of free airspace, which can only be achieved by augmenting the voice message and command system with a combined voice/data message and command system with 90 percent reliance on data link communications and 10 percent reliance on voice communications. AIAA

A94-11718
DATA LINK - A CONCEPTUAL FLIGHT DECK SYSTEM AND RELATED ISSUES
MICHAEL E. MURPHY (Boeing Commercial Airplane Group, Seattle, WA) *In* Enhanced situation awareness technology for retrofit and advanced cockpit design; Proceedings of the SAE Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Warrendale, PA Society of Automotive Engineers, Inc. 1992 p. 111-116.
(SAE PAPER 922002) Copyright

The purpose of this paper is to present a commercial transport category airframe manufacturers perspective on the next generation flight deck data link system. An overview of the system components is discussed, along with specific operational capabilities. Flow diagrams are then presented for both received and initiated messages. Significant issues related to flight deck data link systems are also presented. Conclusions emphasize the conceptual nature of this implementation and its value as a functional model for the evaluation of issues related to the total aeronautical digital communication system.

A94-11719
CERTIFICATION OF AIRBORNE DATA LINK EQUIPMENT
DONALD ARMSTRONG (FAA, Washington) *In* Enhanced situation awareness technology for retrofit and advanced cockpit design; Proceedings of the SAE Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Warrendale, PA Society of Automotive Engineers, Inc. 1992 p. 117-119.
(SAE PAPER 922003) Copyright

The history, present status, and future of the certification process for airborne data link equipment is discussed. The main problems that have had to be worked out in the past are addressed. The equipment to be certified is examined and a summary of the certification process is given. AIAA

A94-11723
***DATA LINK SYSTEM DEVELOPMENT AT THE FAA* TECHNICAL CENTER**
NICHOLAS J. TALOTTA (FAA, Technical Center, Atlantic City, NJ) *In* Enhanced situation awareness technology for retrofit and advanced cockpit design; Proceedings of the SAE Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Warrendale, PA Society of Automotive Engineers, Inc. 1992 p. 161-166.
(SAE PAPER 922026) Copyright

In 1988, the Federal Aviation Administration (FAA) Technical Center began a program of research aimed at the development of ATC services for transmission by data link technology. This paper offers an overview of the design approach that has been developed and applied by the FAA Technical Center during the past four years to produce functional design specifications for a group of initial data link services that are individually tailored to domestic en route and terminal ATC environments. Key features of this approach that are described in the paper include the development and implementation of an adaptable, high fidelity manned simulation facility, continuous involvement of system users in the data link service development process, and an iterative testing methodology for the evolution of ATC service designs and user interfaces. Author (revised)

A94-11724
CONTROLLER EVALUATIONS OF ATC DATA LINK SERVICES
CLARK A. SHINGLEDECKER (NTI, Inc., Dayton, OH) *In* Enhanced situation awareness technology for retrofit and advanced cockpit design; Proceedings of the SAE Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Warrendale, PA Society of Automotive Engineers, Inc. 1992 p. 167-172.
(SAE PAPER 922027) Copyright

The central thrust of Data Link research at the Federal Aviation Administration Technical Center has been a series of manned simulation studies conducted to refine and test candidate designs for ATC services, and to examine operational and human factors issues associated with the use of digitally transmitted messages to maintain the safe and efficient control of aircraft traffic in the National Airspace System. This paper describes some of the design requirements and issues that have emerged from air traffic controller evaluations of services developed for terminal and en route ATC environments. It also summarizes the results of preliminary investigations of the impact of data link on voice radio frequency congestion and of the effects of transaction delays on the usability of the system. The paper discusses a group of focal human factors issues that will be addressed in future controller studies planned by the FAA Technical Center. Author (revised)

A94-11970
THE INCREASING ROLE OF COMMUNICATION SATELLITES IN COMMERCIAL AIRCRAFT OPERATIONS
BILL RUHL and RICHARD HOBBY (Honeywell, Inc., Minneapolis, MN) Oct. 1992 10 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992
(SAE PAPER 921920) Copyright

An evaluation is presented of the potential benefits accruing to airlines as a result of more aggressive use of satellites for both communications and navigation; these extend to improvements in ATC communications, passenger-employed switched-telecommunications services, intensive meteorological information, and higher navigational accuracy and safety through direct pilot/ATC controller communications. Flight deck workloads will also be reduced. An account is given of the architecture and capabilities of the Aviation Satellite Telecommunications System AIAA

A94-12119
SOXO AIR SIG S7 ILS, FROM EARLY DEVELOPMENT TO AN ENDURING WORLD STANDARD
FRANK B. BRADY Navigation (ISSN 0028-1522) vol. 40, no. 2 Summer 1993 p. 109-120. refs
Copyright

The Instrument Landing System (ILS) may set a record for major electronic system longevity. Stemming from early experiments dating back to 1919, it was developed into its present basic signal format in the mid-1930s. It was well on its way to national standardization by the time of U.S. entry into World War II. At that time, it was strictly a national system, almost unknown outside of the United States. In January 1944, the Aircraft Radio Laboratory at Wright Field sponsored a mission to have the SCS-51 military ILS tested by the RAF and the 8th Air Force. The code name for the mission was SOXO AIR SIG S-7. A small team and production ground and airborne equipment were sent to England for joint British-American trials. Tests were conducted at an RAF Flight Research airfield in central England, The tests gave a large number of key aviation officials their first look at ILS. As the program progressed, the ready availability of ground stations allowed both military and civil operators to become familiar with the system, so that when postwar international conferences were held to select a landing system, ILS had a distinct advantage and was selected as the international standard, Author (revised)

A94-12120
HISTORY OF DOPPLER RADAR NAVIGATION
WALTER R. FRIED (Hughes Aircraft Co., Fullerton, CA) Navigation (ISSN 0028-1522) vol. 40, no. 2 Summer 1993 p. 121-136. refs
Copyright

This paper traces the history of the development and applications of Doppler radar navigation systems from their inception in the mid-1940s to the present. The early design concepts, problems, tribulations, and obstacles are discussed. With only noncoherent pulse radar transmitters available at that time, a unique technique of self-coherence had to be invented and implemented in order to allow Doppler signal extraction. Similarly, the severe leakage problems of CW radars had to be overcome. In spite of these problems, both pulse Doppler and CW Doppler radar navigation systems were successfully developed and produced. The next problem needing a solution was the measurement of negative velocity as required in helicopter operation. This led to the development of coherent pulse and frequency-modulated CW Doppler radars and new frequency trackers with wide application for navigation and hovering indication over land and water. The development and production of Doppler systems for the commercial airlines followed, and a Doppler radar was used for velocity measurement on the Surveyor and the Appollo Lunar Excursion Module for the achievement of soft landing on the moon. Most modern military helicopters and strategic aircraft, as well as many drones, are currently implemented with Doppler navigation radars. Author (revised)

A94-12121
USE OF SIMULATED ATMOSPHERIC NOISE IN THE CALIBRATION AND CHARACTERIZATION OF LORAN-C RECEIVERS FOR AIRCRAFT NAVIGATION
J. A. WEITZEN (Massachusetts Univ., Lowell), J. V. CARROLL, and B. T. DAO (DOT, National Transportation Systems Center, Cambridge, MA) Navigation (ISSN 0028-1522) vol. 40, no. 2 Summer 1993 p. 137-149. refs
Copyright

The LF band used for Loran-C navigation is susceptible to the effects of atmospheric noise. The two main components of LF atmospheric noise are background Gaussian noise and impulsive lightning noise. As the FAA continues in its efforts to incorporate Loran-C into the National Airspace System for use as a supplementary navigation aid, it is necessary to develop a better understanding of the effect of atmospheric noise on the accuracy, availability, and integrity of Loran-C. A simulation facility has been developed which provides a controlled, repeatable, and realistic noise environment for the calibration and testing of Loran receivers. This paper describes three of the noise models used in the simulator, and how they are created, calibrated, and used in the evaluation of Loran receivers.

A94-12122
PRECISION AIRCRAFT HEIGHT ESTIMATION WITH MULTIPLE RADARS
J. M. TEN HAVE (National Aerospace Lab., Amsterdam, Netherlands) Navigation (ISSN 0028-1522) vol. 40, no. 2 Summer 1993 p. 151-160. refs
Copyright

Civil aviation authorities have a requirement for the application of devices that are capable of determining the geometric height of aircraft above flight level 290 with a high degree of precision. These devices, called height monitoring units (HMUs), should pave the way for the safe and expeditious introduction of a reduced vertical separation of 1000 ft above flight level 290 (29,000 ft). This paper outlines the design philosophy, as well as the prototype development, of such an HMU, called the Dual-synchronized Autonomous Monitoring System (DAMS). This device operates fully independently of any airborne equipment, such as secondary surveillance radar transponders. The configuration consists basically of two standard marine radars with both axes of revolution situated in a horizontal plane. With this configuration, it is possible to determine the trajectory of an aircraft and, in particular, the geometric height above ground level within typical radar slant range coverage of some 18 km. Author (revised)

A94-12123
FLIGHT EVALUATION OF A BASIC C/A-CODE DIFFERENTIAL GPS LANDING SYSTEM FOR CATEGORY I PRECISION APPROACH
W. HUNDLEY, S. ROWSON, G. COURTNEY (Wilcox Electric, Inc., Kansas City, MO), V. WULLSCHLEGER, R. VELEZ (FAA, Technical Center, Atlantic City, NJ), and P. O'DONNELL (Mitre Corp., McLean, VA) Navigation (ISSN 0028-1522) vol. 40, no. 2 Summer 1993 p. 161-178. refs
Copyright

Flight tests were conducted to evaluate the capability of local area C/A-code differential GPS (DGPS) to provide accuracy suitable for precision approach operations under Category I conditions. An aircraft was equipped with DGPS receiving equipment and additional computing capability that derived GPS-based instrument approach paths, converted DGPS position information to lateral/vertical deviations from the approach path, and drove the appropriate aircraft flight instruments. A mobile ground station using identical DGPS receiving equipment and a VHF data transmitter was employed to send differential corrections to the airborne system. Other than the differential corrections, no other augmentation of the airborne data was employed. Analysis of data collected from 82 hand-flown approaches using ground truth provided by theodolite or laser tracker shows that the system achieved vertical accuracies meeting Category I requirements with a substantial margin when narrow-correlator spacing GPS receivers were used. Lateral accuracies met Category III requirements.

A94-12124
RAIM AVAILABILITY FOR GPS AUGMENTED WITH BAROMETRIC ALTIMETER AIDING AND CLOCK COASTING
YOUNG C. LEE (Mitre Corp., McLean, VA) Navigation (ISSN 0028-1522) vol. 40, no. 2 Summer 1993 p. 179-198. refs
Copyright

An account is given of activities associated with the use of GPS in IFR operations of the National Airspace System (NAS); one of the most fundamental criteria to be met is the availability of receiver autonomous integrity monitoring (RAIM) detection and identification functions. A relatively simple GPS augmentation involving barometric altimeter-aiding and clock-coasting is here discussed in light of technical analyses, and with a view to the resulting enhancement of GPS RAIM availability. AIAA

A94-12228
HELICOPTER RADIO COMMUNICATION - GENERAL TREND
B. BOISMOREAU (Thomson- CSF, Boulogne-Billancourt, France) 1992 27 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

Current trends in helicopter radio communication in Army Aviation are briefly reviewed, with particular attention given to three specific systems currently used in Europe. These are the PR4G system, operating in the 30-88 MHz band; the SATURN system (second generation anti-jam tactical UHF for NATO), operating in the 225-400 MHz band; and the MIDS (Multiple Information Distribution System), operating in the 960-1215 MHz band. These systems are characterized by resistance to electronic warfare, provide new services, and employ new transmission media, such as satellite and millimeter and optical frequency ranges. The systems also meet the requirements of ruggedness, friendly operating interface, adaptability, versatility, and interoperability. AIAA

A94-12230
ON THE TRACK OF THE TIGER - THE NAVIGATION SYSTEM FOR THE TIGER MISSIONS
JACQUES CONTET (Sextant Avionique, Valence, France) 1992 15 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The autonomous navigation system developed for the PAH2/HAC, HAP Tiger Helicopter Program is described. The system included two strapdown inertial units with a three-axis laser-gyro, two air data units, two strapdown magnetometers, a Doppler velocity sensor, a radar-altimeter, and an option for a P-code GPS receiver. The hybridization of these components provides the parameters required for piloting, displays, and guidance of the helicopter and its weapon system with high degree of accuracy, reliability, and safety. The discussion covers the architecture and structure of the system and the design of its main components. AIAA

A94-12533
ADAPTIVE STRUCTURAL CONTROL AND ISOLATION OF SIMPLE STRUCTURAL MEMBERS
JOHN F. SCHULTZE, ROBERT W. ROST, and IVAN E. MORSE (Cincinnati Univ., OH) *In* International Modal Analysis Conference, 10th, San Diego, CA, Feb. 3-7, 1992, Proceedings. Vol. 2 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 1079-1086. refs
Copyright

This paper investigated the active vibration control of structural systems via adaptive control of the response level of preselected locations on the structure. Included in this research was an examination of spatial considerations of hardware implementation for two cases; a cantilever beam (single input/single output, SISO) and a soft suspension rectangular plate (single point attenuation). The SISO beam studies indicated strong dependence of spatial distance between response transducer and control actuator on the ability to reduce vibration levels. Global versus local attenuation was quantified for the various operating shapes of the closed-loop beam tests. The single point isolation of the elastically supported plate demonstrated good isolation for most points with harmonic excitation. These tests also showed that the Filtered-U algorithm worked well for random vibration control.

A94-12551
INST. OF NAVIGATION, ANNUAL MEETING, 48TH, WASHINGTON, JUNE 29-JULY 1, 1992, PROCEEDINGS
Alexandria, VA Institute of Navigation 1992 482 p. For individual items see A94-12552 to A94-12577
Copyright
The present volume on navigation discusses GPS as a possible replacement for other navigational aids, aircraft and marine navigation, land and vehicular location and navigation, and GPS applications. Attention is given to GPS/GLONASS development and precision landing applications, the history of navigation since Columbus, the mechanism of China's south-pointing carriage, and the transition from marine to air navigation. Topics addressed include the advantages of interoperability for the prudent navigator, flight testing of the exploratory gimballed airborne ESG system, and the possibility of a berthing support system. Also discussed are performance analyses of triangulation techniques, attitude error estimation with a general GPS observation matrix, a tunnel concept risk allocation methodology for aircraft navigation systems, and an evaluation of GPS on-the-fly ambiguity resolution techniques.
AIAA

A94-12552
ISSUES FOR GNSS-BASED PRECISION APPROACH
STEPHEN HEPPE (Stanford Telecommunications, Inc., Sunnyvale, CA) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 29-37. Research supported by Volpe National Transportation Systems Center and FAA
Copyright
This paper assesses twenty well-known issues associated with the application of GNSS technology to precision approach and landing. These issues vary in terms of theft impact on the far-term National Airspace System (NAS), the worldwide Future Air Navigation System (FANS), and the projected cost of these multi-faceted systems. These issues are currently being examined and resolved as part of the world-wide effort to define the role of the GNSS in the NAS and the FANS. This paper attempts to put these issues into perspective, to provide a basis for systems engineering, R&D funding decisions, and policy-making.

A94-12553
LOW ALTITUDE NAVIGATION AND APPROACH REQUIREMENTS V/STOL AND CTOL
R. R. WILKINS (Boeing Co., Helicopters Div., Philadelphia, PA) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 39-45. refs
Copyright
V/STOL and CTOL aircraft operating in a low-altitude environment require additional or enhanced navigational systems especially in areas of reduced navigational aid coverage, whether ground-based or spaces-based. Low-altitude navigation, nearer to obstacles and terrain than mid- and high-altitude navigation, requires increased accuracy and the capability to make use of this increased accuracy. Because of their inherent design capabilities, especially for V/STOL aircraft, navigation and approach guidance modes reflecting increased lateral deviation accuracy as well as vertical guidance are needed. These include tighter navigation cross track tolerances, steep approach angles/departure angles, and reduced vectoring/final approach/departure speeds.
AIAA

A94-12556
THE APPLICATION OF MAGNETIC VARIATION - PAST, PRESENT, FUTURE (?)
MICHAEL J. MIRESSI (FAA, Office of Aviation System Standards, Washington) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 91-95.
Copyright
The advent of radionavigation stations has done nothing to diminish the magnetic compass' hold on navigation. Navigation stations, aligned with Magnetic North, ensure that their plotted radials coincide with those of the magnetic compass. The Magnetic North Pole is not fixed; variations for a given location constantly change. Navigators took this in stride until the recent advent of sophisticated navigation systems - many with their own magnetic variation models - produced a new problem: systems' indications of a magnetic course often disagree with published flight data. This paper addresses the application of magnetic variation to components of NAS, discusses rates of change and differences in variation, and recommends rules for making this ancient mariners' computation more relevant for modern navigators.
Author (revised)

A94-12557
GPS MULTIPATH AND SATELLITE INTERFERENCE
RICHARD D. J. VAN NEE (Delft Univ. of Technology, Netherlands) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 167-177. refs
Copyright
Multipath tracking errors on pseudo-ranges and carrier phase measurements are analyzed for both coherent and noncoherent delay lock loops with arbitrary early-late spacings. The coherent delay lock loop is shown to have a major advantage; for a relatively high fading bandwidth it has a zero tracking error, while a noncoherent delay lock loop can have a bias error of up to tens of meters. Carrier phase measurements are proven to be free of biases. For a small fading bandwidth, both coherent and noncoherent loops yield the same maximum multipath errors. Further, the effect of satellite interference is explained. Measurements of tracking errors due to multipath and satellite interference are presented, showing pseudo-range errors in the range of several meters up to more than 100 m, while carrier phase errors are limited to several centimeters. Author (revised)

A94-12558
COOPERATIVE AREA PASSIVE TRACKING SYSTEMS (CAPTS)
CARL SCHWAB (Cardion, Inc., Woodbury, NY) and FRED GOODRICH *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 189-196. refs
Copyright
CAPTS, a ground-based multilateration system which uses emission from either ATCRBS or Mode 'S' transponders to provide information regarding the identification and position of cooperative targets, is discussed. CAPTS is designed for ATC/management use in terminal areas and provides continuous, seamless coverage from a range of 60 miles from the terminal continuing on the airport surface right up to the gate. CAPTS employs time difference of arrival to locate the position of transponder-equipped aircraft. This system uses asynchronous regular transmission of the aircraft identity and pressure altitude in standard ATCRBS or Mode 'S' format. Data representing the accuracy of the system are presented, and its impact on Mode 'S' as a data link and CAPTS advantages over rho-theta systems for handling high-density terminal area traffic are discussed.
AIAA

A94-12559

DETERMINATION OF THE PROBABILITY DENSITY FUNCTION OF GPS (GLOBAL POSITIONING SYSTEMS) POSITIONING ERROR

MASAHIKO KOBAYASHI, FRANK INGELS, and GEORGE BENNETT (Mississippi State Univ., Mississippi State) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 219-231. refs

Copyright

The pdfs of the position error of the GPS were determined using existing error scatter data sets. A standard curve-fit method was used; several known probability density functions, namely, the Rayleigh distribution, Weibull distribution, exponential distribution, and Gaussian distribution were applied. Existing data sets which were acquired by other agencies' studies in static measurement conditions on the surface of the earth were used. As a result, the probability density functions showed relatively large differences when compared to one another. Surprisingly the Weibull probability density function gave the best fit for each of the data sets used, indicating that the most suitable probability density function for modeling GPS position accuracy is the Weibull function.

A94-12560

ENHANCEMENT OF THE NAVIGATION POSITION REFERENCE FOR INS TESTING USING DIFFERENTIAL GPS PSEUDORANGE MEASUREMENTS

RANDALL N. PASCHALL and WILLIAM J. NEGAST (USAF, Inst. of Technology, Wright-Patterson AFB, OH) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 233-242. refs

Copyright

An enhancement is proposed to the Completely Integrated Reference Instrumentation System (CIRIS), namely, the Enhanced Navigation Reference System, which takes advantage of newer ring laser gyro strapdown INS technology, ground transponders from the current CIRIS, and differential GPS (DGPS) measurements. Analysis conducted using in the Kalman filter development package Multimode Simulation for Optimal Filter Evaluation is presented. A large-order baseline truth model for the ENRS is developed and full- and reduced-order Kalman filters are designed. It is suggested that the proposed ENRS with DGPS aiding can provide a navigation position solution at least one order of magnitude better than the current CIRIS. AIAA

A94-12561

WIDE AREA DIFFERENTIAL GPS-POTENTIAL FOR ACCURATE GLOBAL NAVIGATION

PREM MUNJAL and MOHAN ANANDA (Aerospace Corp., Los Angeles, CA) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 243-253. refs

Copyright

This paper presents the results of a simulation analysis that was performed to evaluate the navigation accuracy achieved by utilizing Wide Area Differential GPS capability. The results show that the GPS Standard Positioning Service radionavigation accuracy can be significantly improved with minimum impact to the user equipment, and most of the systematic errors including the errors associated with selective availability are minimized. The errors due to ionospheric effects have also been studied, and the results further show that a horizontal position accuracy on the order of 10 m (1 sigma) is obtained by utilizing single-frequency calibrations without involving complex modeling techniques. Author (revised)

A94-12562

ATTITUDE ERROR ESTIMATION WITH A GENERAL GPS OBSERVATION MATRIX

CHARLES A. BASS (U.S. Navy, Naval Command, Control and Ocean Surveillance Center, San Diego, CA), CONSTANTINE G. KARMOKOLIAS, and AZAAD KHATRI (Galaxy Scientific Corp., Warminster, PA) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 255-263. Research supported by DARPA and U.S. Navy refs

Copyright

This paper describes the development of an approach to estimate attitude errors in vehicles with changing attitude independent of the value of the specific forces. The paper includes derivation of a more general GPS observation matrix which captures any attitude and attitude rate information that was lost in the conventional derivations and simulation results. The technique developed here has the advantage of being readily implementable in a conventional GPS receiver with only minor software modifications. Author (revised)

A94-12564

DESIGN IMPLEMENTATION AND TESTING OF A HELICOPTER INTEGRATED NAVIGATION SYSTEM (HINS)

D. B. REID, BRYAN H. KLIEWER (Applied Analytics Corp., Canada), JAN ZYWIEL, ROSS RIDDELL, and TOM FLYNN (DND, Ottawa, Canada) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 279-289. Research sponsored by DND refs

Copyright

The HINS design and an evaluation of flight trial results are described. HINS comprises a mission computer, referred to as the Navigation Computer System (NCS), and three primary sensor subsystems. HINS was tested in a four-phase test program involving simulation, laboratory testing, van testing, development flight tests and evaluation flight tests. HINS performance over water in the INS/GPS/DVS and INS/GPS configurations is discussed. In two of the eight tests conducted, it was determined that GPS performance had degraded well outside specification. The INS/DVS configuration meets its performance specification. INS/DVS performance is influenced by sea bias. HINS can provide better in-air INS alignment performance with DVS over land because DVS performance over water is degraded significantly by sea-bias effects. AIAA

A94-12567

A GPS COVERAGE MODEL

TRENT A. SKIDMORE (Ohio Univ., Athens) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 307-316. refs

(Contract DTRS-57-87-C-00006)

Copyright

This paper summarizes the results of several case studies using the Global Positioning System coverage model developed at Ohio University. Presented are results pertaining to outage area, outage dynamics, and availability. Input parameters to the model include the satellite orbit data, service area of interest, geometry requirements, and horizon and antenna mask angles. It is shown for precision-landing Category I requirements that the planned GPS 21 Primary Satellite Constellation produces significant outage area and unavailability. It is also shown that a decrease in the user equivalent range error dramatically decreases outage area and improves the service availability.

A94-12568

GPS RELATIVE NAVIGATION - AN ALTERNATIVE PRECISION APPROACH AID

DON BROWN and ROB CONLEY (Overlook Systems Technologies, Inc., Colorado Springs, CO) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 329-340. refs

Copyright

This paper describes the approach and results of an initial precision approach system research effort conducted for the Federal Aviation Administration. The research concerned the innovative application of a GPS-based navigation system to the precision approach problem. Our proposed system is based upon the relative navigation concept, which precisely locates GPS receivers relative to one another. This paper reviews the results of the key points from the technical feasibility assessment portion of our research. We review our approach for performing the assessment, an approach which applies measured ranging error data to a dynamic precision approach simulation process. We deal specifically with the ability of the relative navigation concept to support precision approach accuracy, availability, and integrity requirements. We also discuss practical methods for dealing with some of the technical issues associated with a relative navigation system. Chief among these technical issues was determining how to ensure consistent satellite tracking among all receivers within the terminal control area, a critical prerequisite for any relative navigation implementation. Author (revised)

A94-12569
GNSS INTEGRITY FOR AIRCRAFT PRECISION APPROACH
PAUL M. CREAMER, E. M. GEYER, JOSEPH J. PISANO, and DAVID P. FRANK (*Analytic Sciences Corp., Reading, MA*) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 341-350. Research sponsored by Volpe National Transportation Systems Center and FAA refs
Copyright

The concept of satellite-based precision approach is attractive to many in the aviation community. The work reported herein is intended to provide initial quantitative information concerning the integrity capability of a satellite-based system which utilizes local differential corrections and smoothed code processing. Both the planned Department of Defense (DoD) Global Positioning System (GPS) satellites and enhanced constellations are considered.

A94-12570
INTEGRATION OF GPS, GLONASS AND INS ON A RAW DATA BASIS - FIRST RESULTS OF AN EXPERIMENTAL STUDY
WOLFGANG LECHNER (Avionics Center, Braunschweig, Germany), ROLF JESKE (Aerodata Flugmesstechnik GmbH, Braunschweig, Germany), STEFAN VIEWEG (Braunschweig, Technische Univ., Germany), and SERGEJ KLYUSHNIKOV (Russian Inst. of Radionavigation and Time, St. Petersburg, Russia) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 351-358. Research supported by Ministry of Transportation of Germany refs
Copyright

Results are reported of an experimental study of the integration of GPS, the Russian Global Navigation Satellite System (GLONASS), and INS performed on the basis of raw data. It is shown that GLONASS has at least the same accuracy potential as GPS if there is no selective availability (SA) on the GPS signal. In this case GLONASS could be at least twice or three times more accurate than GPS affected by SA. AIAA

A94-12571
TUNNEL CONCEPT RISK ALLOCATION METHODOLOGY FOR AIRCRAFT NAVIGATION SYSTEMS
ROBERT J. KELLY (AlliedSignal Communications Systems, Baltimore, MD) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 359-372. refs
Copyright

A generic aircraft/navigation risk methodology is described which is applicable to all navigation sensors and to all phases of flight-takeoff, climb, cruise, descent, approach, and landing. Each phase of flight can be viewed as a sequence of windows. These windows form a tunnel-in-space whose dimensions are determined from a top-down risk allocation which in turn defines the required navigation performance (RNP). Using the RNP defined accuracy, integrity, and continuity-of-service, specific generic system requirements are derived. These requirements are the flight technical error, navigation sensor errors, monitor alarm limits, and equipment redundancy. This methodology was adopted by an All Weather Operations Panel working group of ICAO. Using this risk allocation methodology the working group proposed generic integrity and continuity-of-service requirements for non-aircraft navigation system elements used in precision RNAV final approach and landings. Author (revised)

A94-12572
OPERATIONAL ASPECTS OF GPS FOR PRECISION APPROACH AND LANDING
MANFRED DIEROFF, XIAOGANG GU, BERND TIEMEYER, and STEFAN VIEWEG (Braunschweig, Technische Univ., Germany) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 373-382. Research sponsored by BMFT refs
Copyright

The operational aspects of using differential GPS (DGPS) for precision approaches of general aviation aircraft under a contract with the German Ministry of Research and Technology are discussed. The operational investigations are subdivided into simulation, ground test, and flight test. The simulation is used to explore the issue of integrating GPS and inertial sensors as well as additional sensors such as altimeters if they are necessary. The simulation is also used to investigate the problem of the integrity of this integrated system with respect to GPS failures. It is shown that the complementary integration of DGPS and inertial reference systems with Kalman filters enables high-precision navigation. Even with degraded inertial reference systems the accuracy of such a system is high enough for precision approaches of aircraft and comparable with the ILS and MLS accuracies. AIAA

A94-12574
GPS IN THE GULF WAR
MUNEENDRA KUMAR (DMA, Washington) and BRYN A. FOSBURGH (U.S. Army, Topographic Engineering Center, Fort Belvoir, VA) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 403-407.
Copyright

Aspects of how the GPS had a direct and indirect impact on the success of the military effort under operations Desert Shield and Desert Storm are discussed. GPS with small powerful computers provided the military surveyors with technology that increased their operational effectiveness, especially over vast terrain with no features. GPS absolute positioning capability provided the army surveyors timely and accurate survey control in a matter of hours that was accurate to within a few meters. This accuracy level more than met the majority of the armed forces tactical positioning requirements. After initial sets of transformation constants became available, the GPS survey data were sent to Defense Mapping Agency Systems Center for computation of station coordinates with precise ephemeris; this set of coordinates was then used to finalize the datum transformation shifts. AIAA

A94-12575
EVALUATION OF GPS ON-THE-FLY AMBIGUITY RESOLUTION TECHNIQUES
JON BURGESS (U.S. Army, Topographic Engineering Center, Fort Belvoir, VA) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 409-416. refs
Copyright

The study presents a technical discussion on resolving carrier-phase ambiguities OTF using techniques proposed by Euler et al. (1992) and Remondi (1984-1991), as well as data processed using their algorithms compared with a truth system. Both algorithms and software in a postprocessed mode were able to resolve ambiguities and provide 10 cm level trajectories for baselines of less than 1 km in length with near 100 percent reliability. The formulations show that with the present data set, in a postprocessed mode Remondi's GPS OTF software based on the ambiguity function method is able to consistently achieve near 10 cm level results on baselines varying from less than 1 km to

20 km. Euler's GPS OTF software is found to be less capable when used to formulate trajectories of any length, although it is quite successful with 1 km and with the shorter baselines (less than 15 km) that have near cycle slip free data for at least a half-hour period. AIAA

A94-12576
AN EVALUATION OF THE USE OF GPS AND LASER RANGING TO POSITION STATIONARY OBJECTS FROM A DISTANCE
ERIN M. O'LEARY, ALAN G. EVANS, and T. N. SMITH (U.S. Navy, Naval Surface Warfare Center, Dahlgren, VA) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 417-426. refs
Copyright

The feasibility of combining the GPS with a laser rangefinder (LRF) to remotely estimate the positions of stationary objects is discussed. An observer with a target in view uses GPS to determine his location and then uses an eyesafe LRF to establish the distance to the targeted object (+/- 5 m). These data, along with angular measurements, are used to estimate the position of the target in the GPS reference frame. The accuracy of obtaining angular information from GPS in pointing and relative positioning modes and from auxiliary instruments is discussed. Test results are presented where known coordinates of the targeted objects are compared with the estimated values. Accuracies of each component of the test are presented. Author (revised)

N94-10933# Computer Resource Management, Inc., Herndon, VA.
NATIONAL AIRSPACE SYSTEM OPERATIONAL CONCEPT Final Report
WILLIAM TRENT and THOMAS PICKERELL Jun. 1993 567 p
(Contract DTFA01-91-Y-01004)
(DOT/FAA/SE-93/1; NAS-SR-130) Avail: CASI HC A24/MF A04

The Federal Aviation Administration (FAA) has established specific goals for modernization of the National Airspace System (NAS) over the next decade. These goals include the replacement and modernization of aging air traffic control and navigation equipment and the development of a more comprehensive and coordinated system design to reflect specific needs of the user and specialist communities, to enhance safety, to improve efficiency and capacity, and to reduce operating costs. The programs to achieve these objectives are documented in the Capital Investment Plan (CIP). In conjunction with the CIP, the FAA has prepared system engineering management documents to assist in the orderly development and integration of CIP programs. The NAS Systems Requirements Specification (NASSRS) is a compilation of requirements which describe the operational capabilities for the NAS as envisioned to exist by the year 2000. The organization of this NAS Operational Concept corresponds to the major paragraphs of the NASSRS and provides an in-depth discussion of the higher level descriptions found in the NASSRS. This operational concept provides an overview of the NAS along with operational sequence diagrams and operational scenario diagrams to amplify the eight major sections of the NASSRS. Author (revised)

N94-11103 Massachusetts Inst. of Tech., Cambridge. Lexington Lincoln Lab.
THE MEMPHIS PRECISION RUNWAY MONITOR PROGRAM INSTRUMENT LANDING SYSTEM FINAL APPROACH STUDY Project Report
MARTHA R. OWEN 24 May 1993 120 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract F19628-90-C-0002; DTFA01-93-Z-02012)
(AD-A266035; ATC-194; DOT/FAA/NR-92/11) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

This report documents the study of the lateral positions of aircraft on Instrument Landing System (ILS) approaches during the Memphis, Tennessee, Precision Runway Monitor (PRM) demonstration. The PRM is an advanced radar monitoring system that improved the arrival capacity of closely spaced parallel runways in poor weather conditions. The results of this study are used to assist in determining the minimum runway spacing that will be authorized for PRM. The objective of this study was to quantify the lateral character of ILS arrivals and the consequent impact on independent simultaneous ILS arrival on closely spaced parallel runways. The sensitivity of the arriving aircrafts' lateral positions to different variables such as visibility, wind runway, aircraft type, autopilot performance, and localizer beam width was determined. Also, the Memphis arrival data were compared to FAA Technical Center Chicago O'Hare approach data. The analysis was primarily based on surveillance reports of 4,000 ILS arrivals into Memphis International Airport, collected with the PRM AMPS sensor (ATCRBS Monopulse Processing System). A major result of the study was that lateral aircraft positions will not hamper independent arrivals to parallel runways spaced 3,400 feet apart, but will impede operations at 3,000 feet or smaller unless approach modifications are introduced. Lateral deviations were found to be most sensitive to reduced visibility and certain autopilots. Lateral deviations were also found to be somewhat more at Memphis relative to Chicago O'Hare. Recommendations for further data analysis and collection are discussed. DTIC

N94-11525*# Ohio State Univ., Columbus. Dept. of Electrical Engineering.
PERFORMANCE OF TRAFFIC-ALERT COLLISION AVOIDANCE (TCAS) ANTENNAS IN THE PRESENCE OF SCATTERERS
K. S. SAMPATH, R. G. ROJAS, and W. D. BURNSIDE Jul. 1993 142 p
(Contract NAG1-1058)
(NASA-CR-193569; NAS 1.26:193569; TR-722792-5) Avail: CASI HC A07/MF A02

The performance of two TCAS systems is studied in the presence of electromagnetic scatterers. TCAS is an aircraft mounted angle of arrival (AOA) system, which estimates the bearing of a signal transmitted from a mode-S transponder on another nearby aircraft (intruder). Two systems are studied: (1) Comparison of Relative Amplitude system (CRA), and (2) Spiral Phase Antenna (SPA). The CRA antenna receives the reply via four switched beams. The bearing is estimated by comparing the amplitudes of the received signal. The SPA is based on the phase interferometer, which utilizes the received phase via sum and difference beams. The AOA is computed by comparing the reply with similar values on a calibration table, which is generated by modeling the TCAS antenna on the bare fuselage of a Boeing 727-200. The antenna patterns for the TCAS are found via high frequency methods based on the Uniform Geometric theory of Diffraction (UTD). By minimizing the standard deviation of the bearing error in a specified angular sector, optimal locations for top and bottom mounted TCAS antennas are found on the Boeing 727-200, 737-300 and 747-200 airframes. It will be shown that the overall bearing errors of the amplitude system are consistently smaller than the spiral phase TCAS. The effect of two types of nearby scatterers--antennas, and engine inlets--is studied. The AT741 L-band blade, DMC60-1 VHF Communication antenna were chosen as being representative antenna interference examples. Models are derived for the blades via a moment method analysis followed by a least squares procedure to synthesize the scattering patterns. Studies were conducted to estimate the minimum separation between the two antennas for acceptable operation. It will be shown that the spiral phase TCAS is adversely affected by the presence of a blade antenna. The amplitude system does not suffer from this limitation, especially for the forward look angles which are of most interest here. A model to represent the inlet scattering is based on the multiple scattering method and UTD. The engine on top of the B727-200 fuselage is modeled by a terminated circular waveguide. Then, the effect of moving the antenna forward on the fuselage is studied. It is again shown that the performance of the amplitude system is superior. Author

N94-11626# Department of Transportation, Cambridge, MA. National Transportation Systems Center.
IMPACT OF SHUTTING DOWN EN ROUTE PRIMARY RADARS WITHIN CONUS INTERIOR Final Report, Jun. 1992 - Feb. 1993
JANIS VILCANS Jun. 1993 43 p
(DOT-VNTSC-FAA-93-1; DOT/FAA/NR-93-1) Avail: CASI HC A03/MF A01

The impact on the Air Traffic Control (ATC) operations resulting from the shutdown of all en route primary radars (except for ARSR-4s) within the CONUS interior will result in loss of real-time weather data and aircraft skin tracking over 33 percent primary surveillance loss of coverage in the CONUS and an increase in the accident rate of one accident in 11 years as predicted on recent statistics. The report concludes that real-time weather data while of limited quality must be retained until it can be replaced by data from the NEXRAD weather radar or other weather data source. Ability to track non-transponder equipped aircraft is significant but less critical and can be minimized by other system improvements. These include: better beacon radar (Mode S) in combination with Traffic Alert and Collision Avoidance System (TCAS) and Automatic Dependent Surveillance (ADS); increased transponder equipage; reduced altitude for non-transponder equipped aircraft to 10,000 feet; increased DF network to 370 sites; and better siting of beacon-only antennas. Based on current availability projections (derived from Capital Investment PLan (CIP) schedules) the most feasible en route primary radar shutdown date is the year 2008. If weather data from external sources can be made available on controllers displays before that time (for example by 1998 when ISSS is installed) that data can be advanced. Author (revised)

N94-11863# Massachusetts Inst. of Tech., Lexington.
EVALUATION OF THE CAPACITY AND DELAY BENEFITS OF TERMINAL AIR TRAFFIC CONTROL AUTOMATION
STEVEN B. BOSWELL 14 Apr. 1993 76 p
(Contract F19628-90-C-0002; DTFA01-88-Z-0200)
(AD-A265323; ATC-192) Avail: CASI HC A05/MF A01

The benefits that the Center/TRACON Automation System (CTAS) component of the FAA Terminal Air Traffic Control Automation program (TATCA) offers to aviation users are reviewed. In particular, the prospects that exist for increasing arrival capacity during Instrument Meteorological Conditions (IMC) by introducing CTAS functionality into current operations are reported. The impact of anticipated capacity gains on air traffic delays is analyzed. Savings in delay are translated into dollar savings using FAA statistics on the fleet-weighted direct cost of delay to domestic air carriers. Also, the value of passenger time is considered. Economic impacts are estimated and reported on an annualized, nationwide basis. Adopting FAA projections of future traffic growth, estimates of delay and attendant cost savings to air carriers and their passengers are provided for fiscal years 1995-2015. Taking the nominal estimate of a 12% gain in IMC arrival capacity, a nationwide implementation of CTAS would be estimated to save an average of 412,000 hours of air carrier delay annually over this 21-year period, and 273 million gallons of fuel per year. With current fuel and labor costs, this amounts to average direct operating savings to air carriers of $1.5 billion per year, and value to passengers of over $3 billion per year, in constant 1988 dollars. There may be factors outside the scope of this study that restrict the implementation of CTAS to certain sites, or that limit the weather conditions in which CTAS is effective. Methods are discussed for modifying benefits estimates in response to such considerations. DTIC

N94-11879# Aeronautical Systems Div., Wright-Patterson AFB, OH.
EVALUATION OF THE C/EC/KC-135 GROUND COLLISION AVOIDANCE SYSTEM (GCAS), STUDY 2 Final Report, 1 Feb. - 30 Apr. 1992
JUSTIN D. RUEB, JORDAN R. KRISS, and JOHN A. HASSOUN Mar. 1993 150 p
(AD-A265193; ASC-TR-93-5004) Avail: CASI HC A07/MF A02

This report represents the second of a two-study evaluation program. The first study evaluated the original Cubic GCAS algorithm in four distinct phases. Throughout the four phases, concerns and recommendations were forwarded to the System Program Office and to the Cubic Corporation. This resulted in modification of the algorithm prior to the next phase of the evaluation. Phase 1 efforts focused on the verification and validation of the algorithm. This phase simply established how well the algorithm predicted altitude loss based on current inputs. Phase 2 was the robot pilot model phase. During this phase, a computer pilot model tested the GCAS under different aircraft configurations and environmental conditions. The man-in-the-loop phase, Phase 3, used a subset of the configuration in Phase 2 in addition to a series of Instrument Landing System (ILS) runs to determine algorithm ability to accurately predict under realistic conditions (human reaction times). In the final phase, current operational pilots flew mission scenarios based on selected CFIT mishaps. This phase permitted an evaluation of the Cubic GCAS algorithm under real-world conditions. Study 2 used the same four-phase approach as that used during Study 1. However, the evaluation was performed on the newly revised Cubic algorithm. The revised algorithm incorporated more extensive changes than those conducted after each of the Study 1 phases. Additionally, Study 2 evaluated Phase 1-Phase 4 without any delay. Unlike Study 1, the algorithm was not returned to Cubic for modification prior to the next phases. DTIC

N94-12355*# California Polytechnic State Univ., San Luis Obispo.
HELICOPTER APPROACH CAPABILITY USING THE DIFFERENTIAL GLOBAL POSITIONING SYSTEM
DAVID N. KAUFMANN Aug. 1993 58 p
(Contract NCC2-775)
(NASA-CR-177618; A-93110; NAS 1.26:177618) Avail: CASI HC A04/MF A01

The results of flight tests to determine the feasibility of using the Global Positioning System (GPS) in the differential mode (DGPS) to provide high accuracy, precision navigation and guidance for helicopter approaches to landing are presented. The airborne DGPS receiver and associated equipment is installed in a NASA UH-60 Black Hawk helicopter. The ground-based DGPS reference receiver is located at a surveyed test site and is equipped with a real-time VHF data link to transmit correction information to the airborne DGPS receiver. The corrected airborne DGPS information, together with the preset approach geometry, is used to calculate guidance commands which are sent to the aircraft's approach guidance instruments. The use of DGPS derived guidance for helicopter approaches to landing is evaluated by comparing the DGPS data with the laser tracker truth data. Both standard (3 degrees) and steep (6 degrees and 9 degrees) glidescope straight-in approaches were flown. DGPS positioning accuracy based on a time history analysis of the entire approach was 0.2 m (mean) +/- 1.8 m (2 sigma) laterally and -2.0 m (mean) +/- 3.5 m (2 sigma) vertically for 3 degree glidescope approaches, -0.1 m (mean) +/- 1.5 m (2 sigma) laterally and -1.1 m (mean) +/- 3.5 m (2 sigma) vertically for 6 degree glidescope approaches, and 0.2 m (mean) +/- 1.3 m (2 sigma) laterally and -1.0 m (mean) +/- 2.8 (2 sigma) vertically for 9 degree glidescope approaches. DGPS positioning accuracy at the 200 ft decision height on a standard 3 degree glidescope approach was 0.3 m (mean) +/- 1.5 m (2 sigma) laterally and -2.3 m (mean) +/- 1.6 m (2 sigma) vertically. These errors indicate that the helicopter position based on DGPS guidance satisfies the International Civil Aviation Organization Category 1 lateral and vertical accuracy requirements. Author

N94-13238*# Colorado Univ., Boulder. Center for Astrodynamics Research.
ERROR ANALYSIS OF REAL TIME AND POST PROCESSED OR BIT DETERMINATION OF GFO USING GPS TRACKING Final Report
WILLIAM S. SCHREINER 5 Oct. 1991 10 p
(Contract NGT-50623)

(NASA-CR-193646; NAS 1.26:193646; CU-1536481) Avail: CASI HC A02/MF A01

The goal of the Navy's GEOSAT Follow-On (GFO) mission is to map the topography of the world's oceans in both real time (operational) and post processed modes. Currently, the best candidate for supplying the required orbit accuracy is the Global Positioning System (GPS). The purpose of this fellowship was to determine the expected orbit accuracy for GFO in both the real time and post-processed modes when using GPS tracking. This report presents the work completed through the ending date of the fellowship. Derived from text

N94-13344# National Aerospace Lab., Tokyo (Japan). Navigation and Flight Experiment Team.

FLIGHT EVALUATIONS OF APPROACH/LANDING NAVIGATION SENSOR SYSTEMS: SUMMARY OF 1990 FLIGHT EXPERIMENTS [MLS TOU KOUHOUKEI HIKOU JIKKEN: HEIZEI 2 NENDO NO JIKKEN GAIYOU]

KOUICHI MATSUSHIMA, TAKATSUGU ONO, MASAAKI MURATA, YOSHIKAZU MIYAZAWA, YOSHINORI OKUNO, KAZUTOSHI ISHIKAWA, TOSHIHARU INAGAKI, HIROKIMI SHINGUU, and TADAO UCHIDA Jul. 1992 70 p In JAPANESE

(ISSN 0389-4010)

(NAL-TR-1175; JTN-93-80491) Avail: CASI HC A04/MF A01

Flight experiments conducted at the Sendai airport (under a joint research project with National Aerospace Laboratory (NAL), National Space Development Agency (NASDA), and Electronic Navigation Research Institute (ENRI) in partial co-operation with Toshiba and NEC Corporations) were utilized to evaluate and establish new navigation sensor technologies which will play a key role in the unmanned spaceplane HOPE (H-2 Orbiting Plane) approach/landing (A/L) navigation system design. The Dornier-228-200 (Do-228), an experimental research aircraft of NAL, is used for the flight experiments. The navigation sensors tested include the Microwave Landing System (MLS), Global Positioning System (GPS), Inertial Navigation System (INS), and radio altimeter. The Differential GPS (DGPS) was also tested in both stand-alone and hybrid modes. The Do-228 is tracked during flight by a laser tracker, with subsequent data being used to provide a reference profile of the aircraft. Navigation accuracy is evaluated in the post-flight performance analysis as the difference between reference profile and navigation output from each navigation sensor or hybrid system. This comparison is made in the Runway Coordinate System (RCS), a reference navigation coordinate system which corresponds to the World Geodetic System 1984 (WGS84). The RCS was constructed using GPS interferometric positioning. In this report, emphasis is placed on describing the tested navigation sensors, data acquisition systems, ground guidance facilities, flight patterns, and analysis strategies. Some preliminary analysis results are also presented which evaluate the stand-alone performance of each navigation sensor as well as a hybrid GPS-INS system. Author (NASDA)

N94-13346# National Aerospace Lab., Tokyo (Japan). Flight Research Div.

PERFORMANCE EVALUATION TESTS OF THE GPS/DGPS NAVIGATION SYSTEM INSTALLED IN THE NAL DORNIER 228: PRELIMINARY GROUND TEST RESULTS [JIKKENYOU KOUKUUKI DORUNIEKI NO GPS KOUHOU SOUCHI HYOUKA JIKKEN: CHIJOU KOTEITEN NIOKERU GPS/DGPS SOUKUI HYOUKA JIKKEN]

TAKATSUGU ONO and KAZUTOSHI ISHIKAWA Aug. 1992 19 p In JAPANESE

(ISSN 0452-2982)

(NAL-TM-649; JTN-93-80493) Avail: CASI HC A03/MF A01

A real-time Differential Global Positioning System (DGPS), incorporating a ground-to-air data link system, was developed for the National Aerospace Laboratory (NAL) Dornier 228-200 flight research airplane. Preliminary ground tests were conducted to evaluate the system's position accuracy prior to flight testing. The onboard and ground GPS receivers used the same antenna in order to avoid unknown common errors (e.g., antenna system and tropospheric delays), and to enable comparison of the optimal case of differential operation. The GPS position accuracies of the stand-alone and differential modes are compared, with results showing that the differential mode improves position accuracy and eliminates Selective Availability (SA) errors. Author (NASDA)

N94-13457# National Aerospace Lab., Tokyo (Japan). STOL Research Aircraft Group.

FLIGHT PATH CONTROL FOR THE APPROACH AND LANDING OF THE QUIET STOL EXPERIMENTAL AIRCRAFT ASKA [TEISOUON STOL JIKKENKI ASKA NO KEIROKAKU SEIGYO TO CHAKURIKU SOUJUUSEI]

NORIAKI OKADA Nov. 1992 53 p In JAPANESE

(ISSN 0389-4010)

(NAL-TR-1183; JTN-93-80505) Avail: CASI HC A04/MF A01

The Upper Surface Blowing STOL experimental aircraft, ASKA, operates well on the backside of the power required curve, so flight path control is accomplished with the throttle lever (thrust) during landing approaches. To compensate for the sluggish flight path response caused by engine lag, the Flight Path Control (FPC) law engages the Stability and Control Augmentation System (SCAS). Flight tests were conducted to evaluate flight path and airspeed response characteristics. This paper describes ASKA's flight path and airspeed response characteristics, as well as the principle involved in the design and construction of the FPC system. Author (NASDA)

N94-13703# Wright Lab., Wright-Patterson AFB, OH.

EVALUATION OF INFRARED SENSORS FOR AUTONOMOUS LANDING GUIDANCE Final Report, 1 May - 30 Jun. 1992

ANTHONY E. ABSI Apr. 1993 25 p

(AD-A266450; WL-TR-93-1054) Avail: CASI HC A03/MF A01

The objective of this program is to test sensors that could provide pilots with images of runway and landing zones under degraded weather conditions such as rain, snow, and fog. During these conditions pilots are unable to land aircraft by visual reference alone. Imaging RF and EO sensors may be able to provide a view of the runway or landing zone that is unaffected by degraded weather. Autonomous landing systems would allow operations at airfields not served by conventional ground-based radio landing aids and allow military operations at unprepared landing sites or drop zones. A test was conducted at Otis Air National Guard Base by Wright Laboratory personnel in June 1992 during heavy fog. Typical staring midwave infrared sensors were used to image a simulated runway (1500 foot asphalt pad) and grass background. The distance at which the pad could no longer be discerned was measured along with supporting meteorological and radiometric ground truth data. This report presents the results and compares them to standard infrared sensor performance prediction models. DTIC

N94-13957*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

HELICOPTER PRECISION APPROACH CAPABILITY USING THE GLOBAL POSITIONING SYSTEM Semiannual Progress Report, Jul. - Dec. 1992

DAVID N. KAUFMANN 31 Dec. 1992 60 p

(Contract NCC2-775)

(NASA-CR-194037; NAS 1.26:194037) Avail: CASI HC A04/MF A01

The period between 1 July and 31 December, 1992, was spent developing a research plan as well as a navigation system document and flight test plan to investigate helicopter precision approach capability using the Global Positioning System (GPS). In addition, all hardware and software required for the research was acquired, developed, installed, and verified on both the test aircraft and the ground-based reference station. Author (revised)

N94-14919# Carnegie-Mellon Univ., Pittsburgh, PA. Robotics Inst.

PERCEPTION FOR OUTDOOR NAVIGATION Annual Report No. 3, 16 Aug. 1991 - 15 Aug. 1992

CHARLES THORPE, TAKEO KANADE, MARTIAL HEBERT, and

DEAN POMERLEAU Sep. 1992 71 p
(Contract DACA76-89-C-0014)
(AD-A266867; CMU-RI-TR-92-16) Avail: CASI HC A04/MF A01

This report reviews progress at Carnegie Mellon from August 16, 1991 to August 15, 1992 on research sponsored by DARPA, DoD, monitored by the U.S. Army Topographic Engineering Center under contract DACA 76-89-C-0014, titled Perception for Outdoor Navigation. Research supported by this contract includes perception for road following, terrain mapping for off-road navigation, and systems software for building integrated mobile robots. We overview our efforts for the year, and list our publications and personnel, then provide further detail on several of our subprojects. DTIC

N94-15124# Rijksluchtvaartdienst, The Hague (Netherlands).
DEVELOPMENTS IN THE EUROPEAN AIR TRAFFIC CONTROL [ONTWIKKELINGEN IN DE EUROPESE LUCHTVERKEERSBEVEILIGING]
J. P. F. DEKONING *In* NAL, Symposium on the Future of Aeronautics in the Netherlands 16 p 1991 In DUTCH
Avail: CASI HC A03/MF A02

Present and future developments in the Air Traffic Control (ATC) are presented. The integrated Eurocontrol ATC operational concept is outlined. The future air traffic control services are presented. The integrated concept includes the combination of civil and military systems. The different system functions have to be compared and possibly adapted. ESA

N94-16439# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
ATCRBS REPLY ENVIRONMENT AT MEMPHIS INTERNATIONAL AIRPORT Project Report
ARNOLD D. KAMINSKY, KATHERINE M. HOLLISTER, and MARTIN J. BRENNAN 28 May 1993 37 p
(Contract F19628-90-C-0002; DTFA01-93-Z-02012)
(AD-A266322; DOT/FAA/NR-93/3) Avail: CASI HC A03/MF A01

This report demonstrates, through data and analysis, how the airport environment can affect ATCRBS surveillance. The Lincoln Laboratory ATCRBS Monopulse Processing Subsystem was used to collect reply data at Memphis International Airport during Mar. 1991. These data show a correlation between aircraft density, potential reflectors, and ATCRBS reply integrity. The number of replies has been shown to be directly related to multipath from reflecting surfaces including taxiing aircraft. Additionally, it is shown that conditions can exist during which not all of the replies from ATCRBS equipped aircraft can be processed when forming target report measurements. Finally, it is shown that the bunching of replies in both time and space can introduce reply decoder overloading. DTIC

N94-16906# Mitre Corp., McLean, VA.
WIDE-AREA DIFFERENTIAL GLOBAL POSITIONING SYSTEM (WDGPS)/WIDE-AREA INTEGRITY BROADCAST (WIB) ALTERNATIVES ANALYSIS Final Report
CHRIS HEGARTY, KELLY MARKIN, and DAN OLAUGHLIN Sep. 1993 44 p
(Contract DTFA01-93-C-00001)
(DOT/FAA/SE-93/3; MTR-93W0000059) Avail: CASI HC A03/MF A01

A study was conducted by MITRE to determine alternative concepts for Wide-area Differential Global Positioning System (WDGPS) for the national airspace system (NAS). The study was undertaken in support of the concept exploration phase analyses required by the Transportation System Acquisition Review Council (TSARC). The results of the study are documented in this paper. The paper provides a description of alternatives to WDGPS, various alternative implementations of WDGPS, advantages and disadvantages of each alternative, and risk areas which were identified. Two WDGPS architecture end-states are recommended. The preferred end-state will depend on the results of required trade-off studies which are identified in this paper. A plan for the transition from the Wide-area Integrity Broadcast (WIB) to the selected WDGPS end-state architecture is also presented. Author

N94-17458 Federal Aviation Administration, Washington, DC. Office of Airport Planning and Programming.
THE 11TH ANNUAL REPORT OF ACCOMPLISHMENTS UNDER THE AIRPORT IMPROVEMENT PROGRAM: FISCAL YEAR 1992 Annual Report
1992 128 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A268328; DOT/FAA/PP-93-2) Avail: CASI HC A07

The Airport and Airway Safety, Capacity, Noise Improvement, and Intermodal Transportation Act of 1992 authorized the extension of AIP at a funding level of $2.05 billion through FY 1993. This Act included provisions resulting in a number of changes in AIP. The primary changes include the expanded eligibility of items under the Military Airport Program; eligibility for the relocation of air traffic control towers and navigational aids (including radar) if they impede other projects funded under the AIP; the eligibility of land, paving, drainage, aircraft deicing equipment, and structures for centralized aircraft deicing areas; and projects to comply with the Americans with Disabilities Act of 1990, Clean Air Act, and Federal Water Pollution Control Act. The Act also increases from three to seven the number of states which may participate in the State Block Grant Program and extends the program through FY 1996. DTIC

N94-17921# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany). Abt. Systemtechnik und Navigation.
ON THE USE OF DIFFERENTIAL GPS FOR AUTOMATIC APPROACH AND LANDING OF SPACE AND AIRCRAFT
YUSUKE SUZUKI (National Space Development Agency, Tokyo, Japan.) Sep. 1992 43 p
(DLR-MITT-93-05; ETN-93-94867) Avail: CASI HC A03/MF A01

The integration of an Inertial Navigation System (INS) with Differential Global Positioning System (DGPS) is investigated with the aim of meeting the critical requirement for the automatic landing of aircraft and recoverable spacecraft according to ICAO, CAT 3 (vertical position accuracy of 0.6 meters (2 sigma)). In a first Kalman filter of the reference system on ground and of the system on board the pseudoranges, ionospheric effects and phase ambiguities are estimated. In a second Kalman filter the pseudorange compensation data and receiver clock errors are estimated on ground and the position, velocity, attitude, and heading and receiver clock errors are estimated on board. Experiments were performed based on GPS receivers SEL GLOBOS 2000 and a simulated INS. The results show that this system can meet the above mentioned requirements. Recommendations for the system improvement are included. ESA

N94-18146# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Abt. fuer Systemtechnik und Navigation.
ABOUT THE ACCURACY OF AN IMAGE-BASED NAVIGATION SYSTEM DURING THE RUNWAY APPROACH [ANALYSE DES FEHLERVERHALTENS EINER LUFTBILD-STUETZUNG IM LANDEANFLUG]
HANS-ULLRICH DOEHLER Jan. 1993 35 p In GERMAN
(DLR-MITT-93-01; ETN-93-94866) Avail: CASI HC A03/MF A01

Flight tests with trajectory measurements in the vicinity of an airport in a runway referenced coordinate system, such as flight inspection systems for testing landing aids in civil airports are considered. Position measurement procedures extracting the position information from images recorded on board the aircraft are studied. To estimate the accuracy of the achieved position data, a simulation of such a system is presented. Under the assumption of different kinds of error sources, regarded as system constraints, the overall position error was numerically determined. ESA

N94-18336# Federal Aviation Administration, Washington, DC. Office of Aviation Policy and Plans.
TERMINAL AREA FORECASTS, FY 1993-2005
Jul. 1993 583 p
(AD-A269855; FAA-APO-93-9) Avail: CASI HC A25/MF A06

This report contains forecasts of aviation activity of 873 airports in the United States for fiscal years 1993-2005. These include 401 airports with FAA air traffic control towers and radar approach control services and 27 FAA contract towers. For each airport, detailed forecasts are made for the four major users of the air traffic system: air carriers, air taxi/commuters, general aviation, and military. Summary tables contain national, FAA regional, and state aviation data and other airport specific-highlights. The forecasts have been prepared to meet the budget and planning needs of the FAA and to provide airport-specific information that can be used by state and local aviation authorities, the aviation industry, and the general public. DTIC

N94-18384 Mitre Corp., Bedford, MA.
VHF AIR/GROUND COMMUNICATIONS FOR AIR TRAFFIC CONTROL. VOLUME 1: A DECISION TREE APPROACH TO SYSTEM INNOVATIONS
CHENG-HONG CHEN, JAMES W. HOWLAND, ROBERT I. MILLAR, BRIAN E. WHITE, and WARREN J. WILSON Jul. 1993 46 p
Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract DTFA01-93-C-0001)
(AD-A268485; MTR-M-93B0000096-VOL-1) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Improvements to VHF air/ground communications for civil aviation in the 118-137 MHz aeronautical mobile frequency band are systematically explored by means of a decision tree approach. Seven individual papers analyze in detail the operational and technical factors involved in making these improvements. Basic tradeoffs between analog and digital modulation are discussed to frame the problem. Near-term improvements utilizing various analog modulations with closer channel spacing are first reviewed. Then far-term improvements employing a wide range of digital modulation and coding techniques are considered. Multiplexing methods - frequency, time, and code division - are discussed in detail. Methods for random access to a shared communications channel are compared, with emphasis upon real-time operations for air traffic control. Volume I provides an executive summary of this work, while Volume II presents the technical details. DTIC

N94-18728# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
VMC LEFT TURN CURVED APPROACHES, TEST RESULTS Technical Note, Sep. 1989 - Jul. 1990
ROSANNE M. WEISS Jul. 1993 45 p
(AD-A269476; DOT/FAA/CT-TN92/46) Avail: CASI HC A03/MF A01

Flight tests were conducted at the Federal Aviation Administration (FAA) Technical Center in 1989 and 1990 to aid in answering questions concerning curved approaches to a heliport under visual meteorological conditions (VMC). These questions include protected airspace within the curved segment of the approach, the most feasible angle of turn and minimum final approach segment. The FAA's Sikorsky S-76 and UH-1H were used for these tests. Data were collected from approaches using turn angles of 45-, 90-, and 180-degrees, each with three different final segments, 800, 1200, and 1600 feet (ft). Due to airspace restrictions at the time of these tests, left turns to final were flown. All maneuvers were tracked by ground-based tracking systems. This report documents the results of these flights. The test procedures, evaluation methodology, and technical and operational issues are described. Analysis of pilot performance as well as pilot subjective input are provided. Conclusions are presented that address the airspace, turn angle, and final segment issues. The results will be considered in future modifications of the FAA Heliport Design Advisory Circular, AC 150/5390-2. All appendixes can be found in Research Directorate for Aviation Technology Division Report DOT/FAA/CT-ACD33093/6. DTIC

N94-19300# Oak Ridge National Lab., TN.
ROBOT NAVIGATION IN UNKNOWN TERRAINS: INTRODUCTORY SURVEY OF NON-HEURISTIC ALGORITHMS
N. S. V. RAO, S. KARETI (Old Dominion Univ., Norfolk, VA.), WEIMIN SHI (Old Dominion Univ., Norfolk, VA.), and S. S. IYENGAR (Louisiana State Univ., Baton Rouge.) Jul. 1993 58 p
(Contract DE-AC05-84OR-21400)
(DE93-019221; ORNL/TM-12410) Avail: CASI HC A04/MF A01

A formal framework for navigating a robot in a geometric terrain through an unknown set of obstacles is considered. Here the terrain model is not known a priori, but the robot is equipped with a sensor system (vision or touch) employed for the purpose of navigation. The focus is restricted to the non-heuristic algorithms which can be theoretically shown to be correct within a given framework of models for the robot, terrain, and sensor system. These formulations, although abstract and simplified compared to real-life scenarios, provide foundations for practical systems by highlighting the underlying critical issues. First, the authors consider the algorithms that are shown to navigate correctly without much consideration given to the performance parameters, such as distance traversed. Second, they consider non-heuristic algorithms that guarantee bounds on the distance traversed or the ratio of the distance traversed to the shortest path length (computed if the terrain model is known). Then they consider the navigation of robots with very limited computational capabilities such as finite automata. DOE

N94-20051# Systems Control Technology, Inc., Arlington, VA.
ROTORCRAFT LOW ALTITUDE IFR BENEFIT/COST ANALYSIS: CONCLUSIONS AND RECOMMENDATIONS Final Report
ROBERT K. ANOLL, ROBERT B. NEWMAN, and EDWIN D. MCCONKEY Oct. 1993 152 p
(Contract DTFA01-87-C-00014)
(DOT/FAA/RD-93/22; DOT/FAA/DS-89/11; SCT-92RR-8)
Avail: CASI HC A08/MF A02

The Rotorcraft Master Plan advocates the establishment of additional communications, navigation, and surveillance (CNS) facilities, as well as the analysis and development of systems to satisfy the increasing demand for widespread instrument flight rules (IFR) rotorcraft operations within the National Airspace System (NAS). The objective of this study is to determine if there is an economic basis for improvement of these low altitude IFR services within the NAS in order to better support rotorcraft IFR operations. The findings of this study will aid FAA decision making in that regard. In view of prior implementation decisions on LORAN-C and GPS, the emphasis in this effort is on communications, surveillance, procedural changes, and avionics. This report is the last of a series of three reports that address rotorcraft low altitude benefit/cost analysis. The other two are: Rotorcraft Low Altitude CNS Benefit/Cost Analysis: Operations Data, DOT/FAA/DS-89/9, and Rotorcraft Low Altitude IFR Benefit/Cost Analysis: Operations Analysis, DOT/FAA/RD-89/10. This final report reviews the operational requirements and constraints for specific rotorcraft missions identified in the previous reports in this series. It also reviews all of the alternatives identified for improving rotorcraft operations. The alternatives considered include additional communications and surveillance equipment, both existing equipment and future systems identified in the Aviation Systems Capital Investment Plan (CIP), and the air traffic control (ATC) procedural changes. A benefit/cost (B/C) analysis is conducted for each communication, surveillance, and procedural improvement identified. When site specific data is available, it is used to calculate actual B/C ratios. When no data exists, a break-even analysis is provided. Author

N94-20197 Department of the Navy, Washington, DC.
ALL-WEATHER PRECISION LANDING SYSTEM FOR AIRCRAFT IN REMOTE AREAS Patent
GERALD E. HART, inventor (to Navy) 4 May 1993 16 p
Filed 24 Jul. 1990
(AD-D015924; US-PATENT-5,208,601;

US-PATENT-APPL-SN-556606) Avail: US Patent and Trademark Office

An all-weather aircraft landing system includes a plurality of ground based passive 90 deg dihedral reflectors for producing two-bounce reflected signals without ground reflections and an airborne radar system which may transmit and receive same sense circularly polarized radiation, while completely rejecting opposite sense polarization returns or else utilizing them to indicate weather conditions. Radar clutter from objects such as rain, buildings, and trees which produce opposite sense reflections are rejected by the same sense receiver or switched to an opposite sense receiver to provide weather/obstacle condition information. By properly orienting a plurality of 90 deg dihedral angle reflectors of a particular size in a predetermined array pattern and tilt-angle adjacent a runway, the reflections from airborne radar signals are processed and displayed to provide a visual means for determining glide slope deviation and approach vector of the landing aircraft.
DTIC

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A94-10717*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

POST-OPTIMALITY ANALYSIS IN AEROSPACE VEHICLE DESIGN

ROBERT D. BRAUN (NASA, Langley Research Center, Hampton, VA), ILAN M. KROO, and PETER J. GAGE (Stanford Univ., CA) Aug. 1993 13 p. AIAA, Aircraft Design, Systems and Operations Meeting, Monterey, CA, Aug. 11-13, 1993 refs
(AIAA PAPER 93-3932) Copyright

This analysis pertains to the applicability of optimal sensitivity information to aerospace vehicle design. The present analysis demonstrates that post-optimality information generated through first-order computations can be used to accurately predict file effect of constraint and parameter perturbations on the optimal solution. This assessment is based on the solution of an aircraft design problem in which the post-optimality estimates are shown to be within a few percent of the true solution over the practical range of constraint and parameter variations. Through solution of a reusable, single-stage-to-orbit, launch vehicle design problem, this optimal sensitivity information is also shown to improve the efficiency of the design process. For a hierarchically decomposed problem, this computational efficiency is realizable by estimating the main-problem objective gradient through optimal sensitivity calculations. By reducing the need for finite differentiation of a re-optimized subproblem, a significant decrease in the number of objective function evaluations required to reach the optimal solution is obtained. Author (revised)

A94-10777

AEROTHERMODYNAMIC PHENOMENA AND THE DESIGN OF ATMOSPHERIC HYPERSONIC AIRPLANES

E. H. HIRSCHEL (MBB GmbH, Munich, Germany) *In* Advances in hypersonics. Vol. 1 - Defining the hypersonic environment Boston, MA Birkhaeuser 1992 p. 1-39. Previously announced in STAR as N91-16015 refs
Copyright

The design problems of aerodynamic hypersonic airplanes and the aerodynamic tools such as wind tunnels and computation methods are reviewed simultaneously with their validation problems. Aerodynamic phenomena such as viscosity, heat loads, heat transfer and real gas effects are studied with consideration of the design and simulation problems. It is remarked that research and development must be increased in the area of turbulence and laminar turbulent transition.

A94-10778

CONCEPTS OF HYPERSONIC AIRCRAFT

P. PERRIER (Dassault Aviation, Saint-Cloud, France) *In* Advances in hypersonics. Vol. 1 - Defining the hypersonic environment Boston, MA Birkhaeuser 1992 p. 40-71. refs
Copyright

The main constraint in the design of hypersonic aircraft derives from heating considerations. The main problems to be evaluated as possible sources of uncertainty in hypersonic design and for which the state of the art is a mandatory constraint determining what is acceptable are discussed. Two extreme designs are presented; one is conservative and the other more advanced but limited in Mach number both by the propulsion and also by local overheating in complex concave shapes. Constraints by propulsion integration are examined. Axisymmetric design is argued to have a definite advantage in stress and weight reduction. Attention is also given to constraints by control requirements. AIAA

A94-10802

AIRCRAFT FAILURE DETECTION AND IDENTIFICATION USING NEURAL NETWORKS

MARCELLO R. NAPOLITANO, CHING I. CHEN, and STEVE NAYLOR (West Virginia Univ., Morgantown) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 6 Nov.-Dec. 1993 p. 999-1009. refs
Copyright

A neural network is proposed as an approach to the task of failure detection following damage to an aerodynamic surface of an aircraft flight control system. Several drawbacks of other failure detection techniques can be avoided by taking advantage of the flexible learning and generalization capabilities of a neural network. This structure, used for state estimation purposes, can be designed and trained on line in flight and generates a residual signal indicating the damage as soon as it occurs. From an analysis of the cross-correlation functions between some key state variables, the identification of the damage type can also be achieved. The results of a nonlinear numerical simulation for a damaged control surface are reported and discussed.

A94-10859

WIND-TUNNEL EVALUATION OF MID-AIRFRAME INSTALLED TURBOJET ENGINES

J. S. LILLEY (U.S. Army, Missile Command, Redstone Arsenal, AL) and S. L. PENGELLY (Boeing Defense & Space Group, Huntsville, AL) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 6 Nov.-Dec. 1993 p. 858-866. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992, AIAA Paper 92-3752. Previously cited in issue 23, p. 4059, Accession no. A92-54150 refs
Copyright

A94-11041

BEHAVIOR OF A CARGO SUSPENDED UNDER A HELICOPTER [POVEDENIE GRUZA, PODVESHENNOGO POD VERTOLETOM]

A. N. RYABININ and B. F. TYURIN Sankt-Peterburgskij Universitet, Vestnik, Seriya 1 - Matematika, Mekhanika, Astronomiya (ISSN 0024-0850) no. 1 Jan. 1993 p. 87-91. In RUSSIAN refs
Copyright

A mathematical model is developed which describes the swinging of a cargo suspended from a helicopter due to gravity and aerodynamic forces. Solutions to the equations of motion describing the swinging of the cargo are solved analytically and numerically. The solutions are analyzed for stability, and stable solutions are identified. AIAA

A94-11352*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

OPTIMIZATION OF ACTUATOR ARRAYS FOR AIRCRAFT INTERIOR NOISE CONTROL

R. H. CABELL (Virginia Polytechnic Inst. and State Univ., Blacksburg), H. C. LESTER (NASA, Langley Research Center, Hampton, VA), G. P. MATHUR, and B. N. TRAN (McDonnell

Douglas Aerospace, Long Beach, CA) Oct. 1993 11 p. AIAA, Aeroacoustics Conference, 15th, Long Beach, CA, Oct. 25-27, 1993 refs
(AIAA PAPER 93-4447) Copyright

A numerical procedure for grouping actuators in order to reduce the number of degrees of freedom in an active noise control system is evaluated using experimental data. Piezoceramic actuators for reducing aircraft interior noise are arranged into groups using a nonlinear optimization routine and clustering algorithm. An actuator group is created when two or more actuators are driven with the same control input. This procedure is suitable for active control applications where actuators are already mounted on a structure. The feasibility of this technique is demonstrated using measured data from the aft cabin of a Douglas DC-9 fuselage. The measured data include transfer functions between 34 piezoceramic actuators and 29 interior microphones and microphone responses due to the primary noise produced by external speakers. Control inputs for the grouped actuators were calculated so that a cost function, defined as a quadratic pressure term and a penalty term, was a minimum. The measured transfer functions and microphone responses are checked by comparing calculated noise reductions with measured noise reductions for four frequencies. The grouping procedure is then used to determine actuator groups that improve overall interior noise reductions by 5.3 to 15 dB, compared to the baseline experimental configuration. Author (revised)

A94-11358
MD-11 IN-FLIGHT THRUST REVERSER SIMULATION
JOHN W. CRAFT (McDonnell Douglas Corp., Long Beach, CA) *In* The use of simulation in aircraft accident prevention and investigation; Proceedings of the Conference, London, United Kingdom, Nov. 11, 12, 1992 London Royal Aeronautical Society 1992 p. 3.1-3.8. refs
Copyright

A method is presented for determining the flow characteristics surrounding a thrust reverser when deployed in flight. This method is used to extrapolate thrust reverser effects from flight tested conditions to the remainder of the flight envelope. The normal flight profile was evaluated in the MD-11 Full Flight Simulator.

A94-11363
THE ROLE OF THE DRA ADVANCED FLIGHT SIMULATOR FOR THE FLIGHT CLEARANCE OF THE VAAC HARRIER EXPERIMENTAL SYSTEM
G. T. SHANKS and F. J. SCORER (Defence Research Agency, Bedford, United Kingdom) *In* The use of simulation in aircraft accident prevention and investigation; Proceedings of the Conference, London, United Kingdom, Nov. 11, 12, 1992 London Royal Aeronautical Society 1992 p. 8.1-8.11. refs
Copyright

The objective of the VAAC Harrier program is to develop and evaluate aircraft handling concepts including design and assessment techniques. The program takes concept studies through piloted ground-based simulation to in-flight simulation using the VAAC Harrier fly-by-wire research aircraft. Prior to flight testing, it is essential that candidate flight control law designs are evaluated on ground simulators for flight clearance purposes and for compliance testing against the design requirements. The VAAC Harrier two crew aircraft enables the safety pilot to take control from the subject pilot should the need arise. The FCS computing architecture is simplex-monitored and is implemented with dissimilar redundancy for failure detection and isolation. The flight clearance philosophy relies on the monitoring function and the role of the safety pilot. The DRA Bedford AFS facility has been used to design the critical parts of the monitor. The flight clearance, qualification, and pilot familiarization of the control response types are also addressed with this simulator. Author (revised)

A94-11364
THE USE OF EH101 DEVELOPMENT COCKPIT SIMULATOR FOR PILOT ASSESSMENT
COLIN HAGUE, J. ROMANS, and A. H. SHAW (Westland Helicopters, Ltd., Yeovil, United Kingdom) *In* The use of simulation in aircraft accident prevention and investigation; Proceedings of the Conference, London, United Kingdom, Nov. 11, 12, 1992 London Royal Aeronautical Society 1992 p. 9.1-9.12.
Copyright

This paper will highlight some of the major uses of the EH101 Development Simulator with particular regard to the Pilot Assessment of cockpit layout, information retrieval/presentation and redundancy. Particular attention will be given to those systems which influence the operability of the aircraft and therefore affect safety. A brief outline of the facility and the reasons for its procurement will be discussed. Three development programs have been chosen from the many assessments undertaken within the simulator. They are: Cockpit Ergonomics, the Electronic Instrument System, and the Automatic Flight Control System. The selection of these programs was on the basis of their effect on the operability of the aircraft and their impact on safety. The paper provides an insight into the development process and the value of the pilot in the assessments. It is estimated that over 500 flying hours have been saved through the use of the simulator. Coupled with this is the use for pilot familiarization prior to the first flight. To underline the consideration given to safe operation, a brief overview of the major features of the EH101 helicopter is provided.

A94-11392
COMPARISON OF THEORY AND EXPERIMENT FOR NON-LINEAR FLUTTER AND STALL RESPONSE OF A HELICOPTER BLADE
D. M. TANG and E. H. DOWELL (Duke Univ., Durham, NC) Journal of Sound and Vibration (ISSN 0022-460X) vol. 165, no. 2 Aug. 8, 1993 p. 251-276. Research supported by North Carolina Supercomputing Center refs
(Contract DAAL03-87-K-0023)
Copyright

The purpose of the present paper is to study the flutter instability and forced response of a non-rotating helicopter blade model with a parabolic or cubic and freeplay torsional stiffness non-linearity based upon the semi-empirical (linear and) non-linear ONERA stall aerodynamic model. An experiment has also been carried out in the Duke University low speed wind tunnel. The wind tunnel test results show good agreement between theory and experiment for linear and non-linear flutter instability; for periodic, limit cycle and chaotic flutter motion and forced response behavior; and for the effects of an initial disturbance on non-linear flutter instability. Comparisons of the results from theory and experiment are helpful in understanding physically the non-linear aeroelasticity phenomena and chaotic oscillations.

A94-11966
THE TILT WING ADVANTAGE - FOR HIGH SPEED VSTOL AIRCRAFT
WILLIAM F. CHANA and T. M. SULLIVAN (William F. Chana Associates, Inc., San Diego, CA) Oct. 1992 11 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921911) Copyright

After presenting a development history of tilt-rotor (turboshaft) and tilt-wing (turboprop) configurations for high-speed VTOL aircraft, a comparative evaluation of the operational characteristics and efficiencies of the two configurational principles is undertaken for the cases of the V-22 Osprey tilt-rotor and a projected family of tilt-wing aircraft. Comparative advantages are projected for such considerations as public acceptance, block time in typical missions, direct operating costs, payloads, propulsive efficiency, reliability/maintainability, and development/production costs. The tilt-wing configuration is endorsed. AIAA

A94-11977* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TRANSONIC PROPULSION AERODYNAMICS RESEARCH AT NASA LANGLEY RESEARCH CENTER
LAURENCE D. LEAVITT and BOBBY L. BERRIER (NASA, Langley Research Center, Hampton, VA) Oct. 1992 24 p. SAE,

Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921937) Copyright

The Propulsion Aerodynamics Branch (and its predecessors) at the NASA Langley Research Center has been conducting propulsion aerodynamics research since 1941. During that time, branch research has had an impact on almost every aircraft flown. Before 1982, the primary contribution was in the form of experimental data obtained in the 16-Foot Transonic Tunnel and an associated static test facility. During the last decade, computational fluid dynamics research has played an increasing role in branch contributions. This paper provides an overview of the propulsion/airframe integration activities conducted in the branch during the last several years and some indication of the direction of future research.

A94-11978* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

APPLICATION OF ADVANCED TECHNOLOGIES TO VERY LARGE SUBSONIC TRANSPORTS

DENNIS W. BARTLETT (NASA, Langley Research Center, Hampton, VA), MARVIN E. MCGRAW, JR. (Lockheed Engineering & Sciences Co., Hampton, VA), PHILIP C. ARCARA, JR. (NASA, Langley Research Center, Hampton, VA), and KARL A. GEISELHART (Lockheed Engineering & Sciences Co., Hampton, VA) Oct. 1992 14 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921938) Copyright

A NASA-Langley study has used the interdisciplinary Flight Optimization System to examine the impact of advanced technologies on the performance and plausible size of large, long-range subsonic transport aircraft. The baseline, four-engine configuration studied would carry 412 passengers over 7300 n. mi.; the technologies evaluated encompass high aspect ratio supercritical-airfoil wings, a composite wing structure, an all-composite primary structure, and hybrid laminar flow control. The results obtained indicate that 600-passenger transports, whose takeoff gross weight is no greater than that of the 412-passenger baseline, are made possible by the new technologies. AIAA

A94-11979* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ADVANCED TAKEOFF PROCEDURES FOR HIGH-SPEED CIVIL TRANSPORT COMMUNITY NOISE REDUCTION

E. D. OLSON (NASA, Langley Research Center, Hampton, VA) Oct. 1992 15 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921939) Copyright

Advanced takeoff procedures were developed for a Mach 2.62 high-speed civil transport configuration (HSCT) equipped with turbine bypass engines, with the goal of reducing the takeoff noise levels for certification to FAR 36, Stage 3 noise levels. The detailed takeoff and landing module for the Flight Optimizations System (FLOPS) computer program was used to generate takeoff profiles. All takeoff procedures were constrained to meet a FAR takeoff field length of 11,000 feet, as well as the minimum required engine-out climb gradients for each airbome segment. Aircraft noise levels at the FAR 36 certification points were calculated using the Aircraft Noise Prediction Program (ANOPP). The study showed that using advanced takeoff procedures in noise certification could result in a 2.25 dB reduction in the amount of noise suppression required to certify this configuration for Stage 3 noise limits. Advanced procedures also resulted in an 8 percent reduction in the 100 EPNdB noise footprint area compared to basic FAR 36 takeoff procedures. In addition, improvements in the lift-to-drag ratio using high-lift devices were shown to produce 1.81 dB more noise reduction when used in combination with advanced takeoff procedures. Author (revised)

A94-11980

A THERMAL MANAGEMENT ASSESSMENT TOOL FOR ADVANCED HYPERSONIC AIRCRAFT

F. ISSACCI, A. T. WASSEL, J. L. FARR, JR., C. E. WALLACE (Science Applications International Corp., San Diego, CA), and V. VAN GRIETHUYSEN (USAF, Wright-Patterson AFB, OH) Oct. 1992 19 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921941) Copyright

An engineering thermal management computational tool capable of performing component, subsystem, and system level thermal management assessment, design and optimization is the subject of this paper. The Vehicle Integrated Thermal Management Code (VITMAC) simulates the coupled aircraft active cooling system thermal-hydraulics, associated airframe structure thermal response, and vehicle internally/externally generated heat loads. The formulation allows for predicting both the steady-state and transient thermal-hydraulic parameters along the coolant flow paths, as well as the temperature of the surrounding airframe/engine structures, to render the distributions of mass flow rate, pressure, and temperature of the operating fluids throughout the aircraft. Steady-state and transient illustrative examples are presented in this paper to demonstrate code capabilities. These examples show the coupling between the coolant-side thermalhydraulics and structure-side thermal response. Dynamic interactions among the network components, hydraulic fittings, pumps, turbines, and coolant supply tanks are clearly demonstrated.

A94-12012

FLIGHT TESTING OF PNEUMATIC FOREBODY VORTEX CONTROL ON THE X-29 TECHNOLOGY DEMONSTRATOR

F. LURIA and R. GUYTON (USAF, Wright Lab., Wright-Patterson AFB, OH) Oct. 1992 12 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922008) Copyright

The US Air Force's X-29 Experimental aircraft was used to demonstrate a Wright Laboratory initiative, the Vortex Flow Control (VFC) program. This program involved manipulation of forebody vortices through the use of nitrogen blown from small nose mounted nozzles. AVFC flight test program was recently completed at Edwards AF BCA. Sixty flights were flown between May-August 92 as part of this program, which involved the Air Force's Wright Laboratory and Flight Test Center, NASA, and Grumman Aircraft Systems Division. This paper presents the results of this initiative.

A94-12016* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

COMPARISON OF 30X11.5 - 14.5 BIAS-PLY AND RADIAL-BELTED TIRE CHARACTERISTICS

PAMELA A. DAVIS (NASA, Langley Research Center, Hampton, VA) Oct. 1992 12 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922012) Copyright

An investigation at NASA Langley Research Center was conducted to determine the static and dynamic mechanical characteristics of 30x11.5-14.5, Type VIII, bias-ply and radial-belted aircraft tires. The tire characteristics were determined by application of vertical and fore-and-aft loads. The results of the study are presented to show static load deflection curves, hysteresis losses, and stiffness and damping characteristics of each tire type tested. The advantages and disadvantages of each type of tire are also given.

A94-12023

YF-23A HYDRAULIC MANAGEMENT SYSTEM

K. W. VIETEN (Northrop Corp., Pico Rivera, CA) Oct. 1992 11 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992
(SAE PAPER 922028) Copyright

The next-generation YF-23 fighter requires high control surface actuation rates and large actuator excursions at low speeds, as well as sufficient power for the generation of large hinge moments at supersonic speeds. The hydraulic system configuration chosen to satisfy these requirements uses hydraulic-logic as well as electronic controls, which are managed by quad-redundant vehicle-management computers. Attention is given to the configuration and functions of the hydraulic system switching valves. AIAA

A94-12024
SELECTING THE CORRECT HYDRAULIC COMPONENT MATERIAL FOR MINIMUM LIFE CYCLE COST
G. E. MARONEY, C. T. SLEDZ, and P. B. CREDIT (M.C. Aerospace, Lake Orion, MI) Oct. 1992 13 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922031) Copyright
This paper discusses a procedure for selecting the correct material for a hydraulic component. The discussion includes the variables of pressure duty cycle, temperature duty cycle, component specifications, manufacturing processes, reliability requirements, and available materials. The goal of the procedure is to minimize component life cycle cost. It is shown that 7075-T73 aluminum is the best material for selected 34 MPa (5000 psi) hydraulic components.

A94-12026
AIRPLANE SIZE EFFECTS ON OCCUPANT CRASH LOADS
H. JAMSHIDIAT, EDWARD WIDMAYER, and J. MCGREW (Boeing Commercial Airplane Group, Seattle, WA) Oct. 1992 19 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922035) Copyright
Beam-FEM models of the B 737-400 and B 747-400 airliners have assessed the effect of aircraft size on the crash loads potentially borne by cabin occupants. The B 747-400 is shown to transmit significantly lower impulse levels to its applicants than the smaller, B 737-400 aircraft; the larger fuselage structure, although the stronger of the two, allows greater deformation to occur over a more prolonged period. Study results indicate that it may be possible to generate FAR 25.561-.562 crash loads in impact-survivable accidents for B 747 and larger aircraft. AIAA

A94-12032
AIRCRAFT BRAKING INDUCED TIRE WEAR
JOE PADOVAN (Akron Univ., OH), PAT PADOVAN (USAF, Wright-Patterson AFB, OH), and AMIR KAZEMPOUR (Goodyear Tire and Rubber Co., Akron, OH) Oct. 1992 13 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922042) Copyright
A combined mechanical abrasion and thermochemical degradation model is used to simulate bounds on potential aircraft tire braking induced tread wear during landing. The model includes various hierarchical levels: macro system motion (tire rotation, vehicle translation); tire rolling fields (contact forces); tread lug/rib deformation; and interfacial thermal/wear fields. Other major factors considered are aircraft lift and drag behavior; multidisk brake properties; and rectilinear/rotary tire equilibria. AIAA

A94-12036
CENTRIFUGE TEST OF AN AIRCRAFT VAPOR CYCLE ENVIRONMENTAL CONTROL SYSTEM
PETER F. DEXTER, MAYRA I. MARTINEZ, GERALD C. MAXWELL, and ROLAND J. WATTS (USAF, Wright Lab., Wright-Patterson AFB, OH) Oct. 1992 9 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Research sponsored by USAF refs
(SAE PAPER 922051) Copyright
The Integrated Closed Environmental Control System (ICECS), a digitally controlled vapor cycle system with a two-phase refrigerant, is being developed for electronic cooling on advanced fighter aircraft. Performance degradation and controls stability of a flight weight design of the ICECS are to be evaluated on an upgraded Dynamic Environment Simulator centrifuge. A description is given of the Armstrong Laboratory's facility, flight load simulation testing, and vapor cycle component design for maneuvers up to 9 G accelerations. AIAA

A94-12038
RUSSIAN SUB-ORBITAL COMMERCIAL PASSENGER TRANSPORT SYSTEM
GLEB E. LOZINO-LOZINSKIJ, EDUARD N. DUDAR' (NPO Molniya, Moscow, Russia), and VLADIMIR P. PLOKHIKH (TsAGI, Zhukovski, Russia) Oct. 1992 10 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922056) Copyright
Russia's Multipurpose Aerospace System ('MAKS'), based on the six-turbofan AN-225 megalifter, encompasses three versions which differ as to the nature of the 'second stage' carried atop the fuselage: this may take the form of the Buran space-shuttle, a 'space-tug', and the BOR-4 suborbital passenger transport (SPT). Attention is given to the SPT, which, like the two other variants, is equipped with the same three-propellant/two-regime rocket propulsion system. Flight-simulation analysis results are presented for a plausible set of airline routes linking Moscow with Rio de Janeiro, Sidney, and Singapore. AIAA

A94-12040
THE SWEDISH FIGHTER
STEWART PENNEY Aerospace (UK) (ISSN 0305-0831) vol. 20, no. 9 Sept. 1993 p. 12-19.
Copyright
An account is given of the development history, design features, performance capabilities and deployment plans for the JAS39 'Gripen' fighter currently entering service with the Swedish Air Force. It is hoped that this small, single-engine multirole fighter will find a large export market. The engine is a derivative of the F404 low-bypass turbofan. Attention is given to the comprehensive territorial defense scheme, designated BAS90, within which the Gripen was devised. BAS90 maintains aircraft survivability through widespread dispersal of aircraft for refueling and rearming. AIAA

A94-12044
THE HIGH SPEED HELICOPTER
A. VUILLET (Eurocopter France, Marignane) Sep. 1992 25 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs
The helicopter has yet to reach its maximum speed and range potential, as demonstrated by the present evaluation of performance levels reached by recent technology-demonstrator helicopters. The results of a trend analysis conducted on the basis of these data indicate that the diminution of speed increases in recent years is associated with increases in vehicle gross weight, rather than the approach of comfort or safety limits inherent in helicopter design. Technical improvements that can lead to higher cruise speeds in future helicopters are noted to include refined fuselage aerodynamics, vibration-isolation devices, and more aggressive use of structural composites. AIAA

A94-12047
'WILL ROTOR HUBS LOSE THEIR BEARINGS'? - A SURVEY OF BEARINGLESS MAIN ROTOR DEVELOPMENT
HELMUT HUBER (Eurocopter Deutschland GmbH, Munich, Germany) Sep. 1992 20 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs
A development status evaluation is conducted for bearingless main rotor (BMR) technologies, giving attention to such critical aspects of BMR design as the flexbeam and pitch-control structure, the prospects for furnishing in-plane-damping by means of various couplings, and the choice of elastomeric materials for vibration-damping devices. An account is given of representative results of recent BMR design efforts; promising development trends are noted. AIAA

A94-12061 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ON A FINITE-STATE INFLOW APPLICATION TO FLAP-LAG-TORSION DAMPING IN HOVER
DONIZETI DE ANDRADE (Inst. Tecnologico de Aeronautica, Sao Jose dos Campos, Brazil) and DAVID A. PETERS (Washington Univ., Saint Louis, MO) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by U.S. Army refs
(Contract NAG2-728; NAG1-170)
An aerodynamic model with a coupled set of generalized dynamic wake equations and hybrid equations of motion for an

elastic blade are applied here to a two-blade untwisted stiff in-plane hingeless small-scale model rotor with torsionally soft blades. Blade root offset, precone, blade droop, pitch control stiffness, and blade pitch angle are included in the model rotor. Numerical results show that 3D tip relief effects within the nonuniform steady-state inflow are significant to predict steady-state aerodynamic loads and blade deflections. Eigenvalue results confirm the importance of unsteady 3D aerodynamics in predicting lead-lag damping and frequency. Eigenvector analysis correlations reinforced qualitative and quantitative shortcomings associated with quasi-steady 2D aerodynamic theory for aeroelastic applications in hover. AIAA

A94-12068
RECONSTRUCTION OF SPANWISE AIR LOAD DISTRIBUTION ON ROTORBLADES FROM STRUCTURAL FLIGHT TEST DATA
H. OERY and H. W. LINDERT (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by DFG refs

During flight tests performed with Kamov-26 and Hughes 500E helicopters in Hungary, rotor blade structural response was measured with strain gauges applied to the blade. The measured response data were evaluated using a force reconstruction method. This method computes the acting air load forces on the rotating blade from measured blade response data. For each helicopter a blade was prepared for testing and the structural parameters measured. Strain gauges were applied at specific spanwise locations. The flapping angle and azimuth position of the blade were recorded during flight testing. The signals from the blade instrumentation were transmitted by a telemetric system from the rotating rotor to a stationary receiving unit on the ground. Flight tests consisted of several hovering and forward flights at different flight speeds with both helicopters. Reconstruction results of the spanwise air load forces are presented for both helicopter types. Reconstruction results for the Hughes helicopter at low flight speeds show blade-vortex-interactions at the appropriate locations. This is also the case for some hovering flight test data evaluations.

A94-12073
FLIGHT PATH CALCULATIONS FOR A HELICOPTER IN AUTOROTATIVE LANDING
A. GEBHARD (National Aerospace Lab., Amsterdam, Netherlands) Sep. 1992 18 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

In theory the autorotative landing can be carried out safely when the restrictions of the height-velocity diagram are taken into account. A safe autorotative landing requires professional management from the pilot with respect to the energy exchange. A computer simulation program has been developed for the calculation of the flight path for a helicopter in autorotative landing. The computation method is based on the energy method where one source of energy can be exchanged for that of other sources. Interviews with helicopter test pilots have provided a review of the practical techniques and procedures to accomplish a safe autorotative landing. These interviews have been determined and translated into usable procedures for a control model. The autorotative flight can be investigated by variation of the pilot inputs, the pilot cues and the initial and boundary conditions. This model can be used to analyze the most optimal performance of an autorotative landing by manual iterations. Author (revised)

A94-12075
OUTSIDE VISION FROM A HELICOPTER CREW CABIN - APPROACHES TO ITS FORMING IN DESIGN PROCESS
B. A. GUBAREV (Kamov Helicopter Scientific and Technology Co., Lyubertsy, Russia) Sep. 1992 12 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

An account is given of the design considerations governing the design of helicopter cockpits in order to accommodate field-of-view requirements. These considerations encompass crew ergonomics, helicopter flight profile characteristics, and prominent configurational constraints. Aspects of the simulation of field-of-view characteristics in a range of operational circumstances are discussed. AIAA

A94-12078
DEVELOPMENT OF THE BK 117 C-1 WITH ARRIEL 1-E ENGINES
WERNER BERGNER and KARL WOELFL (Eurocopter Deutschland GmbH, Munich, Germany) Sep. 1992 8 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

The BK117 C-1 with Arriel 1-E engines is the newest member of the BK117 family. The Arriel 1-E engine will be offered as an alternative to the Lycoming LTS 101-750 B-1 engine. With this concept Eurocopter enables the customer to select an engine especially tailored to his requirements. The engine installation and the certification program were carried out as international teamwork between Eurocopter Deutschland, Kawasaki Japan and Turbomeca/CGTM France. This paper summarizes the technical main features and milestones of the BK117C-I program. Special development and certification test campaigns (e.g. air intake icing tests with a full scale helicopter in the wind tunnel of the Bundesversuchs- und Forschungsanstalt Arsenal at Vienna) as well as the performance aspects are presented. Author (revised)

A94-12080
EH101 - THE OPTIMUM NAVAL HELICOPTER
K. J. ANDREWS (Westland Helicopters, Ltd., Yeovil, United Kingdom) and F. MUSSI (Agusta S.p.A., Cascina Costa di Samarate, Italy) Sep. 1992 15 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

The UK-Italian EH101 helicopter was developed to satisfy naval, civil transport, and utility operations requirements. It is presently shown that the optimization of this helicopter configuration for naval missions has endowed it with exceptional abilities for operation from either fixed offshore platforms or deep-sea floating platforms. Attention is given to the maintainability and preventive-maintenance capabilities incorporated by the EH101 design. AIAA

A94-12081
HIGH SPEED DAUPHIN (DGV) 200 KNOTS TOWARD THE FUTURE
B. FOUQUES and J. C. WEISSE (Eurocopter France, Marignane) Sep. 1992 7 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

The Dauphin Grande Vitesse (DGV) experimental helicopter was designed for technology-demonstration functions associated with high speed flight. An account is presently given of the aerodynamic and mechanical system changes that have been made to the conventional Dauphin design in order to conduct such high speed researches. DGV flights to date have tested the influence of rotor rpm on performance, the influence of Mach number of performance, and the accuracy levels of performance and vibration models. AIAA

A94-12082
MERGING THE TWO ENDS OF THE VTOL SPECTRUM
EVAN A. FRADENBURGH (Sikorsky Aircraft, Stratford, CT) Sep. 1992 17 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

This paper reviews the problems associated with developing a vertical takeoff and landing (VTOL) aircraft that has desirable helicopter-like attributes in hover and low speed operation but is capable of efficient high subsonic cruise speed. A number of different configurations that have been proposed are reviewed and an assessment is made of the relative probabilities of future success. Factors considered to be important discriminators include speed potential, disk loading, empty weight fraction, the need for supplementary propulsion systems or convertible engines, and technical risk. The tiltrotor configuration has considerable merit but will not achieve the highest speeds that might be desired. It is concluded that incorporation of variable geometry, in the form of a variable diameter rotor system, has the best chance of providing the 'ideal' VTOL. The variable diameter tiltrotor adds considerably to the speed potential of the tiltrotor, reduces disk loading, and provides numerous other benefits as well. For highest speeds, the variable-diameter single stowed rotor configuration has the desired combination of attributes.

A94-12085
SOME COMMENTS ON TAIL ROTOR GROUND RESONANCE PROBLEM
YU. A. MYAGKOV (Moscow Helicopter Plant, Design Bureau, Russia) Sep. 1992 8 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

An oscillation stability problem involving ground resonance in helicopter tail rotors is solved for an alternative Mi-38 helicopter model with elastic blades. The solution takes into account the dependence of blade oscillation form on the angular speed of rotation as well as the dependence of damper elasticity and its damping properties on the oscillation frequency. AIAA

A94-12086
THE APPLICATION OF FINITE DIFFERENCE TECHNIQUES TO HELICOPTER ROTOR BLADE RESPONSE CALCULATIONS
W. R. WALKER (Defence Research Agency, Farnborough, United Kingdom) Sep. 1992 23 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

Numerical procedures that may be used to calculate helicopter rotor response are reviewed, with emphasis placed on the finite difference approach. The treatment is neither exhaustive nor rigorous, but is aimed at providing a general discussion to aid in the choice of a suitable method. Procedures are discussed which are appropriate to different formulations of the problem. A transfer matrix technique is identified which is thought to be most efficient for performing calculations for hovering and vertical flight. Two further methods are derived which are suited to calculations for maneuvering flight. The first method utilizes a modal representation of the rotor and so promotes the solution in time only, while the second integrates the equations of motion directly and progresses the solution in both space and time.

A94-12087
THE USE OF PILOT MODELS IN DYNAMIC PERFORMANCE AND ROTOR LOAD PREDICTION STUDIES
J. C. HAMM (Westland Helicopters, Ltd., Yeovil, United Kingdom) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by Ministry of Defence Procurement Executive refs

This paper describes the Westland method of using a helicopter engineering simulation, controlled by a pilot model, for dynamic performance and rotor load prediction studies. The reasons for using a pilot model are explained and current and future uses of the models are given. The aims and philosophy of pilot modelling are presented and the method of use for performance prediction studies is outlined, including the methods used to validate the model, and to generate the performance data for inclusion in the rotorcraft flight manual. The structure of the Westland pilot model method is given and the capability of the method is illustrated by examples.

A94-12088
PROPOSED REVISIONS TO MIL-STD-1290 ROTARY WING AIRCRAFT CRASH RESISTANCE
LEROY T. BURROWS (U.S. Army, Aviation Systems Command, Fort Eustis, VA) Sep. 1992 12 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The current MIL-STD-1290 provides one set of crash resistance design criteria for military helicopters. It is recognized that for small helicopters it is more difficult to meet the seat stroke and high mass component retention than for a medium and large size helicopter and to meet current design criteria. In addition, how a helicopter crashes must be taken into account. Accident data shows that low inertia rotor blade helicopters with high disk loadings crash at higher impact velocities than the same weight aircraft with high inertia rotor blade systems and lower disk loadings. In addition, indications are that the helicopter type (i.e., attack, air assault, utility, cargo) also affects aircraft crash modes. Suggested different levels of design criteria for crash resistance are presented with rationale to support the need for variable design criteria. Author (revised)

A94-12089
USEABLE CUE ENVIRONMENT (UCE) AND ITS APPLICATION TO SIMULATOR TESTING
DAVID A. DOWNEY (U.S. Army, Boscombe Down, United Kingdom) Sep. 1992 12 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The proposed updated helicopter specification, MIL-H-8501C, is contained in Aeronautical Design Standard - 33C (ADS-33C). ADS-33C presents new and significantly different test methodology. This paper describes the Useable Cue Environment (UCE) evaluation process. The UCE determination is the first step in determining vehicle compliance with ADS-33C. Tests have been conducted in the United States, Germany and in the UK. This paper is specific to simulators. New helicopters and developmental programs will involve considerable amounts of simulator engineering and development before a first flight. Future programs such as the European Active Control Technology program and the RAH-66 Commanche have and will involve extensive simulation. ADS-33C is the next Helicopter Handling Qualities Specification. An understanding of its new and novel testing techniques is required.

A94-12094* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN EXPLORATORY INVESTIGATION OF THE FLIGHT DYNAMICS EFFECTS OF ROTOR RPM VARIATIONS AND ROTOR STATE FEEDBACK IN HOVER
ROBERT T. N. CHEN (NASA, Ames Research Center, Moffett Field, CA) Sep. 1992 36 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Previously announced in STAR as N93-19380 refs

This paper presents the results of an analytical study conducted to investigate airframe/engine interface dynamics, and the influence of rotor speed variations on the flight dynamics of the helicopter in hover, and to explore the potential benefits of using rotor states as additional feedback signals in the flight control system. The analytical investigation required the development of a parametric high-order helicopter hover model, which included heave/yaw body motion, the rotor speed degree of freedom, rotor blade motion in flapping and lead-lag, inflow dynamics, a drive train model with a flexible rotor shaft, and an engine/rpm governor. First, the model was used to gain insight into the engine/drive train/rotor system dynamics and to obtain an improved simple formula for easy estimation of the dominant first torsional mode, which is important in the dynamic integration of the engine and airframe system. Then, a linearized version of the model was used to investigate the effects of rotor speed variations and rotor state feedback on helicopter flight dynamics. Results show that, by including rotor speed variations, the effective vertical damping decreases significantly from that calculated with a constant speed assumption, thereby providing a better correlation with flight test data. Higher closed-loop bandwidths appear to be more readily achievable with rotor state feedback. The results also indicate that both aircraft and rotor flapping responses to gust disturbance are significantly attenuated when rotor state feedback is used.

A94-12095
EXPERIMENTAL EVALUATION OF THE EH101 TAIL ROTOR DYNAMICS IN FLIGHT
L. LUTI, S. SCORBATI, and G. VIGNATI (Agusta, S.p.A., Cascina Costa di Samarate, Italy) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

At the beginning of the EH101 Tail Rotor flight trials, the results obtained from the testing of EH101 helicopter Ground Testing Vehicle (GTV) and Prototypes indicate that the tail rotor lag frequencies drop rapidly as blade pitch is increased. It is of interest to examine the effects that some variables, such as the imposed cuff pitch angle, exert on the mode frequencies. Furthermore, to facilitate a better understanding of the rotor lag dynamics it is necessary to identify the specific rotor modes. This paper reports two new procedures developed in AGUSTA that have permitted the evaluation of the dynamic behavior of the EH 101 Tail Rotor.

A94-12097
EUROFAR SIMULATION TRIALS ON EPOPEE SIMULATOR
PHILIPPE ROLLET (Eurocopter France, Marignane) and CHRISTINE THIBAUDAT (Aerospatiale, Div. Avions, Les Mureaux, France) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The EPOPEE cockpit flight controls simulator has been modified to evaluate the handling qualities of the EUROFAR tilt-rotor VTOL aircraft project's flight control laws. Over 60 hours of simulated flight have been logged in pursuit of a characterization of EUROFAR handling qualities. These characteristics will be assessed during the next simulation phase for this aircraft, with due enhancement of the EUROFAR aircraft model. AIAA

A94-12098
A GENERIC TILT-ROTOR SIMULATION MODEL WITH PARALLEL IMPLEMENTATION AND PARTIAL PERIODIC TRIM ALGORITHM
J. S. G. MCVICAR and R. BRADLEY (Glasgow Univ., United Kingdom) Sep. 1992 20 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

A generic tilt-rotor simulation model (GTILT) has been developed at the University of Glasgow. This model is centered round an individual blade rotor model which provides higher levels of fidelity than existing rotor disk models. However, individual blade models are numerically intensive and consequently most sequential programming facilities are unable to provide the performance necessary to make such models practical. In order to reduce computational run-times to an acceptable level GTILT has been parallelized and implemented on a computing surface. Another facet of individual blade models is that they generate periodic forces and moments when in the trim. Consequently, existing trimming algorithms formulated for use with quasi-steady disk models are inappropriate. A specialized partial periodic trimming algorithm has been developed and incorporated as part of GTILT; this algorithm is robust and has been found to produce rapid convergence. Longitudinal trim states predicted by GTILT have been verified against those of the Bell C81 model for a range of nacelle incidences and airspeeds with good correlation being obtained in all cases. GTILT has also been successfully employed to investigate the behavior of the tilt-rotor configuration during transitional flight using a trim map to predict the control displacements necessary to produce a prescribed flight path during the transition phase.

A94-12104
HELICOPTER HEALTH AND USAGE MONITORING SYSTEMS - OBJECTIVES AND PHILOSOPHY FOR SYSTEM IMPLEMENTATION
A. FISCHER (Eurocopter Deutschland GmbH, Munich, Germany) Sep. 1992 10 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

Attention is given to the implementation of a main gearbox-dedicated helicopter health and usage monitoring system (HUMS), on the basis of tests which yielded the main gearbox load spectrum. Lessons that can be drawn for the more general implementation of HUMS in helicopters are noted and discussed. The HUMS presently described encompasses both onboard units for data acquisition, preprocessing, and storage, as well as a ground station for detailed load-spectrum analysis. AIAA

A94-12226
LIGHTNING AND HIGH INTENSITY RADIATED FIELD TEST ON HELICOPTER - IMPLEMENTATION OF A METHODOLOGY FOR A SUPER PUMA AS 332 L2 CERTIFICATION
MARC PONCON (Eurocopter France, Marignane) 1992 14 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

An account is given of the test procedures by means of which the Super Puma helicopter was certified for suitable performance in high intensity radiated field (HIRF) and lightning-related indirect effects. Attention is given to the conducted and radiated environment that occurs at both the equipment component and system levels, when the helicopter is threatened at the highest levels stipulated by regulations for lightning and HIRF certification. AIAA

A94-12232
THE TIGER COCKPIT AND ITS SIMULATOR
H. HELLMUTH, K. KAMPA, and W. KARL (Eurocopter Deutschland GmbH, Munich, Germany) 1992 11 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The cockpit of the Franco/German Anti Tank Helicopter TIGER (HAC, PAH2, HAP) is described, with attention given to its geometric baseline and the man-machine interface. In particular, the discussion covers the general layout of the cockpit, seats, panels and consoles, glare shields and visors, doors and windows, frame structure, flight controls, and the principal cockpit systems and their functions. The discussion then focuses on the technical concept and capabilities of the development simulator for the TIGER. Consideration is given to the hardware and software concepts, the on-line simulation model, landing gear model, noise, and validation of the simulation model. AIAA

A94-12235
HELICOPTER LANDING GEAR DESIGN
F. JAN (Messier-Bugatti, France) 1992 9 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The major principles governing the design of the helicopter landing gear are examined, and it is shown how these principles are applied in practice. In particular, attention is given to landing gear design requirements, including energy absorption characteristics for normal, hard, and crash landings. A discussion of the development of landing gear covers landing gear configuration, shock absorber design, sizing, materials, and design approval. Finally, some current and future trends in the field of landing gear are briefly reviewed. AIAA

A94-12237
SMART AIRFOILS FOR HELICOPTER CONTROL
S. HANAGUD, R. L. ROGLIN, and G. L. NAGESH BABU (Georgia Inst. of Technology, Atlanta) 1992 12 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The application of shape memory alloys to actuate a shape change (camber) in the chordwise direction of an airfoil is investigated. Such shape changes can be used to actively control the camber and airflow over a helicopter rotor blade. In this paper the feasibility of designing such a mechanism with the goal of performing changes in the shape of the airfoil to achieve collective control is investigated.

A94-12238
HELICOPTER STRUCTURAL INTEGRITY MONITORING
D. E. GOOD and D. T. DEIBLER (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) 1992 14 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

Research and development activities related to structural integrity monitoring at the Aviation Applied Technology Directorate (AATD), U.S. Army Aviation and Troop Command, are reviewed. The discussion covers the safe-life fatigue methodology, the need for structural integrity monitoring, structural usage monitoring, structural loads monitoring, and potential implementation. Particular attention is given to the implementation of the Helicopter Structural

Integrity Program (HSIP), designed to govern and control the integrity of fatigue-critical parts throughout the life cycle of a rotorcraft. AIAA

A94-12240

DESIGN, FABRICATION AND TESTING OF THE COMPOSITE BEARINGLESS ROTOR SYSTEM FOR ROTARY-WING AIRCRAFT

TAKAHIRO ICHIHASHI (Japan Defense Agency, Technical Research and Development Inst., Tokyo) and SHUNICHI BANDOH (Kawasaki Heavy Industries, Ltd., Aerospace Engineering Div., Gifu, Japan) 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

Results of a program aimed at manufacturing a prototype composite bearingless rotor system for helicopters are reported. The design concept underlying the two prototype rotor systems fabricated under the study is examined, and the main components and operation of the rotor system are described. Results of the ground and flight testing of the composite bearingless rotor system are presented. It is shown that the system has sufficient control force, as indicated by the minus G maneuver capability and the high roll performance for high maneuverability in the NOE flight. The results demonstrate the applicability of the system to full-scale helicopter development to achieve high maneuverability and good maintainability. AIAA

A94-12241

HIGHLY EFFICIENT SENSITIVITY ANALYSIS FOR AERO-SERVO-ELASTIC OPTIMIZATION OF HELICOPTER ROTORS

LIVIU GAITA, RADU UDRESCU, VICTOR GIURGIUTIU, and MARILENA PAVEL (Inst. for Theoretical and Experimental Analysis of Aeronautical Structures, Bucharest, Romania) 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

An optimization algorithm for helicopter rotors with higher harmonic control, using constraints and objects, is presented in its block layout. The most time-expensive part of the optimization procedure was identified to be the sensitivity analysis for aeroelastic criteria and constraints. This paper briefly describes a new package of computer programs, named HELDYN, designed for the aeroelastic analysis of nonuniform rotor blades undergoing moderate deformation. The programs are presented in their essential aspects that make them highly efficient in the sensitivity analysis. The performances of HELDYN were tested in a comprehensive parametric study that also highlighted important aspects useful for the sensitivity analysis. Author (revised)

A94-12242

CURRENT STATE OF THE ART REGARDING HELICOPTER VIBRATIONS REDUCTION AND AEROELASTIC STABILITY AUGMENTATION

F. BEROUL, L. GIRARD, E. ZOPPITELLI, and T. KRYSINSKI (Eurocopter France, Marignane) 1992 10 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The research conducted by Eurocopter France in the field of helicopter vibration reduction is reviewed. In particular, attention is given to dynamic force measurement at the rotor hub, aerodynamic and dynamic parameters, helicopter vibration response, passive and active vibration control, and aeromechanical stability augmentation by active control. The discussion is illustrated by test results. AIAA

A94-12244

AEROELASTIC ANALYSIS OF ROTOR BLADES WITH FLAP CONTROL

Y. YILLIKCI (Undersecretariat for Defence Industries, Ankara, Turkey), S. HANAGUD, D. P. SCHRAGE, and J. P. HIGMAN (Georgia Inst. of Technology, Atlanta) 1992 16 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

A trim procedure and a solution method for calculating the periodic response of elastic rotor blades with flap controls are developed. An approximate trim formulation is shown to be efficient for initial performance calculations, and trim solutions obtained for torsionally stiff configurations can be within the accuracy of conventional pitch control trim calculations. An aerodynamic formulation for the unsteady oscillating rotor blade airfoil with trailing edge flap controls and a conditionally stable explicit finite element scheme are found to provide an efficient method of response analysis. AIAA

A94-12245

HHC EFFECTS ON HUB AND BLADE LOADS

H.-J. LANGER and R. KUBE (DLR, Inst. fuer Flugmechanik, Braunschweig, Germany) 1992 14 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The effect of different HHC (higher harmonic control) input to noise and vibration is examined with reference to wind tunnel tests performed on a 4-m diameter hingeless model rotor under conditions corresponding to a moderate descent helicopter flight. It is found that the rotor trim condition changes under HHC input, with the change affecting all the six hub components but mainly the rolling and pitching moments. It is shown, in particular, that HHC input can reduce 4p hub loads but increase amplitudes for other harmonics (e.g., 6p hub acceleration). It is also shown that the HCC input-phase changes the blade tip deflection for nearly all harmonics, even the 1p. This may influence the directivity of the BVI noise. AIAA

A94-12246

INDIVIDUAL BLADE CONTROL OF HINGED BLADES USING SMART STRUCTURES

FRED NITZSCHE and ELMAR BREITBACH (DLR, Inst. fuer Aeroelastik, Goettingen, Germany) 1992 14 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The feasibility of employing piezoceramic smart materials in active control of the higher harmonic vibration of hinged helicopter blades is investigated. The individual-blade-control concept is adopted to build feedback controllers that employ collocated smart sensors and actuators and are optimized to achieve damping augmentation for blade modes that significantly contribute to the airframe dynamic response. The results indicate that there is a parameter that will help the development of efficient smart rotors.

A94-12248

INVESTIGATIONS OF HELICOPTER TAIL ROTOR LOADING IN HOVERING TURNS

M. G. ROZHDESTVENSKIJ (Mil Moscow Helicopter Plant, Russia) 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

A method for analyzing tail rotor blade loads in hovering and the results obtained are presented. The single algorithm of the method covers all known types of blade-to-head attachments, and the tail rotor as a whole is considered in the analysis. The method can thus be used for calculating loads on gimballed rotors, two-bladed teetering rotors, and their combinations in the form of four-bladed rotors consisting of two pairs of two-bladed teetering rotors, with full consideration given to the elastic attachment properties of each two-bladed module. AIAA

A94-12249* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AEROELASTIC MODELING OF COMPOSITE ROTOR BLADES WITH STRAIGHT AND SWEPT TIPS

KUO-AN YUAN, PERETZ P. FRIEDMANN, and COMANDUR VENKATESAN (California Univ., Los Angeles) 1992 39 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

(Contract NAG1-833)

This paper presents an analytical study of the aeroelastic behavior of composite rotor blades with straight and swept tips. The blade is modeled by beam type finite elements. A single finite element is used to model the swept tip. The nonlinear equations of motion for the FEM are derived using Hamilton's principle and based on a moderate deflection theory and accounts for: arbitrary cross-sectional shape, pretwist, generally anisotropic material behavior, transverse shears and out-of-plane warping. Numerical results illustrating the effects of tip sweep, anhedral and composite ply orientation on blade aeroelastic behavior are presented. It is shown that composite ply orientation has a substantial effect on blade stability. At low thrust conditions, certain ply orientations can cause instability in the lag mode. The flap-torsion coupling associated with tip sweep can also induce aeroelastic instability in the blade. This instability can be removed by appropriate ply orientation in the composite construction. These results illustrate the inherent potential for aeroelastic tailoring present in composite rotor blades with swept tips, which still remains to be exploited in the design process.

A94-12482
DECOUPLING SYSTEM FOR AIRBUS A340 G.V.T
BRUNO CARRE (SOPEMRA, Velizy, France) and THIERRY MATRINAGE (Aerospatiale, Toulouse, France) *In* International Modal Analysis Conference, 10th, San Diego, CA, Feb. 3-7, 1992, Proceedings. Vol. 1 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 79-84.
Copyright
The design of a low-frequency suspension system developed in order to perform ground vibration tests on Airbus A340 is described, and test results are reported. The new suspension system employs a low-frequency decoupling system using pneumatic technology. Ground vibration measurements are presented for two different load configurations. An important conclusion of the study is the adaptability of the suspension to the different mass configurations of the structures to be decoupled, resulting in substantial time savings during each configuration change. AIAA

A94-12612
INTEGRATED TECHNOLOGIES IN AIRCRAFT DESIGN OPTIMIZATION
GEORGE T. J. TZONG, GREGORY D. SIKES, MATTI J. LOIKKANEN, and JOSEPH P. GIESING (Douglas Aircraft Co., Long Beach, CA) *In* Control and dynamic systems. Vol. 52 - Integrated technology methods and applications in aerospace systems design San Diego, CA Academic Press, Inc. 1992 p. 1-55. refs
Copyright
The aeroelastic design optimization program (ADOP) is being presently developed (Dodd et al., 1990) for designing large finite element aircraft structural models subject to strength, dynamic modal, and flutter constraints. This paper describes the technologies of multidisciplinary design optimization of aircraft structures which are included or being currently implemented in ADOP. These technologies include numerical optimization, design variable linking, static strength, aeroelastic loads, modal analysis, dynamic transient response, and flutter analysis. AIAA

A94-12702
TECHNIQUES FOR AIRCRAFT CONCEPTUAL DESIGN FOR MISSION PERFORMANCE COMPARING NONLINEAR MULTIOBJECTIVE OPTIMIZATION METHODS
AUGUSTINE R. DOVI and GREGORY A. WRENN (Lockheed Engineering & Sciences Co., Hampton, VA) *In* Control and dynamic systems. Vol. 54 - System performance improvement and optimization techniques and their applications in aerospace systems San Diego, CA Academic Press, Inc. 1992 p. 1-22. refs
Copyright
A new technique which converts a constrained optimization problem to an unconstrained one where conflicting figures of merit may be simultaneously considered has been combined with a complex mission analysis system. The method is compared with existing single and multiobjective optimization methods. A primary benefit from this new method for multiobjective optimization is the elimination of separate optimizations for each objective, which is required by some optimization methods. A typical wide body transport aircraft is used for the comparative studies.

A94-12706* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INVESTIGATION ON THE USE OF OPTIMIZATION TECHNIQUES FOR HELICOPTER AIRFRAME VIBRATIONS DESIGN STUDIES
T. SREEKANTA MURTHY (Lockheed Engineering & Sciences Co., Hampton, VA) *In* Control and dynamic systems. Vol. 54 - System performance improvement and optimization techniques and their applications in aerospace systems San Diego, CA Academic Press, Inc. 1992 p. 225-261. refs
(Contract NAS1-19000)
Copyright
Results of the investigation of formal nonlinear programming-based numerical optimization techniques of helicopter airframe vibration reduction are summarized. The objective and constraint function and the sensitivity expressions used in the formulation of airframe vibration optimization problems are presented and discussed. Implementation of a new computational procedure based on MSC/NASTRAN and CONMIN in a computer program system called DYNOPT for optimizing airframes subject to strength, frequency, dynamic response, and dynamic stress constraints is described. An optimization methodology is proposed which is thought to provide a new way of applying formal optimization techniques during the various phases of the airframe design process. Numerical results obtained from the application of the DYNOPT optimization code to a helicopter airframe are discussed. AIAA

N94-10344*# Oregon State Univ., Corvallis. Dept. of Electrical and Computer Engineering.
NONLINEAR STABILITY AND CONTROL STUDY OF HIGHLY MANEUVERABLE HIGH PERFORMANCE AIRCRAFT Final Report
R. R. MOHLER 20 Jul. 1993 118 p
(Contract NAG1-1081)
(NASA-CR-193480; NAS 1.26:193480; OSU-ECE-NASA-93-03)
Avail: CASI HC A06/MF A02
This project is intended to research and develop new nonlinear methodologies for the control and stability analysis of high-performance, high angle-of-attack aircraft such as HARV (F18). Past research (reported in our Phase 1, 2, and 3 progress reports) is summarized and more details of final Phase 3 research is provided. While research emphasis is on nonlinear control, other tasks such as associated model development, system identification, stability analysis, and simulation are performed in some detail as well. An overview of various models that were investigated for different purposes such as an approximate model reference for control adaptation, as well as another model for accurate rigid-body longitudinal motion is provided. Only a very cursory analysis was made relative to type 8 (flexible body dynamics). Standard nonlinear longitudinal airframe dynamics (type 7) with the available modified F18 stability derivatives, thrust vectoring, actuator dynamics, and control constraints are utilized for simulated flight evaluation of derived controller performance in all cases studied.
Author (revised)

N94-10728# National Aerospace Lab., Tokyo (Japan). STOL Aircraft Project Group.
AERODYNAMIC MODEL IDENTIFICATION OF QUIET STOL EXPERIMENTAL AIRCRAFT ASKA FROM DYNAMIC FLIGHT TEST DATA [TEISOUON STOL JIKKENKI ASUKA NO DOUTEKI HIKOU SHIKEN NIYORU KUURIKI MODERU DOUTEI]
MASAAKI YANAGIHARA and TOSHIO BANDOU Jan. 1992 34 p In JAPANESE
(ISSN 0389-4010)
(DE93-767967; NAL-TR-1138; JTN-93-80424) Avail: CASI HC A03/MF A01
A method to identify an aircraft aerodynamic model using

dynamic flight tests was investigated by National Aerospace Laboratory (NAL). This method is subsequently being applied to flight test data of the Quiet Short Take-Off and Landing (QSTOL) experimental aircraft 'ASKA' to obtain its nonlinear non-dimensional aerodynamic model. Estimated static parameters were evaluated by comparing results from steady/quasi-steady state tests, whereas estimated dynamic parameters were compared with theoretical ones. In addition, an overall evaluation was performed by calculating simulated time histories using the identified model and comparing the results with recorded test data. Good correlations were obtained, except for configurations in which limited flight tests had been conducted, thereby demonstrating the effectiveness of this method. Author (NASDA)

N94-10935*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DETERMINING XV-15 AEROELASTIC MODES FROM FLIGHT DATA WITH FREQUENCY-DOMAIN METHODS
C. W. ACREE, JR. and MARK B. TISCHLER May 1993 68 p
Prepared in cooperation with Army Aviation Systems Command, Moffett Field, CA
(Contract RTOP 505-61-51)
(NASA-TP-3330; A-91002; NAS 1.60:3330; USAATCOM-TR-93-A-004) Avail: CASI HC A04/MF A01

The XV-15 tilt-rotor wing has six major aeroelastic modes that are close in frequency. To precisely excite individual modes during flight test, dual flaperon exciters with automatic frequency-sweep controls were installed. The resulting structural data were analyzed in the frequency domain (Fourier transformed). All spectral data were computed using chirp z-transforms. Modal frequencies and damping were determined by fitting curves to frequency-response magnitude and phase data. The results given in this report are for the XV-15 with its original metal rotor blades. Also, frequency and damping values are compared with theoretical predictions made using two different programs, CAMRAD and ASAP. The frequency-domain data-analysis method proved to be very reliable and adequate for tracking aeroelastic modes during flight-envelope expansion. This approach required less flight-test time and yielded mode estimations that were more repeatable, compared with the exponential-decay method previously used. Author

N94-10945 Aeronautical Systems Div., Wright-Patterson AFB, OH.
AN ENVIRONMENTAL STUDY OF THE NATIONAL AEROSPACE PLANE Final Report, 1 Dec. 1991 - 30 Dec. 1992
CHARLES BROWN, TED WIERZBANOWSKI, HELMUT REDA, and GREGORY T. DUECKER Dec. 1992 39 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A266071; ASC-TR-93-5007) Avail: CASI HC A03

The overall objective of the United States (US) National Aero-Space Plane (NASP) Program is to develop the hypersonic technologies required for future military and civilian aerospace plane systems to reduce payload cost to orbit and provide for flexible-responsive space operations. If successful, the NASP Program will be the stimulus for developing a whole new class of airbreathing hypersonic aircraft powered by clean-burning scramjet engines using liquid hydrogen as the primary fuel. As part of this development, the potential environmental impacts from these vehicles must be considered and analyzed. This process has been initiated using the NASP Program's proposed X-30 flight research vehicle and flight test program as a basis for analysis. Environmental issues addressed include the following: noise and sonic booms, stratospheric ozone depletion, public health and safety, hazardous materials/waste, air quality, biological and cultural resources, geology and soils, and water use. Although this study is not yet complete, preliminary analysis has determined that the X-30 vehicle and flight test program would have minimal environmental impact. DTIC

N94-11056 Syracuse Univ., NY.
ADVANCED ROTORCRAFT FLIGHT SIMULATION: MODEL DEVELOPMENT, VALIDATION AND PARALLEL IMPLEMENTATION Ph.D. Thesis
SRIPRAKASH PARTHA SARATHY 1992 243 p
Avail: Univ. Microfilms Order No. DA9312589

The development of parallel algorithms for the real-time rotorcraft flight simulation is addressed. The objective is to employ more refined models that better predict helicopter behavior. A new Rotating Blade Element (RBE) model is developed, implemented, and validated. The new model includes coupled blade flap, lag, and pitch motions. The development of a parallel version of this model, together with appropriate parallel algorithms, is discussed for all phases of the flight simulation model. The 14 processor Encore Multimax (shared memory MIMD) parallel computer is used to implement the parallel flight simulation code. Results for the sequential and parallel implementations are provided. The RBE formulation is compared with results from CAMRAD for the OH-6 helicopter. The fully coupled nonlinear forward flight trim results compare well with those of CAMRAD. The coupled blade response is validated against Runge-Kutta integration. The timing results from the parallel code demonstrated speed up factors between 10 and 12 for the trim and response tasks. Dissert. Abstr.

N94-11150*# MCAT Inst., San Jose, CA.
SUPERSONIC AIRPLANE STUDY AND DESIGN
SAMSON CHEUNG Jun. 1993 17 p Original contains color illustrations
(Contract NCC2-617)
(NASA-CR-193219; NAS 1.26:193219; MCAT-93-10) Avail: CASI HC A03/MF A01; 3 functional color pages

A supersonic airplane creates shocks which coalesce and form a classical N-wave on the ground, forming a double bang noise termed sonic boom. A recent supersonic commercial transport (the Concorde) has a loud sonic boom (over 100 PLdB) and low aerodynamic performance (cruise lift-drag ratio 7). To enhance the U.S. market share in supersonic transport, an airframer's market risk for a low-boom airplane has to be reduced. Computational fluid dynamics (CFD) is used to design airplanes to meet the dual constraints of low sonic boom and high aerodynamic performance. During the past year, a research effort was focused on three main topics. The first was to use the existing design tools, developed in past years, to design one of the low-boom wind-tunnel configurations (Ames Model 3) for testing at Ames Research Center in April 1993. The second was to use a Navier-Stokes code (Overflow) to support the Oblique-All-Wing (OAW) study at Ames. The third was to study an optimization technique applied on a Haack-Adams body to reduce aerodynamic drag.
Author (revised)

N94-11233*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
GROUND VIBRATION AND FLIGHT FLUTTER TESTS OF THE SINGLE-SEAT F-16XL AIRCRAFT WITH A MODIFIED WING
DAVID F. VORACEK Jun. 1993 60 p
(Contract RTOP 533-02-35)
(NASA-TM-104269; H-1906; NAS 1.15:104269) Avail: CASI HC A04/MF A01

The NASA single-seat F-16XL aircraft was modified by the addition of a glove to the left wing. Vibration tests were conducted on the ground to assess the changes to the aircraft caused by the glove. Flight Luther testing was conducted on the aircraft with the glove installed to ensure that the flight envelope was free of aeroelastic or aeroservoelastic instabilities. The ground vibration tests showed that above 20 Hz, several modes that involved the control surfaces were significantly changed. Flight test data showed that modal damping levels and trends were satisfactory where obtainable. The data presented in this report include estimated modal parameters from the ground vibration and flight flutter test.
Author

N94-11318# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Munich (Germany). Military Aircraft Div.
SMART STRUCTURES: A TECHNOLOGY FOR NEXT GENERATION AIRCRAFT
W. SCHMIDT and C. BOLLER *In* AGARD, Smart Structures for Aircraft and Spacecraft 14 p Apr. 1993
Copyright Avail: CASI HC A03/MF A04

Performance of aircraft structures has progressed in a sequence of steps during the past. Since composite materials have gained broad application because of significant technological improvement, it is timely to look for the next step in improvement of aircraft performance. It is very likely that this step is related to smart structures technology. Smart structures technology is able to meet various aircraft design objectives such as improved military aircraft effectiveness through improved aircraft capabilities and reduced life cycle cost or reduced direct operating cost of civil aircraft through improvement in performance, fuel consumption, and aircraft maintainability. Active/adaptive structures, structure health monitoring, and structure integrated avionics are the three areas which are felt to be the areas where smart structures technology is most beneficial. Ways for cooperation between various engineering and natural sciences, being a major driving force for the success of smart structures, are described as well as some laboratory scale experiments which were recently performed. It is felt that an increased effort in engineers in various fields towards realization of smart structures can be a new rewarding challenge for the aircraft industry in developing next generation aircraft. Author (revised)

N94-11321# Eurocopter Deutschland G.m.b.H., Munich (Germany).
SMART MATERIALS FOR HELICOPTER ROTOR ACTIVE CONTROL
H. STREHLOW and H. RAPP *In* AGARD, Smart Structures for Aircraft and Spacecraft 16 p Apr. 1993
Copyright Avail: CASI HC A03/MF A04

A major improvement of helicopter performance and comfort can be achieved by the implementation of rotor active control technology (RACT). The introduction of individual blade control (IBC) is a subject of current research activities. But the breakthrough of this technology is still missing due to the lack of appropriate rotating blade actuation systems. Smart materials may open a new possibility for the realization of rotor active control. A survey of current hydraulic individual blade actuation systems shows that these are very complicated and heavy. Blade actuation by smart materials offers the change for an electrical system integrated into the blade itself. A study of different blade actuation systems shows that in principle there is the possibility of achieving this goal. But, today the available materials are not ready for real 'smart' applications. The preferred materials - piezoceramics - show a too low tension strength and very low active strains. Therefore, at this time the only feasible blade actuation system for individual blade control seems to be a hinged flap at the outer third of a rotor blade. This flap can be controlled by a smart (piezoelectric) actuator. Estimations show that such a system will work on the desired yaw. Author (revised)

N94-11341*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE IMPACT OF ACTIVE CONTROLS TECHNOLOGY ON THE STRUCTURAL INTEGRITY OF AERONAUTICAL VEHICLES
THOMAS E. NOLL, EDWARD AUSTIN (Army Aviation Research and Technology Activity, Hampton, VA.), SHAWN DONLEY (Naval Air Development Center, Warminster, PA.), GEORGE GRAHAM (National Defence Headquarters, Ottawa, Ontario.), TERRY HARRIS (Wright Lab., Wright-Patterson AFB, OH.), IAN KAYNES (Defence Research Agency, Farnborough, England.), BEN LEE (Institute for Aerospace Research, Ottawa, Ontario.), and JAMES SPARROW (Aeronautical Research Labs., Melbourne, Australia.) *In* AGARD, Smart Structures for Aircraft and Spacecraft 10 p Apr. 1993
Copyright Avail: CASI HC A02/MF A04

The findings of an investigation conducted under the auspices of The Technical Cooperation Program (TTCP) to assess the impact of active controls technology on the structural integrity of aeronautical vehicles and to evaluate the present state-of-the-art for predicting loads caused by a flight-control system modification and the resulting change in the fatigue life of the flight vehicle are summarized. Important points concerning structural technology considerations implicit in applying active controls technology in new aircraft are summarized. These points are well founded and based upon information received from within the aerospace industry and government laboratories, acquired by sponsoring workshops which brought together experts from contributing and interacting technical disciplines, and obtained by conducting a case study to independently assess the state of the technology. The paper concludes that communication between technical disciplines is absolutely essential in the design of future high performance aircraft. Author (revised)

N94-11345# Stirling Dynamics Ltd., Bristol (England).
ACTIVE LANDING GEAR CONTROL FOR IMPROVED RIDE QUALITY DURING GROUND ROLL
TYRONE F. CATT, DAVID COWLING (Bristol Univ., England.), and ALAN SHEPHERD *In* AGARD, Smart Structures for Aircraft and Spacecraft 11 p Apr. 1993 Sponsored in part by British Aerospace Public Ltd. Co.
Copyright Avail: CASI HC A03/MF A04

Active control of an aircraft landing gear can give improved passenger ride quality during take-off and landing. The active control system studied uses feedback from airframe mounted sensors to modify rigid body and structural response. The system is based primarily on modifying the damping characteristics in the nose gear oleo. This is achieved by reducing the damping orifice area, with active control of the area about this new datum value. In addition, the benefits of a fully active nose gear using a separate supply of high pressure hydraulic fluid are evaluated. Significant benefits are demonstrated with the active damping control system compared with the basic landing gear. Responses to general runway roughness and discrete runway bumps are considered. The active damping control system is shown to be effective in reducing peak and rms passenger normal accelerations at all fuselage stations, particularly nose and tail. Good improvement can be obtained from active damping control of the nose gear, with no modification to the main gear. The first fuselage bending mode response can be reduced by active damping control. The benefits from the fully active system are marginal, considering the additional system complication. These effects are illustrated for a typical transport aircraft configuration. Author

N94-11347# Wright Lab., Wright-Patterson AFB, OH.
MULTIDIMENSIONAL INTELLIGENT CONTROL FOR SUPERLIGHT AIR VEHICLES
AIVARS SMITCHENS, ANTHONY DETHOMAS, KURT GREVSTAD (Boeing Co., Seattle, WA.), and DOUG MOORE (Rockwell International Corp., El Segundo, CA.) *In* AGARD, Smart Structures for Aircraft and Spacecraft 12 p Apr. 1993
Copyright Avail: CASI HC A03/MF A04

Flexible wing technology was explored in a number of design studies. Wind tunnel experiments generally affirm the results of these studies that a flexible, variable twist wing holds the potential for dramatic air vehicle performance improvements. However, the attendant control reversal, increase in control parameter nonlinearities, and the need for an active control system to suppress flutter has discouraged the application of this technology in production designs. Advancement of a robust control capability for damping structural modes; embedded sensors to provide required inputs to the control system for active flutter control and, possibly, battle damage tolerance; high-speed on-board computation; and other technologies promise the capability to exploit the benefits promised by more flexible structures. Current proposals to reduce air vehicle structural weight are briefly reviewed and implications on the control system are assessed. Even though control system concerns exist, they are resolvable and it may be timely to undertake the development and demonstration of an actively controlled flexible wing. Author (revised)

N94-11464# Howell (J. R.), Bradenton, FL.
COMPARING AIRCRAFT AGILITY USING MAHALANOBIS DISTANCES Final Report
J. R. HOWELL and NORMAN E. HOWELL 2 Dec. 1992 6 p
(PB93-175446; AGILITY-1) Avail: CASI HC A02/MF A01

Suppose a set of p agile maneuvers is executed and measured N1 times on an aircraft of one type, and N2 times on an aircraft of another type. Based on these agility measurements, the paper shows how to calculate a generalized Mahalanobis agility distance between the two aircraft. If there are more than two types of aircraft, the agility distance between each pair can be calculated and compared. NTIS

N94-11587*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FURTHER STUDIES USING MATCHED FILTER THEORY AND STOCHASTIC SIMULATION FOR GUST LOADS PREDICTION
ROBERT C. SCOTT, ANTHONY S. POTOTZKY (Lockheed Engineering and Sciences Co., Hampton, VA.), and BOYD III PERRY Jul. 1993 15 p Presented at the AIAA 34th Structures, Structural Dynamics, and Materials Conference, La Jolla, CA, 19-21 Apr. 1993 Previously announced in IAA as N93-33932
(Contract RTOP 505-63-50-15)
(NASA-TM-109010; NAS 1.15:109010) Avail: CASI HC A03/MF A01

This paper describes two analysis methods -- one deterministic, the other stochastic -- for computing maximized and time-correlated gust loads for aircraft with nonlinear control systems. The first method is based on matched filter theory; the second is based on stochastic simulation. The paper summarizes the methods, discusses the selection of gust intensity for each method and presents numerical results. A strong similarity between the results from the two methods is seen to exist for both linear and nonlinear configurations. Author

N94-11858# Kansas Univ., Lawrence. Flight Research Lab.
GENERAL AVIATION AIRCRAFT-NORMAL ACCELERATION DATA ANALYSIS AND COLLECTION PROJECT Final Report
JAMES E. LOCKE, HOWARD W. SMITH, EDWARD A. GABRIEL, and THOMAS DEFLORE Feb. 1993 341 p
(AD-A265055; KR-FRL-926-1; DOT/FAA/CT-91/20) Avail: CASI HC A15/MF A03

The analysis and condensation of repeated flight loads obtained from 77 airplanes that participated in the NASA VGH General Aviation Program are reported. In addition, the load spectra for 98 airplanes in the NASA VGH data base are presented as plotted and tabulated data. Curve fit equations are listed for the original data and for extrapolation, which was used in the statistical analysis. Airspeed, normal load factor, and altitude were recorded continuously during flight. The load factor data were separated into gust and maneuver normal accelerations. The reduced data are presented as cumulative number of occurrences per nautical mile versus acceleration fraction (incremental normal acceleration divided by incremental limit load factor). For statistical analysis, the airplanes were grouped into seven single and twin-engine operational usage groups. The mean (weighted by flight time); weighted mean plus one, two, and three standard deviation spectra; and the 90% probability/95% confidence spectra were determined for each operational usage group and for several of the groups combined. An estimate of the scatter associated with groups having small sample size was determined by computing a pooled variance and pooled standard deviation. The resulting load spectra are to be used for wing fatigue test or safe-life estimation. DTIC

N94-11872# Naval Postgraduate School, Monterey, CA.
LIFT ENHANCEMENT OF A WING/STRAKE USING PNEUMATIC BLOWING M.S. Thesis
CRAIG J. ZGRAGGEN Mar. 1993 92 p
(AD-A265074) Avail: CASI HC A05/MF A01

A low-speed wind-tunnel study to quantitatively measure the lift and drag effects of pneumatically controlling strake and leading-edge vortices generated by a half-span, generic-fighter model was conducted. The study measured the increase in lift and drag on the model throughout a range of angles of attack. The study utilized various blowing tubes of different geometries and orientations. Results showed that blowing produced changes in lift with minimal effect on drag. Blowing appeared to reattach flow during the initial stages of stall. Blowing increased lift a maximum of 9 percent at an angle of attack of 20 degrees, and up to 7 percent at angles of attack greater than 20 degrees. Blowing rates were varied from C(sub mu) of 0.0094 to C(sub mu) of 0.022. Near axial blowing produced the largest increases in lift. It was found that lift increases were directly proportional to changes in blowing rate. DTIC

N94-11892# Naval Aerospace Medical Research Lab., Pensacola, FL.
AIRCRAFT WINDSCREENS ENHANCE VISUAL SEARCH DISRUPTION PRODUCED BY LASER GLARE Interim Report
J. A. DANDREA, R. N. SHULL, and J. C. KNEPTON, JR. Dec. 1992 16 p
(AD-A265167; NAMRL-1380) Avail: CASI HC A03/MF A01

Naval aircrews may be exposed to laser radiation that is used for a variety of purposes. Consequently, there is high probability of both deliberate and accidental exposure of personnel to laser radiation. One deliberate use of laser radiation may be as a mission deterrent to disrupt aircrew visual performance. The purpose of this study was to determine how low-intensity laser glare interacts with an aircraft windscreen and if flat or wraparound aircraft windscreens differentially enhance glare and disrupt visual search performance. In addition, we evaluated the effectiveness of laser glare in high ambient light. Visual search time to locate target disks viewed through either a flat or curved windscreen under laser glare conditions was significantly longer compared to a no glare control. The glare pattern and disruption of visual search under low ambient light, simulating dawn or dusk, was more extensive when viewed through a wraparound F/A-18 windscreen than a flat A/4 windscreen. Detection of targets also depended on their location relative to the center of the laser glare pattern. Visual search performance returned to baseline levels under daytime ambient lighting conditions. The results of this experiment illustrate that aircraft windscreens can significantly increase laser-produced glare as measured by a visual search performed under low levels of ambient lighting. Eye protection is needed to prevent mission disruption, even at laser intensities that are not harmful to the eye. DTIC

N94-12630# Institute of Flow Research, Tokyo (Japan).
IDEA OF UNDERGROUND AIRPLANE [CHICHUU HIKOUKI NO AIDEIA]
HIROSHI SATOU *In* NAL, Proceedings of the 9th and 10th NAL Workshop on Investigation and Control of Boundary-Layer Transition p 79-81 Nov. 1992 In JAPANESE
Avail: CASI HC A01/MF A02

An underground airplane is proposed as a rapid transit system between large cities. A large-diameter tunnel is constructed and medium-size airplanes are operated at around 600 km/hr. The tunnel can be used also for storage and transportation of material, energy, and information. Author (NASDA)

N94-12850*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A METHOD OF PREDICTING QUASI-STEADY AERODYNAMICS FOR FLUTTER ANALYSIS OF HIGH SPEED VEHICLES USING STEADY CFD CALCULATIONS
ROBERT C. SCOTT and ANTHONY S. POTOTZKY (Lockheed Engineering and Sciences Co., Hampton, VA.) Jul. 1993 10 p Presented at the AIAA 34th Structures, Structural Dynamics, and Materials Conference, LaJolla, CA, 19-21 Apr. 1993 Previously announced in IAA as A93-33931
(Contract RTOP 505-63-50-15)
(NASA-TM-109009; NAS 1.15:109009) Avail: CASI HC A02/MF A01

High speed linear aerodynamic theories like piston theory and Newtonian impact theory are relatively inexpensive to use for flutter analysis. These theories have limited areas of applicability depending on the configuration and the flow conditions. In addition, these theories lack the ability to capture viscous, shock, and real gas effects. CFD methods can model all of these effects accurately, but the unsteady calculations required for flutter are expensive and often impractical. This paper describes a method for using steady CFD calculations to approximate the generalized aerodynamic forces for a flutter analysis. Example two-and three-dimensional aerodynamic force calculations are provided. In addition, a flutter analysis of a NASP-type wing will be discussed. Author (revised)

N94-13338# National Aerospace Lab., Tokyo (Japan). Control Systems Div.

DEVELOPMENT OF AN ON-BOARD AIRCRAFT OPTICAL FIBER DATA BUS SYSTEM [KOUKUUKI TOUSAIGATA HIKARI DETABASU NO KAIHATSU]

MITSUYOSHI MAYANAGI, MINORU TAKIZAWA, TADAO UCHIDA, TOSHIHARU INAGAKI, KOUKI HOZUMI, and KAZUTOSHI ISHIKAWA Jun. 1992 87 p In JAPANESE

(ISSN 0389-4010)

(NAL-TR-1163; JTN-93-80485) - Avail: CASI HC A05/MF A01

An optical fiber data bus system was developed to provide the necessary technological foundation to use on a Fly-By-Light (FBL) control system which will be required on future aircraft. This data bus system was designed and built in accordance with the protocol and system organization requirements set forth in MIL-STD-1553B (USAF). It is an on-board model comprised of a bus control unit, two remote terminal units, an optical transmission unit having three optical transmitters/receivers. an eight to eight star coupler, a pressurized bulkhead optical connector, and three sets of fiber optic cables. A single fiber optic cable is utilized as the data transmission medium, and it employs a newly developed electrically passive/transmitting eight to eight star coupler and a pressurized bulkhead optical connector for optical coupling. New serial bus control and message handling techniques were also developed for the data bus. In addition, an electrical transmission line is provided to back up the optical fiber transmission line, thereby, providing the necessary system reliability for testing the FBL control system. Performance evaluations of the optical fiber data bus were conducted by testing the optical transmission units, and by conducting environmental, laboratory, and flight test with results verifying suitable adaptability to the FBL control system. Author (NASDA)

N94-13459# National Aerospace Lab., Tokyo (Japan). Aerodynamics Div.

HYPERSONIC AERODYNAMIC CHARACTERISTICS OF SSTO-TYPE AEROSPACE PLANES. PART 1: THE NAL 0-TH CONFIGURATION [SUPESUPUREN NO GOKUCHOUONSOKU KUURIKI TOKUSEI SHIKEN: DAI 0-JI KEIJOU]

SHIGEYA WATANABE, KOUICHI HOZUMI, AKIRA YOSHIZAWA, TADAO KOYAMA, and SHOUICHI TSUDA Dec. 1992 57 p In JAPANESE

(ISSN 0389-4010)

(NAL-TR-1186; JTN-93-80507) Avail: CASI HC A04/MF A01

Tests to determine the aerodynamic characteristics of a horizontal takeoff, Single Stage To Orbit (SSTO) type aerospace plane (NAL 0-th configuration) were conducted at a Mach number of 7.1. Six components of force and moment were measured in the blowdown-type 50 cm hypersonic wind tunnel at the National Aerospace Laboratory. Flow visualizations were also performed using the schlieren, surface oil flow, and vapor screen techniques. The force and moment test results showed that the configuration had a lift-to-drag ratio of 2.2 in the ascent flight condition and that Dutch-roll mode instability occurred due to directional instability. The focus of future aerodynamic configuration improvements are discussed in connection with these results. Author (NASDA)

N94-13606* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

AIRBORNE ARCTIC STRATOSPHERIC EXPEDITION: OZONE (Videotape)

Dec. 1988 Videotape: 5 min. playing time, in color, with sound

(NASA-TM-109312; NONP-VT-93-185319) Avail: CASI VHS A01/BETA A22

This video shows the rollout of the ER-2 and DC-8 at Ames, takeoffs and landings, and operations aboard the DC-8 and ER-2 in Puntas Arenas, Chile. Animation of the north polar regions showing the ozone hole is also included. Author (revised)

N94-13618*# North Carolina State Univ., Raleigh. Mars Mission Research Center.

MULTIDISCIPLINARY DESIGN TECHNIQUES APPLIED TO CONCEPTUAL AEROSPACE VEHICLE DESIGN Ph.D. Thesis Final Technical Report

JOHN ROBERT OLDS and GERALD D. WALBERG 1993 181 p

(Contract NCC1-168)

(NASA-CR-194409; NAS 1.26:194409) Avail: CASI HC A09/MF A02

Multidisciplinary design optimization (MDO) is an emerging discipline within aerospace engineering. Its goal is to bring structure and efficiency to the complex design process associated with advanced aerospace launch vehicles. Aerospace vehicles generally require input from a variety of traditional aerospace disciplines - aerodynamics, structures, performance, etc. As such, traditional optimization methods cannot always be applied. Several multidisciplinary techniques and methods were proposed as potentially applicable to this class of design problem. Among the candidate options are calculus-based (or gradient-based) optimization schemes and parametric schemes based on design of experiments theory. A brief overview of several applicable multidisciplinary design optimization methods is included. Methods from the calculus-based class and the parametric class are reviewed, but the research application reported focuses on methods from the parametric class. A vehicle of current interest was chosen as a test application for this research. The rocket-based combined-cycle (RBCC) single-stage-to-orbit (SSTO) launch vehicle combines elements of rocket and airbreathing propulsion in an attempt to produce an attractive option for launching medium sized payloads into low earth orbit. The RBCC SSTO presents a particularly difficult problem for traditional one-variable-at-a-time optimization methods because of the lack of an adequate experience base and the highly coupled nature of the design variables. MDO, however, with it's structured approach to design, is well suited to this problem. The result of the application of Taguchi methods, central composite designs, and response surface methods to the design optimization of the RBCC SSTO are presented. Attention is given to the aspect of Taguchi methods that attempts to locate a 'robust' design - that is, a design that is least sensitive to uncontrollable influences on the design. Near-optimum minimum dry weight solutions are determined for the vehicle. A summary and evaluation of the various parametric MDO methods employed in the research are included. Recommendations for additional research are provided. Author (revised)

N94-13687# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.

DEVELOPMENT AND APPLICATION OF A COMPREHENSIVE, DESIGN-SENSITIVE WEIGHT PREDICTION METHOD FOR WING STRUCTURES OF TRANSPORT CATEGORY AIRCRAFT

E. TORENBEEK Sep. 1992 59 p

(LR-693; ETN-93-94417) Avail: CASI HC A04/MF A01

The development of an analytical empirical method to predict the structural weight of transport aircraft wings is described. The method is suitable for the preliminary design stage, when sensitivity studies are required of the effects of geometry and other variations on the design characteristics. The wing weight is computed as the sum of several functional components. The basic weight required to resist bending and shear loads is computed from integration of a spanwise material distribution. Weight penalties are derived for nonoptimum effects, including stiffness required to cope with aeroelastic effects. Methods for leading and trailing edge structures, including high lift devices and control surfaces are derived. Instead of using the suggested statistical data for mean stress levels, the user may input more accurate data, if available. The baseline is 1980+ technology. The method is applied to present day transport aircraft. For the cases considered the prediction error was below 4%. ESA

N94-13690# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.
COMPUTATIONAL METHODS FOR RELIABLE FATIGUE AND DAMAGE TOLERANCE DIMENSIONING OF AIRCRAFT STRUCTURES
BOERJE ANDERSSON Feb. 1993 23 p Presented at the 5th Nordic Seminar on Computational Mechanics, Aalborg, Denmark, 5-6 Nov. 1992 Sponsored by Defence Material Administration, Stockholm, Sweden
(FFA-TN-1993-05; ETN-93-94489) Avail: CASI HC A03/MF A01

A computational procedure for reliable stress and linear elastic fracture mechanics analysis of aircraft components of high complexity is described. The numerical analysis is based on the h-p version of the finite element method. For analysis of stresses at fillets, a rational analysis procedure is developed. From one three dimensional fracture mechanics analysis, analytical formulae are obtained that accurately predict pointwise stresses as a function of geometry parameters, for example, the radius at a fillet. A model example is analyzed in order to demonstrate the simplicity, reliability, and accuracy obtainable with the suggested approach. Results from an analysis of an aircraft fuselage, using a model having two million degrees of freedom, exemplify the practical usefulness of the procedure when solving very complex aircraft design problems. ESA

N94-13839 Operational Research and Analysis Establishment, Ottawa (Ontario).
AN ANALYSIS OF HELICOPTER ATTRITION USING A LOW LEVEL COMBAT SIMULATION
P. J. YOUNG and R. J. HILL Dec. 1992 66 p
(DSIS-93-00282; DLOR-RN-92-5; CTN-93-60797) Avail: CASI HC A04/MF A01

Low level combat simulations were applied to study the attrition of utility tactical transport helicopters (UTTH's) in their proposed roles as the Canadian Army's sole tactical aviation asset. A preliminary analysis is presented of the UTTH in the reconnaissance role only, using the HELSCAM combat simulator program. The effects of the flown nap-of-the-earth altitude and the physical signature of a reconnaissance helicopter on its survivability are examined. The scenarios were simulated with the UTTH at two altitudes: 2 m and 5 m. The observed loss rate at the higher altitude was more than double that at the lower altitude. In addition, the larger size of the UTTH compared to a conventional light observation helicopter operating at the same altitude, increased its loss rate by about 18 percent. The results suggest that the operational doctrine used for the UTTH can have a significant impact on its potential survivability and hence on its performance. Author (CISTI)

N94-13867 Operational Research and Analysis Establishment, Ottawa (Ontario).
HELSCAM V2.0: DEVELOPMENT AND APPLICATION GUIDE
P. J. YOUNG Dec. 1992 128 p
(DSIS-93-00137; DLOR-RN-92-6; CTN-93-60805) Avail: CASI HC A07

The HELicopter SCenario Assessment Model (HELSCAM) was developed to study helicopter operations in support of the ground commander. The completed model comprised a simulation core, an event analyzer, and graphical facilities for route planning and scenario replay. The simulation core included sophisticated algorithms for movement, acquisition, and engagement processes. In the process of streamlining the model and generalizing its algorithms to model a wider variety of weapon systems, HELSCAM changed sufficiently to require a new development and application guide, which is presented. Major modifications to the simulation core of HELSCAM present in the new version 2.0 include addition of fixed wing systems, addition of a merged terrain base in the terrain data files, the modelling of delays imposed by weapon reloading, and revision of the line-of-sight algorithm. The guide includes an overview of HELSCAM system hardware and software requirements, the simulation core, the analytical facility, and input definitions. An air raid scenario and its HELSCAM files are also included. CISTI

N94-13898# Institute for Aerospace Research, Ottawa (Ontario). Applied Aerodynamics Lab.
QUALITATIVE INVESTIGATION OF A GENERIC FIGHTER MODEL IN RADIO CONTROLLED GLIDING FLIGHT
P. J. PENNA Jul. 1992 26 p
(LM-AA-003; CTN-93-60762) Avail: CASI HC A03/MF A01

A generic fighter model was flown in radio controlled gliding flight to investigate qualitatively some of its flight dynamic characteristics. Visual cues from the model's flight path, its motion about its center of gravity, and qualitative knowledge of the pilot's control inputs were used to infer certain dynamic characteristics. The observations showed that the model was statically stable in pitch with the center of gravity moved as far back as 23.3 percent of the mean aerodynamic chord of the wing. However, if the model was rotated rapidly in pitch, it had a tendency to pitch up into a deep stall. The model was found to be prone to entering a spin from a moderate stall. The spin is postulated to be caused by a separated-flow asymmetry at the nose ogive. Finally, the model's ailerons were found to provide acceptable roll control authority, but maximum aileron deflection caused visible adverse yaw. CISTI

N94-14106*# Texas A&M Univ., College Station. Aerospace Engineering Div.
FLIGHT VALIDATION OF A PULSED SMOKE FLOW VISUALIZATION SYSTEM Final Report
DONALD T. WARD and KENNETH M. DORSETT Sep. 1993 44 p Sponsored by NASA. Washington
(Contract NCC2-742; RTOP 533-02-35)
(NASA-CR-186026; H-1914; NAS 1.26:186026) Avail: CASI HC A03/MF A01

A flow visualization scheme, designed to measure vortex fluid dynamics on research aircraft, was validated in flight. Strake vortex trajectories and axial core velocities were determined using pulsed smoke, high-speed video images, and semiautomated image edge detection hardware and software. Smoke was pulsed by using a fast-acting three-way valve. After being redesigned because of repeatedly jamming in flight, the valve shuttle operated flawlessly during the last two tests. A 25-percent scale, Gothic strake was used to generate vortex over the wing of a GA-7 Cougar and was operated at a local angle of attack of 22 degrees and Reynolds number of approximately 7.8 x 10(exp 5)/ft. Maximum axial velocities measured in the vortex core were between 1.75 and 1.95 times the freestream velocity. Analysis of the pulsed smoke system's affect on forebody vortices indicates that the system may reorient the forebody vortex system; however, blowing momentum coefficients normally used will have no appreciable affect on the leading-edge extension vortex system. It is recommended that a similar pulsed smoke system be installed on the F/A-18 High Angle Research Vehicle and that this approach be used to analyze vortex core dynamics during the remainder of its high-angle-of-attack research flights. Author (revised)

N94-14615# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
SRISTI: THE NAL METHOD FOR THE DESIGN AND ANALYSIS OF NATURAL LAMINAR FLOW (NLF) AIRFOILS
K. R. SRILATHA, G. S. DWARAKANATH, and P. RAMAMOORTHY *In its* Proceedings of the Fluid Dynamics Symposium in Honour of Professor R. Narasimha on his 60th Birthday p 191-203 Jul. 1993
Avail: CASI HC A03/MF A03

A software package (called SRISTI) for the design and analysis of NLF airfoils is described. As an illustration, an NLF airfoil for NAL's Light Transport Aircraft has been designed using this package. Its aerodynamic characteristics have been extensively compared with GAW-2 airfoil and also with wind tunnel experiments. Author

N94-14616# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
VSAERO ANALYSIS OF A PIPER CUB AIRCRAFT
ASHOK SRIVASTAVA, DAVID LEDNICER (Analytical Methods, Inc., Redmond, WA.), IAN GILCHRIST (Analytical Methods, Inc., Redmond, WA.), and JAHAN SAGHAFI (Analytical Methods, Inc., Redmond, WA.) *In its* Proceedings of the Fluid Dynamics Symposium in Honour of Professor R. Narasimha on his 60th Birthday p 205-210 Jul. 1993 Sponsored by Dept. of Science and Technology and Agency for International Development
Avail: CASI HC A02/MF A03

A Piper Cub aircraft configuration has been analyzed using the VSAERO code and the aerodynamic characteristics have been obtained at two incidences. Detailed pressure distributions have been computed along wing-body-tail sections. A comparison of lift characteristics with flight data shows reasonable agreement. Author

N94-14951# Army Research Lab., Aberdeen Proving Ground, MD.
STATIC AEROELASTIC RESPONSE OF AN AIRCRAFT WITH ASYMMETRIC WING PLANFORMS REPRESENTATIVE OF COMBAT DAMAGE Final Report, Oct. 1991 - Oct. 1992
JONG-HO WOO Jun. 1993 65 p
(Contract DA PROJ. 1L1-62618-AH-80)
(AD-A266890; ARL-TR-153) Avail: CASI HC A04/MF A01

An analysis of the static aeroelastic response of an aircraft with asymmetrical wing planforms representing combat damage is described. The analysis was performed using the MSC/NASTRAN Aeroelastic Code. Structural and aerodynamic models are based on the finite element approach and are created independently for both the damaged and undamaged cases. Fuselage, wings (with aileron), stabilators, and vertical wings (with rudders) are considered as lifting and control surfaces in the aerodynamic model. Five different wings structural models, one undamaged and four damaged, are examined. Doublet-Lattice subsonic theory is used to account for interference effects among multiple lifting surfaces and bodies. The stability and control derivatives, airloads, and trim values are obtained for the damaged-wing aircraft. Effects of damage, including the influence of wing-body interference, on the aircraft's flight dynamics are discussed. DTIC

N94-15321* National Aeronautics and Space Administration, Washington, DC.
MISSION ADAPTIVE WING (Videotape)
Oct. 1986 Videotape: 3 min. 7 sec. playing time, in color, with sound
(NASA-TM-109448; NONP-VT-93-190245) Avail: CASI VHS A01/BETA A22

This document looks at an aircraft wing that can change shape in flights from a flat to curved surface according to the necessary flight mode. CASI

N94-15327* National Aeronautics and Space Administration, Washington, DC.
X-29: EXPERIMENT IN FLIGHT (Videotape)
Jan. 1991 Videotape: 2 min. 51 sec. playing time, in color, with sound
(NASA-TM-109454; NONP-VT-93-190251) Avail: CASI VHS A01/BETA A22

This document examines the goals and accomplishments of the forward sweep-winged X-29. CASI

N94-15328* National Aeronautics and Space Administration, Washington, DC.
XV-15: TILTROTOR (Videotape)
Jan. 1991 Videotape: 2 min. 35 sec. playing time, in color, with sound
(NASA-TM-109455; NONP-VT-93-190252) Avail: CASI VHS A01/BETA A22

This document explains the technology of the XV-15 aircraft that takes off and lands like a helicopter and flies like a jet. CASI

N94-15396* National Aeronautics and Space Administration, Washington, DC..
BETTER WAY TO FLY (Videotape)
Feb. 1988 Videotape: 3 min. 31 sec. playing time, in color, with sound
(NASA-TM-109447; NONP-VT-93-190244) Avail: CASI VHS A01/BETA A22

This document shows the advanced cockpit making piloting more efficient and flying safer. CASI

N94-15651# Aeronautical Research Labs., Melbourne (Australia).
HELICOPTER STRUCTURES: A REVIEW OF LOADS, FATIGUE DESIGN TECHNIQUES, AND USAGE MONITORING
D. C. LOMBARDO May 1993 71 p
(AD-A267115; ARL-TR-15; DODA-AR-007-137) Avail: CASI HC A04/MF A01

This report is a review of traditional practice with respect to helicopter structural integrity. Aspects covered are: significant fatigue loads for the airframe and rotor system, the methods used in the fatigue design of current and previous generation rotorcraft, fatigue test requirements, and health and usage monitoring methods. DTIC

N94-15692# Army Test and Evaluation Command, Aberdeen Proving Ground, MD.
NON-LETHAL UNMANNED AERIAL VEHICLES (UAVS) Final Test Operations Procedure
15 Jun. 1993 43 p Supersedes AD-871331; X70-17501
(AD-A267139; TOP-6-2-040; AD-871331) Avail: CASI HC A03/MF A01

This TOP describes testing methods for determining the technical characteristics of Non-Lethal Unmanned Aerial Vehicles (UAV's). It provides a general description of facilities, instrumentation, and tasks required. It also specifies the documentation required including safety, environmental, and frequency authorization documentation. In details methodology for measuring Center of Gravity, developing flight profiles, performing flight tests, and performing transportability tests. This TOP discusses in general Electromagnetic Environmental, Manpower Integration/Reliability, Availability, Maintainability (MANPRINT/RAM), and Aural/Visual/Acoustic testing. DTIC

N94-15718*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE LIFT-FAN POWERED-LIFT AIRCRAFT CONCEPT: LESSONS LEARNED
WALLACE H. DECKERT Sep. 1993 79 p Sponsored by NASA, Washington
(Contract NASA ORDER A-25364-D)
(NASA-CR-177616; A-93107; NAS 1.26:177616) Avail: CASI HC A05/MF A01

This is one of a series of reports on the lessons learned from past research related to lift-fan aircraft concepts. An extensive review is presented of the many lift-fan aircraft design studies conducted by both government and industry over the past 45 years. Mission applications and design integration including discussions on manifolding hot gas generators, hot gas dusting, and energy transfer control are addressed. Past lift-fan evaluations of the Avrocar are discussed. Lessons learned from these past efforts are identified. Author (revised)

N94-15722*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PHYSICAL PROPERTIES OF THE BENCHMARK MODELS PROGRAM SUPERCRITICAL WING
BRYAN E. DANSBERRY, MICHAEL H. DURHAM, ROBERT M.

BENNETT, DAVID L. TURNOCK (Lockheed Engineering and Sciences Co., Hampton, VA.), WALTER A. SILVA, and JOSE A. RIVERA, JR. Washington Sep. 1993 62 p
(Contract RTOP 505-63-50-16)
(NASA-TM-4457; L-17177; NAS 1.15:4457) Avail: CASI HC A04/MF A01

The goal of the Benchmark Models Program is to provide data useful in the development and evaluation of aeroelastic computational fluid dynamics (CFD) codes. To that end, a series of three similar wing models are being flutter tested in the Langley Transonic Dynamics Tunnel. These models are designed to simultaneously acquire model response data and unsteady surface pressure data during wing flutter conditions. The supercritical wing is the second model of this series. It is a rigid semispan model with a rectangular planform and a NASA SC(2)-0414 supercritical airfoil shape. The supercritical wing model was flutter tested on a flexible mount, called the Pitch and Plunge Apparatus, that provides a well-defined, two-degree-of-freedom dynamic system. The supercritical wing model and associated flutter test apparatus is described and experimentally determined wind-off structural dynamic characteristics of the combined rigid model and flexible mount system are included. Author (revised)

N94-15731# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
AN ANALYSIS OF TACTICAL AIRLIFTER CHARACTERISTICS AND THEIR IMPACT ON THEATER AIRLIFT SYSTEM PERFORMANCE M.S. Thesis
JOHN J. KOGER Mar. 1993 124 p
(AD-A266719; AFIT/GST/ENS/93M-05) Avail: CASI HC A06/MF A02

This study used computer simulation and Response Surface Technology to determine what tactical airlifter characteristics most impact theater airlift system performance in a Southwest Asia (SWA) scenario. Some Aircraft characteristics were grouped into functional sets, while others were considered individually. After screening one characteristic, reliability, with a two-level factorial experiment, a Box-Behnken design was used to estimate second-order metamodels. A stepwise regression procedure indicated that, if attrition rates are ignored, airlift system performance is most impacted by the aircraft's size, survivability, cruise speed, and ability to operate on short fields. The SWA scenario used in this study covers a large geographical area and varying threat levels and types. The results of this study were compared with those of an earlier study that used the much smaller, low threat Central American scenario. It was determined that across a range of scenarios airlift system performance is most affected by the aircraft's size, survivability, cruise speed, ability to operate on short fields, and ability to operate on unprepared surfaces. DTIC

N94-15783*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
IN-FLIGHT INVESTIGATION OF A ROTATING CYLINDER-BASED STRUCTURAL EXCITATION SYSTEM FOR FLUTTER TESTING
LURA VERNON Washington Jun. 1993 22 p See also A93-34074
(Contract RTOP 505-63-50)
(NASA-TM-4512; H-1883; NAS 1.15:4512) Avail: CASI HC A03/MF A01

A research excitation system was test flown at the NASA Dryden Flight Research Facility on the two-seat F-16XL aircraft. The excitation system is a wingtip-mounted vane with a rotating slotted cylinder at the trailing edge. As the cylinder rotates during flight, the flow is alternately deflected upward and downward through the slot, resulting in a periodic lift force at twice the cylinder's rotational frequency. Flight testing was conducted to determine the excitation system's effectiveness in the subsonic, transonic, and supersonic flight regimes. Primary research objectives were to determine the system's ability to develop adequate force levels to excite the aircraft's structure and to determine the frequency range over which the system could excite structural modes of the aircraft. In addition, studies were conducted to determine optimal excitation parameters, such as sweep duration, sweep type, and energy levels. The results from the exciter were compared with results from atmospheric turbulence excitation at the same flight conditions. The comparison indicated that the vane with a rotating slotted cylinder provides superior results. The results from the forced excitation were of higher quality and had less variation than the results from atmospheric turbulence. The forced excitation data also invariably yielded higher structural damping values than those from the atmospheric turbulence data. Author

N94-16122# Texas Univ., Austin. Dept. of Aerospace Engineering and Engineering Mechanics.
ADAPTIVE ALGORITHM FOR AIRCRAFT CONFIGURATION IN TURBULENT FLOW Final Report, 10 Jan. 1991 - 30 Sep. 1992
JOHN KALLINDERIS 25 Nov. 1992 57 p
(Contract AF-AFOSR-0022-91)
(AD-A266188; CAR-92-8; AFOSR-93-0433TR) Avail: CASI HC A04/MF A01

The flow around aircraft configurations has been simulated. A code for numerical simulation and study of 3-D aircraft flowfields has been developed. The code consists of a hybrid scheme which solves the Navier-Stokes equations within the viscous regions around the aircraft while the simple Euler system is solved everywhere else. Efficient resolution of local flow physics such as shear layers, shock waves, and vortices is achieved by a specially developed adaptive grid algorithm. The method employs division and/or deletion of grid cells, as well as redistribution of points in order to resolve local flow features more accurately and efficiently. A hybrid grid consisting of prisms and tetrahedra grid-cells is employed. The first type is appropriate for the viscous regions, while the second type is suitable for the inviscid regions. A grid generator of prisms around an F-16-type aircraft was developed. Flow visualization is greatly enhanced with a developed computer graphics code. DTIC

N94-16498*# Iowa State Univ. of Science and Technology, Ames. Dept. of Aerospace Engineering and Engineering Mechanics.
TRAJECTORY OPTIMIZATION FOR THE NATIONAL AEROSPACE PLANE Final Report, 13 Jun. 1992 - 30 Oct. 1993
PING LU Nov. 1993 28 p
(Contract NAG1-1255)
(NASA-CR-194618; NAS 1.26:194618) Avail: CASI HC A03/MF A01

The objective of this second phase research is to investigate the optimal ascent trajectory for the National Aerospace Plane (NASP) from runway take-off to orbital insertion and address the unique problems associated with the hypersonic flight trajectory optimization. The trajectory optimization problem for an aerospace plane is a highly challenging problem because of the complexity involved. Previous work has been successful in obtaining sub-optimal trajectories by using energy-state approximation and time-scale decomposition techniques. But it is known that the energy-state approximation is not valid in certain portions of the trajectory. This research aims at employing full dynamics of the aerospace plane and emphasizing direct trajectory optimization methods. The major accomplishments of this research include the first-time development of an inverse dynamics approach in trajectory optimization which enables us to generate optimal trajectories for the aerospace plane efficiently and reliably, and general analytical solutions to constrained hypersonic trajectories that has wide application in trajectory optimization as well as in guidance and flight dynamics. Optimal trajectories in abort landing and ascent augmented with rocket propulsion and thrust vectoring control were also investigated. Motivated by this study, a new global trajectory optimization tool using continuous simulated annealing and a nonlinear predictive feedback guidance law have been under investigation and some promising results have been obtained, which may well lead to more significant development and application in the near future. Author (revised)

N94-16865*# North Carolina State Univ., Raleigh. Dept. of Textile Engineering, Chemistry and Science.
AEROELASTIC AIRFOIL SMART SPAR
SKOTT GREENHALGH, CHRISTOPHER M. PASTORE, and MOISHE GARFINKLE (Drexel Univ., Philadelphia, PA.) *In* NASA. Langley Research Center, FIBER-TEX 1992: The Sixth Conference on Advanced Engineering Fibers and Textile Structures for Composites p 343-351 Aug. 1993
Avail: CASI HC A02/MF A03

Aircraft wings and rotor-blades are subject to undesirable bending and twisting excursions that arise from unsteady aerodynamic forces during high speed flight, abrupt maneuvers, or hard landings. These bending excursions can range in amplitude from wing-tip flutter to failure. A continuous-filament construction 'smart' laminated composite box-beam spar is described which corrects itself when subject to undesirable bending excursions or flutter. The load-bearing spar is constructed so that any tendency for the wing or rotor-blade to bend from its normal position is met by opposite twisting of the spar to restore the wing to its normal position. Experimental and theoretical characterization of these spars was made to evaluate the torsion-flexure coupling associated with symmetric lay-ups. The materials used were uniweave AS-4 graphite and a matrix comprised of Shell 8132 resin and U-40 hardener. Experimental tests were conducted on five spars to determine spar twist and bend as a function of load for 0, 17, 30, 45 and 60 deg fiber angle lay-ups. Symmetric fiber lay-ups do exhibit torsion-flexure couplings. Predictions of the twist and bend versus load were made for different fiber orientations in laminated spars using a spline function structural analysis. The analytical results were compared with experimental results for validation. Excellent correlation between experimental and analytical values was found. Author (revised)

N94-17055*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AEROTHERMOELASTIC ANALYSIS OF A NASP DEMONSTRATOR MODEL
JENNIFER HEEG, THOMAS A. ZEILER (Lockheed Engineering and Sciences Co., Hampton, VA.), ANTHONY S. POTOTZKY (Lockheed Engineering and Sciences Co., Hampton, VA.), CHARLES V. SPAIN (Lockheed Engineering and Sciences Co., Hampton, VA.), and WALTER C. ENGELUND Oct. 1993 13 p See also A93-33933
(Contract RTOP 505-63-50-15)
(NASA-TM-109007; NAS 1.15:109007) Avail: CASI HC A03/MF A01

The proposed National Aerospace Plane (NASP) is designed to travel at speeds up to Mach 25. Because aerodynamic heating during high-speed flight through the atmosphere could destiffen a structure, significant couplings between the elastic and rigid body modes could result in lower flutter speeds and more pronounced aeroelastic response characteristics. These speeds will also generate thermal loads on the structure. The purpose of this research is to develop methodologies applicable to the NASP and to apply them to a representative model to determine its aerothermoelastic characteristics when subjected to these thermal loads. This paper describes an aerothermoelastic analysis of the generic hypersonic vehicle configuration. The steps involved in this analysis were: generating vehicle surface temperatures at the appropriate flight conditions; applying these temperatures to the vehicle's structure to predict changes in the stiffness resulting from material property degradation; predicting the vibration characteristics of the heated structure at the various temperature conditions; performing aerodynamic analyses; and conducting flutter analysis of the heated vehicle. Results of these analyses and conclusions representative of a NASP vehicle are provided in this paper. Author

N94-17117 Aeronautical Research Labs., Melbourne (Australia).
A REVIEW OF AUSTRALIAN AND NEW ZEALAND INVESTIGATIONS ON AERONAUTICAL FATIGUE DURING THE PERIOD APRIL 1991 TO MARCH 1993 Technical Note
J. M. GRANDAGE Apr. 1993 40 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A267532; ARL-TN-32; DODA-AR-008-351) Avail: CASI HC A03

This document was prepared for presentation to the 23rd Conference of the International Committee on Aeronautical Fatigue scheduled to be held in Stockholm, Sweden on June 7 and 8, 1993. A review is given of the aircraft fatigue research and associated activities which form part of the programs of the Aeronautical Research Laboratory, Universities, the Civil Aviation Authority, the Australia aircraft industry and the Defence Scientific Establish, New Zealand. The review summarizes fatigue-related research programs as well as fatigue investigations on specific military and civil aircraft. DTIC

N94-17425 Logicon Technical Services, Inc., Dayton, OH.
DEFINITIONS OF TERMS RELATING TO AIRCRAFT WINDSCREENS, CANOPIES, AND TRANSPARENCIES Final Report, Oct. 1990 - Nov. 1992
MARYANN H. BARBATO, WILLIAM N. KAMA, HARRY L. TASK, MARTHA A. HAUSMANN, and JOHN C. BRIDENBAUGH Mar. 1993 45 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract F33615-89-C-0532)
(AD-A268403; AL-TR-1993-0036) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

This report presents a glossary of terms relating to aircraft windscreens, canopies, and transparencies. It addresses the need to have a single reference source which provides a common vocabulary for use by designers, materials engineers, manufacturers, evaluators, maintenance personnel, and user agencies concerned with aircraft transparencies. Its intent is to facilitate and enhance communication between these disciplines by clarifying and defining terms used within the aircraft transparency industry. DTIC

N94-17435 Naval Air Warfare Center, China Lake, CA. Weapons Div.
EQUATIONS OF MOTION OF A HINGED BODY OVER A SPHERICAL EARTH Final Report, May 1990 - 1992
MEGAERA C. HALTER Aug. 1993 41 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A268408; NAWCWPNS-TP-8134) Avail: CASI HC A03

The six-degree-of-freedom (6-DOF) equations of motion are derived in vector form for a hinged vehicle flying over a spherical Earth. Initially, the most general form of the equations is developed assuming that the combustor may roll with respect to the body, as well as deflect in pitch and yaw. Next, the primary case is developed in which the combustor cannot roll with respect to the body. Finally, these equations are specialized to dime simpler cases. The motivation for deriving this set of equations is to support feasibility studies of the low drag ramjet (LDR), which is streamlined by deleting all aerodynamic surfaces. AH directional control comes from thrust vectoring, which is accomplished by deflecting the entire motor rather than just the exhaust nozzle, as in more conventional designs. Since the motor is a large fraction of the total vehicle mass, its inertia has a significant effect on the dynamics of the overall vehicle. Sufficient detail is included to serve as a tutorial. DTIC

N94-17472 General Accounting Office, Washington, DC. National Security and International Affairs Div.
NAVAL AVIATION: THE NAVY IS TAKING ACTIONS TO IMPROVE THE COMBAT CAPABILITIES OF ITS TACTICAL AIRCRAFT. REPORT TO CONGRESSIONAL REQUESTERS
Jul. 1993 32 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A268002; GAO/NSIAD-93-204) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The Chairman of the Legislation and National Security Subcommittee of the House Committee on Government Operations and the Chairman of the Oversight of Government Management

Subcommittee of the Senate Committee on Governmental Affairs asked the General Accounting Office to determine whether certain aircraft had the capabilities needed to perform their assigned missions during Operation Desert Storm. This report focuses on several Navy and Marine Corps aircraft. Several factors contributed to the Gulf War victory by creating favorable conditions under which to plan and fight the war, and these should be considered when assessing the effectiveness of U.S. weapons in the war. Commanders had nearly 6 months to plan and develop an air campaign that when initiated, quickly gained air superiority and effectively neutralized much of Iraq's air defense system. In addition, Iraq's forces remained in a primarily defensive posture throughout the war. These factors helped enable the Coalition to determine its tactics and decide when and where offensive air and ground actions would occur. DTIC

N94-17704 Department of the Navy, Washington, DC.
LIFT ENHANCEMENT DEVICE Patent
SAMUEL GREENHALGH, inventor (to Navy) 13 Jul. 1993 10 p Filed 30 Jan. 1992
(AD-D015868; US-PATENT-5,226,618; US-PATENT-APPL-SN-830206) Avail: CASI HC A02/MF A01

A lift enhancing device for an inextensible, membraneous wing is disclosed. The device comprises the 'forced' reattachment of a section of the trailing edge back to the trailing edge so that a warp is introduced therein. The section is reattached with flexible tape to allow oscillation of the section, and increased lift from the wing, at prescribed airspeeds. DTIC

N94-17734 National Aerospace Lab., Amsterdam (Netherlands). Flight Simulation Div.
TAKE-OFF PERFORMANCE MONITORING SYSTEM ALGORITHM AND DISPLAY DEVELOPMENT
SJACK J. L. H. VERSPAY 15 Nov. 1991 13 p Presented at AIAA Atmospheric Flight Mechanics Conference, New Orleans, MA, 12-14 Aug. 1991 Sponsored by Netherlands Agency for Aerospace Programs, Delft Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(NLR-TP-91395-U; ETN-93-94783) Avail: CASI HC A03

As part of a study into the potential safety benefit of a Take Off Performance Monitoring (TOPM) system the development of the algorithms and displays needed for such a system are presented. The predictive algorithms make use of a first order correction polynome which is shown to be capable of predicting performance better than a zero order correction. Three displays for three different types of TOPM, which represent different levels of sophistication, are presented. ESA

N94-17826# Defence Research Agency, Bedford (England).
COMPARISON BETWEEN SWEPT AND DELTA CANARDS ON A MODEL OF A COMBAT AIRCRAFT
D. G. MABEY and C. R. PYNE Feb. 1993 36 p
(AD-A269561; DRA-TM-AP-23; DRIC-BR-318039) Avail: CASI HC A03/MF A01

The aerodynamic characteristics of a low speed half model of a typical combat aircraft configuration fitted with a 65 deg delta canard planform are compared with those for the same model fitted with 44.3 deg swept canard. Both canards had an RAE 104 aerofoil section. The tests were made in the DRA 13 ft x 9 ft Wind Tunnel on a large model of the DRA High Incidence Research Model (HIRM 1), modified to represent the Experimental Aircraft (EAP) configuration. For a 15% smaller planform area, the delta canard gives higher lift and comparable pitching moments for trimming. For canard and wing buffeting the differences are small. Overall, these low speed measurements suggest that delta canards with round leading edges have significant advantages over swept canards for future combat aircraft. DTIC

N94-18227# Notre Dame Univ., IN. Dept. of Aerospace and Mechanical Engineering.
PRELIMINARY STRUCTURAL DESIGN: DEFINING THE DESIGN SPACE Final Report, Sep. 1989 - Dec. 1992
STEPHEN M. BATILL and RICHARD A. SWIFT Feb. 1993 156 p
(Contract F33615-89-C-3208)
(AD-A268898; WL-TR-93-3004) Avail: CASI HC A08/MF A02

A series of studies were performed to evaluate the application of finite element-based analysis and optimization methods to the preliminary design of lightweight, aerospace structures. Either the internal structural arrangement or the structural materials were used as the design variables in each concept study. The concepts considered ranged from truss structures such as a helicopter tail-boom or complex space truss to a series of semi-monocoque lifting surfaces. Both static and dynamic constraints were used in the design of these concepts. Multidisciplinary optimization and analysis procedures were used to develop detailed information from finite element models for each structural concept. From this detailed design data, neural network representations of the design space were developed for the particular problem. The neural networks were then coupled with either simulated annealing or numerical search optimization techniques to identify improved design concepts. DTIC

N94-18240# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
NON-LINEAR FLIGHT DYNAMICS
P. GUICHETEAU *In* AGARD, Non Linear Dynamics and Chaos 13 p Jun. 1993 Sponsored in part by Services Techniques des Programmes Aeronatiques
Copyright Avail: CASI HC A03/MF A02

In Flight Dynamics, aircraft motion is described by a set of non-linear differential equations, depending on parameters, associating the state vector (angle of attack, sideslip angle, speed, angular rates, etc.) with the control vector (motivators, etc.) through flight dynamics equations, aerodynamic model, and flight control system. Some works which aim at improving the knowledge and the prediction of aircraft behavior, in particular flight phases for which classical linearized analysis of non-linear differential equations is insufficient or not valid, are presented. Author (revised)

N94-18315 Aeronautical Research Labs., Melbourne (Australia).
APPLICATION OF THE A* ALGORITHM TO AIRCRAFT TRAJECTORY GENERATION
M. E. HALPERN Jul. 1993 27 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A268728; ARL-TR-20; DODA-AR-007-078) Avail: CASI HC A03

Work carried out on the development of concepts for an automated trajectory generator for military aircraft is described. The system uses the A* optimization algorithm to design a ground track which represents an optimal tradeoff between a short path and a path over low terrain. This is achieved by minimizing a cost function which is user selectable. This work incorporates path segments consisting of circular arcs, the design of an appropriate cost function and heuristics, as well as the inclusion of threats. Measures taken to improve the computational speed of the system are also described. Some examples of trajectories generated by the system are presented. DTIC

N94-18418# Politecnico di Milano (Italy). Dipt. di Ingegneria Aerospaziale.
A DESIGN PROCEDURE FOR SLOTTED FLAPS
SERGIO DEPONTE, ALESSANDRO CELLA, and MARIO MARCAZZAN *In* AGARD, High-Lift System Aerodynamics 6 p Sep. 1993 Sponsored in part by CNR
Copyright Avail: CASI HC A02/MF A04

In the design of slotted flaps it is attempted to avoid a reacceleration between the trailing edge of an upstream element of the system and the peak velocity of the downstream element, to reach the maximum lift. It is proved that it is possible by means of a numerical procedure based on a vortex distribution. The resulting shapes are then discussed with reference to the application to a real design. Author

N94-18431# Defence Research Agency, Farnborough (England).
AN EXPERIMENTAL INVESTIGATION OF THE OPTIMUM SLAT SETTING ON A COMBAT AIRCRAFT MODEL
I. R. M. MOIR *In* AGARD, High-Lift System Aerodynamics 16 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

Tests have been carried out, on a combat aircraft model with high-lift devices, in the DRA Farnborough 5-meter pressurized low-speed wind tunnel. The deflection angle and position of a leading-edge slat were varied and optimum settings established. The separate effects of Reynolds number and Mach number on overall lift coefficient and on the optimum slat setting were investigated. The results show that optimum performance is achieved at a very high slat deflection angle and the performance is strongly influenced by compressibility effects. Author

N94-18432# Defence Research Agency, Farnborough (England).
AN EXPERIMENTAL INVESTIGATION OF ATTACHMENT-LINE TRANSITION ON THE SLAT OF A COMBAT AIRCRAFT MODEL
B. C. HARDY *In* AGARD, High-Lift System Aerodynamics 11 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

An experimental investigation into scale effect at low speed and high lift has been carried out in the DRA 5-m, pressurized wind tunnel on a subsonic strike-fighter model equipped with slotted high-lift devices. The attachment-line boundary layer on the leading-edge slat was found to be turbulent on the outboard part of the wing near maximum lift for a range of unit Reynolds number. An adverse Reynolds number effect on maximum lift was measured which correlated quite well with the onset of attachment-line transition. The conditions for onset of transition were not consistent with the assumption of gross contamination by the fuselage boundary layer, the attachment-line boundary layer remaining laminar on the inboard slat to more than double the expected free-stream Reynolds number. It is suggested that this result is due to spanwise variation in attachment-line position, which results in suppression of the disturbances emanating from the root region of the high-lift wing. It is concluded that attachment-line transition is a potentially significant factor in wind tunnel testing of high-lift wings equipped with leading-edge slats. Author

N94-18436# Wright Lab., Wright-Patterson AFB, OH.
HIGH LIFT AND THE FORWARD SWEPT WING
LAWRENCE A. WALCHLI *In* AGARD, High-Lift System Aerodynamics 9 p Sep. 1993
Copyright Avail: CASI HC A02/MF A04

A broad overview of the X-29 Forward Swept Wing (FSW) Technology Demonstrator Program traces the aircraft's history from design through flight test. Brief descriptions of the aircraft and its flight control system provide insight for evaluating this unique vehicle. Wind tunnel design data substantiate theory and highlight potential solutions to a more 'missionized' aircraft. Flight test results validate the X-29's wind tunnel data base and provide for piloted simulation of possible improvements for the specific X-29 technologies. Author

N94-18442# Aerospatiale, Toulouse (France). Div. Avions.
HIGH-LIFT RESEARCH: APPLICATION TO THE DESIGN OF THE ATR72 FLAP
P. CAPBERN *In* AGARD, High-Lift System Aerodynamics 10 p Sep. 1993
Copyright Avail: CASI HC A02/MF A04

Due to slightly reduced Clmax objectives in landing configuration for the ATR72, compared to the ATR42, the high-lift system of the ATR72 is made up of a single dropped hinge flap, whereas the ATR42 was equipped with a double slotted vane type flap. Elimination of the vane has had a beneficial effect in greatly simplifying the high-lift system for the ATR72. This simplification has been achieved while ensuring that Clmax levels are maintained or improved at same flap deflection (up to the value required for landing), and take-off L/D ratio is improved, which has a direct repercussion on operational performance, such as minimum runway lengths and maximum take-off weight. This aerodynamic performance has been achieved thanks to the systematic introduction, since 1985, of numerical methods in the design phase, in addition to the empirical and experimental methods used almost exclusively until then. The ATR72 flap is indeed the first to be essentially designed with numerical methods at Aerospatiale. Beside this, more severe new regulations for turboprop A/C, leading to a restriction in the use of large flap deflections for the ATR42, the effect of the elimination of the vane on Clmax has been numerically investigated for this A/C. This study having shown promising results, some wind-tunnel and flight test verifications were conducted which confirmed the reliability of the numerical tools. The development of new design and analysis methods has been pursued; it has involved, on one hand, an extension of their field of use and the quality of the modeling, and, on the other, a reduction in the design cycle time. The objective was twofold: better optimization of high-lift systems, and, above all, an appreciable reduction in the associated design costs. Author

N94-18443# Short Bros. and Harland Ltd., Belfast (Northern Ireland). Aerodynamics Dept.
THE AERO-MECHANICAL DESIGN OF A NOVEL FOWLER FLAP MECHANISM
J. R. MATHEWS *In* AGARD, High-Lift System Aerodynamics 9 p Sep. 1993
Copyright Avail: CASI HC A02/MF A04

The flow around a 2-dimensional wing and flap is reviewed using inviscid and viscous computational fluid dynamic techniques. In particular, the effect of flap gap is explored. The results indicate that for optimum aerodynamic performance at low flap angles, flap gaps in the region of 2 to 3 percent are required. A novel 4-bar Fowler flap mechanism is described which is shown to give these required gaps for flap angles greater than 3 degrees. Such a mechanism can be readily optimized for minimum flap overlap at specified take-off flap settings. A comparison of a track and roller arrangement with the 4-bar mechanism indicates significant advantages for the latter. Author

N94-18444# Boeing Defense and Space Group, Seattle, WA.
DESIGN, DEVELOPMENT, AND FLIGHT EVALUATION OF THE BOEING YC-14 USB POWERED LIFT AIRCRAFT
TED C. NARK *In* AGARD, High-Lift System Aerodynamics 17 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

The Boeing YC-14 was designed to perform a 400nm mission carrying a 26000 lb payload and land in 2000 feet on a semi-prepared landing strip. The high-lift system was one that had never been flown before; a upper surface blowing (USB) concept utilizing the 'Coanda' effect. The take-off and landing performance estimates developed from wind tunnel data were completely substantiated in the flight test program. The critical issue of continuing either a landing or takeoff after the loss of one of the two CF6 engines was also proven in the flight test program. The design details behind the performance of the YC-14 are discussed and some of the performance features of the airplane are explained. Author (revised)

N94-18445# Deutsche Airbus G.m.b.H., Bremen (Germany). Aerodynamics Dept.
HIGH-LIFT DESIGN FOR LARGE CIVIL AIRCRAFT
A. FLAIG and R. HILBIG *In* AGARD, High-Lift System Aerodynamics 12 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

A general reflection of the high-lift system design process is given in the first part of the presentation. First the objectives and constraints are reflected which drive the high-lift design for civil transport aircraft. Further information is given on the applied theoretical methods and the Deutsche Airbus wind-tunnel strategy. An example of the high-lift system design process is given in the second part of the presentation. This deals with the conversion of a single-slotted Fowler flap to a part span double slotted flap, a high-lift system which was developed by Deutsche Airbus for the A-321. Author (revised)

N94-18446# De Havilland Aircraft Co. of Canada Ltd., Downsview (Ontario). Technology and Research.
HIGH LIFT SYSTEMS FOR TRANSPORT AIRCRAFT WITH ADVANCED AIRFOILS
B. EGGLESTON and R. J. D. POOLE *In* AGARD, High-Lift System Aerodynamics 13 p Sep. 1993 Sponsored in part by National Research Council of Canada
Copyright Avail: CASI HC A03/MF A04

This paper describes an on-going program of R&D into the development of high lift systems for future propeller driven regional transport aircraft. The work includes tests of two-dimensional airfoils and flaps, while half models are used for wing integration development. Comparisons are made between earlier commuter airfoil designs and advanced supercritical airfoils capable of NLF (natural laminar flow), using single and double-slotted flap systems in both cases. The advanced airfoils were also tested with a leading edge slat. Some effects of Reynolds number on lift characteristics are reviewed which show airfoils without leading edge slats were more sensitive at the scale of the half model used and that higher Reynolds numbers may be required. The advanced airfoils stalled at lower incidences than the commuter airfoils which are much thicker and better tailored to high lift performance. Advanced airfoils will likely require an additional flap segment to achieve similar lift to commuter airfoils. Leading edge slats gave large increases in maximum lift coefficients (up to 30 percent), which would allow substantial increases in wing loading if needed for the future. The half model development has entailed work on improving the sealing of the fuselage to the tunnel wall to minimize leakage. The paper provides some details of such work on high lift models and also on models used for cruise drag investigations. Author

N94-18447# Alenia Aeronautica, Naples (Italy). Flight Technology.
CHOICE AND OPTIMIZATION OF A HIGH-LIFT SYSTEM FOR AN ADVANCED AMPHIBIOUS AIRCRAFT
M. A. AVERARDO, M. DELEO, and V. RUSSO *In* AGARD, High-Lift System Aerodynamics 13 p Sep. 1993
Copyright Avail: CASI HC A03/MF A04

The design history of a flap system for an advanced amphibious aircraft is presented in this paper. All the most significant phases of the 2D theoretical studies and the experimental 2D and 3D investigations which have allowed to achieve the final geometry of the high-lift device will be described and, hence, the design criteria, the methods of analysis, the choices will be pointed out. Starting from the preliminary design of several flap systems, the development of this project needed a great deal of numerical studies and wind-tunnel tests in order to select, step by step, the most efficient geometries and to optimize the flap configurations. So, different technical aspects involved with these activities will be discussed: the choice of the flap types to be investigated, related to the special aerodynamic requirements of an amphibious aircraft and to the needs of other design areas (structure, weight, production); the geometrical elements effecting the aerodynamic performance of a high-lift device; general problems connected with theoretical and experimental studies of multi-body systems. Author (revised)

N94-18577 KSA Technology, Columbus, OH.
LIFT AND PITCHING MOMENT INDUCED ON JET STOVL AIRCRAFT HOVERING IN GROUND EFFECT Final Report
RICHARD E. KUHN and VEARL R. STEWART Jun. 1993 593 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract F33615-89-C-3611)
(AD-A269700; KSA-92-2; WL-TR-93-3044) Avail: CASI HC A25

The data obtained during an investigation of the effects of crossflow on the suckdown and fountain effects induced by various arrangements of vertically impinging jets are presented in this report. The jet arrangements included circular and rectangular jets in various single, dual, and triple jet configurations. The tests were conducted in the 14 by 22 foot tunnel at the NASA LaRC. Tests covered a range of heights above the ground, nozzle pressure ratios, and forward velocities. DTIC

N94-18733# KSA Technology, Columbus, OH.
LIFT AND PITCHING MOMENT INDUCED ON JET STOVL AIRCRAFT BY THE GROUND VORTEX Final Report, May 1990 - 1993
RICHARD E. KUHN and VEARL R. STEWART Jun. 1993 106 p
(Contract F33615-89-C-3611)
(AD-A269816; KSA-92-1; WL-TR-93-30445) Avail: CASI HC A06/MF A02

The data obtained during an investigation of the effects of the ground vortex on a generic wing-body configuration are presented in this report. Circular, rectangular, and thrust reverser jets were tested. The tests were conducted in the 14 by 22 foot tunnel at the NASA Langley Research Center. The tests covered a range of heights above the ground, forward velocities, and ground belt speeds. DTIC

N94-18779# Wright Lab., Wright-Patterson AFB, OH.
PROCEDURES AND DESIGN DATA FOR THE FORMULATION OF AIRCRAFT CONFIGURATIONS Final Report, Jan. 1992 - Jun. 1993
THOMAS R. SIERON, DUDLEY FIELDS, A. W. BALDWIN, and DAVID W. ADAMCZAK Aug. 1993 153 p
(AD-A270150; WL-TR-93-3068) Avail: CASI HC A08/MF A02

This report contains design data and rapid analysis methods to assist in establishing an initial aircraft configuration to begin the conceptual design process. It is based on an array of data acquired over many years for fighter, bomber, and transport aircraft. The data is compiled to estimate the gross take-off weight and physical size of a representative configuration for various range, payload, and speed requirements. Other data and procedures are included to define the general dimensions of the fuselage, wing, vertical, and horizontal stabilizers. Aerodynamic methods and data are provided to rapidly estimate the drag and lift characteristics at subsonic, transonic, and supersonic speeds for this class of aircraft. Performance data has been assembled to show the impact of range, payload, speed, maneuverability, take-off and landing requirements on the physical and geometric characteristics of these configurations. A sample problem is presented to illustrate the use of this design data in formulating an aircraft configuration. DTIC

N94-18789# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
VERTICAL DROP TEST OF A METRO 3 AIRCRAFT Final Report, Apr. 1991 - Apr. 1992
ROBERT J. MCGUIRE, WILLIAM J. NISSLEY, and JAMES E. NEWCOMB Jun. 1993 80 p
(AD-A270032; DOT/FAA/CT-93/1) Avail: CASI HC A05/MF A01

A commuter category Fairchild Metro 3 fuselage and wingbox assembly was subjected to a vertical impact test at the Federal Aviation Administration (FAA) Technical Center, Atlantic City International Airport, NJ. The purpose of the test was to measure the structural response of the fuselage, floor, cabin furnishings (including standard and modified seats), and anthropomorphic dummies. The test was conducted to simulate the potentially survivable impact conditions of an actual crash. The airframe was dropped from 11.2 feet and impacted at a velocity of 26.32 feet per second (ft/sec). The test weight simulated an airplane configuration that was approximately 1,450 pounds less than the maximum zero fuel weight (13,100 pounds) of the airplane with a 14,100-pound maximum takeoff weight. Acceleration, load, and deflection data were collected throughout the test. Instrumentation were located on the fuselage, floor, seats, and within the 'crash test dummies.' The vertical impact test resulted in peak accelerations of gravity (g) ranging from 40g to 60g throughout the airframe. DTIC

N94-18795# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
FLIGHT TEST TECHNIQUES FOR AIRCRAFT PARAMETER ESTIMATION IN GROUND EFFECT M.S. Thesis
JAMES M. CLARK 1993 146 p
(AD-A270058; AFIT/CI/CIA-93-145) Avail: CASI HC A07/MF A02

The effect of ground proximity on the performance and handling of an aircraft has received extensive study, particularly in the wind tunnel. Previous research, however, provides few consistent quantitative conclusions regarding ground effect, and flight test methods for directly measuring ground effect are needed. This effort identifies flight test maneuvers suitable for measuring aircraft stability and control parameters in ground effect, using simulated response data and pEst, a parameter estimation program developed at NASA-Dryden. This study also considers the effects of instrument precision, system sampling rate, instrument bias, and response noise. Five simple longitudinal and eleven lateral-directional maneuvers that allow accurate parameter estimation, keep the aircraft in ground effect, and do not result in responses that are unsafe in ground proximity are identified. The longitudinal maneuvers provide accurate lift and moment parameters, and the lateral-directional analysis estimates all fifteen lateral-directional derivatives of interest within ten percent of their simulated values. DTIC

N94-18962* National Aeronautics and Space Administration, Washington, DC.
X-29: RESEARCH AIRCRAFT (Videotape)
Jan. 1991 Videotape: 2 min. 35 sec. playing time, in color, with sound
(NASA-TM-109370; NONP-VT-94-198217) Avail: CASI VHS A01/BETA A22

A preliminary look at the Ames Dryden Flight Research Center in the context of the X-29 aircraft is provided. The uses of the X-29's 30 deg forward swept wing are examined. The video highlights the historical development of the forward swept wing, and its unique blend of speed, agility, and slow flight potential. The central optimization of the wing, the forward canard, and the rear flaps by an onboard flight computer is also described. CASI

N94-19448*# Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
AN INVESTIGATION OF FIGHTER AIRCRAFT AGILITY Final Technical Report, 1 Jan. 1989 - 31 Dec. 1993
JOHN VALASEK and DAVID R. DOWNING 5 Nov. 1993 263 p
(Contract NCC2-588)
(NASA-CR-194608; NAS 1.26:194608; KU-FRL-831-7) Avail: CASI HC A12/MF A03

This report attempts to unify in a single document the results of a series of studies on fighter aircraft agility funded by the NASA Ames Research Center, Dryden Flight Research Facility and conducted at the University of Kansas Flight Research Laboratory during the period January 1989 through December 1993. New metrics proposed by pilots and the research community to assess fighter aircraft agility are collected and analyzed. The report develops a framework for understanding the context into which the various proposed fighter agility metrics fit in terms of application and testing. Since new metrics continue to be proposed, this report does not claim to contain every proposed fighter agility metric. Flight test procedures, test constraints, and related criteria are developed. Instrumentation required to quantify agility via flight test is considered, as is the sensitivity of the candidate metrics to deviations from nominal pilot command inputs, which is studied in detail. Instead of supplying specific, detailed conclusions about the relevance or utility of one candidate metric versus another, the authors have attempted to provide sufficient data and analyses for readers to formulate their own conclusions. Readers are therefore ultimately responsible for judging exactly which metrics are 'best' for their particular needs. Additionally, it is not the intent of the authors to suggest combat tactics or other actual operational uses of the results and data in this report. This has been left up to the user community. Twenty of the candidate agility metrics were selected for evaluation with high fidelity, nonlinear, non real-time flight simulation computer programs of the F-5A Freedom Fighter, F-16A Fighting Falcon, F-18A Hornet, and X-29A. The information and data presented on the 20 candidate metrics which were evaluated will assist interested readers in conducting their own extensive investigations. The report provides a definition and analysis of each metric; details of how to test and measure the metric, including any special data reduction requirements; typical values for the metric obtained using one or more aircraft types; and a sensitivity analysis if applicable. The report is organized as follows. The first chapter in the report presents a historical review of air combat trends which demonstrate the need for agility metrics in assessing the combat performance of fighter aircraft in a modern, all-aspect missile environment. The second chapter presents a framework for classifying each candidate metric according to time scale (transient, functional, instantaneous), further subdivided by axis (pitch, lateral, axial). The report is then broadly divided into two parts, with the transient agility metrics (pitch lateral, axial) covered in chapters three, four, and five, and the functional agility metrics covered in chapter six. Conclusions, recommendations, and an extensive reference list and biography are also included. Five appendices contain a comprehensive list of the definitions of all the candidate metrics; a description of the aircraft models and flight simulation programs used for testing the metrics; several relations and concepts which are fundamental to the study of lateral agility; an in-depth analysis of the axial agility metrics; and a derivation of the relations for the instantaneous agility and their approximations. Author (revised)

N94-19496# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Hubschrauber und Flugzeuge.
NEW AIRCRAFT MATERIALS AND STRUCTURES [NEUE FLUGWERKSTOFFE UND BAUWEISEN]
JUERGEN KLENNER, JOHANN KRAMMER, HANS LONSINGER, and JOSEF VILSMEIER 28 Aug. 1992 41 p In GERMAN Submitted for publication Original contains color illustrations
(MBB-LME-202-S-PUB-502-A; ETN-93-95093) Copyright Avail: CASI HC A03/MF A01

The features of fiber composite materials employed in military aircraft design are reviewed. Fiber reinforced plastics are made with duromer matrices, such as polyester, epoxy, bismaleimide, and polyimide, or thermoplastic matrices, such as polyether ether ketone, polypropylene sulfide, and polyether imide. Carbon fibers were differentiated as high strain, intermediate modulus, and high modulus fibers. Mechanical properties of prepregs and laminates are described. The way in which fiber reinforced composites are fitted to aircraft structure weight minimization is ascertained. The use of the NASTRAN (NASA Structural Analysis) program to calculate aircraft structures with the finite element method is depicted. The importance of multidisciplinary optimization (flight controls, aerodynamics, and flight mechanics) in aircraft design is outlined. Manufacturing processes for composites production, such as tape steering, hot forming, net molding, and co-curing are reviewed. Methods for nondestructive inspection of aircraft materials, such as ultrasonic evaluation, holography, and thermography, are depicted. Carbon fiber composites are concluded to be particularly interesting for aircraft development because of their properties of mechanical strength, repairability, and maintainability. ESA

N94-19500# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Militaerflugzeuge.
THREE DIMENSIONAL NETWORK GENERATION AND EULER CALCULATION FOR A WING FUSELAGE CANARD CONFIGURATION Thesis - Tech. Univ. Munich [DREIDIMENSIONALE NETZGENERIERUNG UND EULERRECHNUNG FUER FLUEGEL-RUMPF-CANARD KONFIGURATION]
OLIVER VOGELGESANG Dec. 1992 92 p In GERMAN Original contains color illustrations
(MBB-LME-211-S-PUB-511-A; ETN-93-95095) Copyright Avail: CASI HC A05/MF A01

A vortex flow model, based on a computer aided design surface model of a body with a curve and surface representation, is developed. After establishing the topology (location and order of blocks in space), each block was described with six simple three dimensional areas and the corresponding block edges. Geometrical data were fed in VDA-FS (German acronym for Union of Automobile Industry - interface) format by the Dogrid surface net generator. All blocks were connected into a calculation domain in order to perform Euler calculations for delta wing configurations with and without canard. Euler equations in a conservative form were solved with a finite volume scheme; a biased upwind difference scheme of Godunov type was used for the fluxes in the cell boundaries and the Newton method supplied a time implicit solution. The front edge vortex on the main wing was accurately obtained and the predicted interferences of both vortex systems of canard and main wing could be attested. ESA

N94-19781 Army Research Lab., Aberdeen Proving Ground, MD.
BLADE AND HUB LOADS OF BALLISTICALLY DAMAGED HELICOPTER ROTORS Final Report, Apr. 1992 - May 1993
KI C. KIM Oct. 1993 44 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A270663; ARL-TR-235) Avail: CASI HC A03

The effects of (simulated) ballistic damage on helicopter rotor blade response and rotor hub loads are investigated. A finite element formulation based on Hamilton's principle is used for structural analysis, and aerodynamic loads are calculated using quasisteady aerodynamic theory. Each blade is as being composed of elastic beams undergoing flap bending, lag bending, elastic twist, and axial deflections. Dynamic responses of multi-blade rotor systems are calculated from nonlinear periodic normal mode equations using a finite element in time scheme. Results are calculated for the SA349/2 Gazelle helicopter for both undamaged and damaged blade configurations. Blade damage effects are determined in terms of blade mode shapes and frequencies, aeroelastic response, and rotor hub loads. Blade dissimilarity due to ballistic damage can induce a luge 1/rev vibratory component on the rotor hub. DTIC

N94-19796# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
NOISE MEASUREMENTS ON TWO TYPES OF AIRPLANES USED FOR SPRAYING IN AGRICULTURE [GELUIDSMETINGEN AAN TWEE TYPEN LANDBOUW-SPROEIVLIEGTUIGEN]
D. M. VANPAASSEN and G. J. J. RUIJGROK Dec. 1992 19 p In DUTCH
(LR-706; ETN-93-94423) Avail: CASI HC A03/MF A01

The flyover noise of two types of propeller driven, single engined airplanes, used for agricultural purposes, was measured. The flyovers were conducted at two different altitudes over the microphone position. The flight runs were further divided into two flight profiles. The first profile required the aircraft to perform a standard climb-out after takeoff using the power setting and air speed for maximum climb rate. The second profile contained the execution of level flights at constant (normal) cruising speed and cruising power. The different noise levels are listed. ESA

N94-19914 Aeronautical Research Labs., Melbourne (Australia).
DEVELOPMENT AND OPERATION OF THE F/A-18 MODEL CONTROL SURFACE ACTUATORS
S. S. LAM and Y. Y. LINK Aug. 1993 29 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A271330; ARL-TN-29; DODA-AR-008-345) Avail: CASI HC A03

A series of test programs in the ARL 2.7m x 2.1m Low Speed Wind Tunnel of a 1/9th scale model of the F/A-18 required the development of a software package to drive the control surfaces. This software is written in VAX FORTRAN for a MicroVAX 2 computer. The software communicates with the model through a specially designed Actuator Module that responds to requests from the MicroVAX 2 computer. In order to establish the relationship between control surface angles and Linear Variable Differential Transformer readings a cubic spline interpolation method has been implemented. This report describes the development and operation of the control surface actuators' software and contains a detailed guide for its use. DTIC

N94-20040 Department of Defense, Arlington, VA. Office of Inspector General.
AUDIT REPORT. NAVY'S AIRCRAFT STRUCTURAL LIFE SURVEILLANCE PROGRAM DATA RECORDERS
12 Nov. 1992 15 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A270391; IG/DOD-93-022) Avail: CASI HC A03

We are providing this final report for your information and use. This audit was performed in response to a DoD Inspector General hotline allegation that the Navy's planned $188 million procurement of structural data recorders under the Navy's Aircraft Structural Life Surveillance Program duplicated existing Navy recorder systems. The recorder monitors the structural stress that an aircraft experiences during operation. Our objective was to evaluate the validity of this allegation. The effectiveness of applicable internal controls was also evaluated. The Navy's Aircraft Structural Life Surveillance Program data recorder does not duplicate any existing Navy recorder systems. The structural data recorder does duplicate functions of a similar Air Force system. However, it is no longer practicable or economical for the Navy and the Air Force to combine their structural recorder systems because both have already installed and integrated these recorder systems in substantial numbers of aircraft. DTIC

N94-20188# Wichita State Univ., KS. National Inst. for Aviation Research.
PROCEEDINGS OF THE TWENTIETH ANNUAL TECHNOLOGYFEST
1993 25 p Technologyfest held in Wichita, KS, 12-13 Nov. 1993; cosponsored by AIAA
Avail: CASI HC A03/MF A01

The program for the twentieth annual Techfest held November 12 - 13, 1993 is accompanied by abstracts of selected topics. Design topics include a supersonic oblique all-wing transport aircraft, an application of neural networks to airfoil design, aircraft nosewheel steering simulation, an alternative parameter airfoil optimization method, a high altitude long endurance aircraft with manufacturing considerations, and integrated design of controllers with bang bang and proportional control effectors. Structures topics include reducing structural loads, failure of aircraft structures due to internal blast, and geriatrics of commercial airplanes. Aerodynamics topics include visualization of the multiple supersonic jet oscillations by swept focused strobed schlieren technique, the near-wake flow behavior of an oscillating airfoil with modified trailing edge, full span flaperons for a biplane, an experimental investigation of helicopter rotor downwash and tail boom interaction at the WSU 7 x 10 foot wind tunnel, and incorporating biplane wing theory into a large subsonic all-cargo transport. CASI

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A94-10114
THE METHODS OF SYSTEMS ANALYSIS AND OPTIMIZATION FOR THE ANEROID BAROMETRIC ALTIMETER
JIANGUO YANG (Beijing Univ. of Aeronautics and Astronautics, China) Beijing University of Aeronautics and Astronautics, Journal (ISSN 1001-5965) no. 1 Jan. 1992 p. 106-111. In CHINESE refs

The system model of an aneroid barometric altimeter is

established, and direct-search algorithms of multivarible optimization are derived. The structural characteristics and the indicative error are analyzed in detail. Methods of simulation adjustment and design optimization for the altimeter are provided.
Author (revised)

A94-11480*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A QUANTITATIVE ANALYSIS OF THE F18 FLIGHT CONTROL SYSTEM
STACY A. DOYLE (Duke Univ., Durham, NC), JOANNE B. DUGAN (Virginia Univ., Charlottesville), and ANN PATTERSON-HINE (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 668-675. refs
(Contract NCA2-617)
(AIAA PAPER 93-4574) Copyright
This paper presents an informal quantitative analysis of the F18 flight control system (FCS). The analysis technique combines a coverage model with a fault tree model. To demonstrate the method's extensive capabilities, we replace the fault tree with a digraph model of the F18 FCS, the only model available to us. The substitution shows that while digraphs have primarily been used for qualitative analysis, they can also be used for quantitative analysis. Based on our assumptions and the particular failure rates assigned to the F18 FCS components, we show that coverage does have a significant effect on the system's reliability and thus it is important to include coverage in the reliability analysis.

A94-11535#
PILOT'S ASSOCIATE - A SYNERGISTIC SYSTEM REACHES MATURITY
ALFONSO A. LAPUMA (USAF, Wright-Patterson AFB, OH) and CAROL A. MARLIN (Lockheed Aeronautical Systems Co., Marietta, GA) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1131-1141. refs
(AIAA PAPER 93-4665)
The concept of the Pilot's Associate (PA) and the progression of the air-to-air development through both phases of the program (to define the functionality necessary to implement a complete PA, and to prove the viability and utility of a PA system) are discussed. The overall objective of the PA program was to apply cooperative knowledge-based systems and advanced computing technologies to the cockpits of advanced tactical fighters in order to improve combat effectiveness and survivability. Each module focused on a functional area: system status, mission planner, situation asssessment, tactics planner, and pilot-vehicle interface. The mission support tool was a premission planner that offered planning and analysis tools. PA offered the first-ever cooperating knowledge-based system, the creation of a workable plan-goal graph to provide true associate system, behavior, compacting to a single avionics rack to prove PA's viability, and the transition to numerous additional applications. AIAA

A94-11711
MMW TECHNOLOGY FOR ENHANCED SITUATION AWARENESS/ENHANCED VISION SYSTEMS
MARK L. SELOGIE (Hughes Aircraft Co., Los Angeles, CA) *In* Enhanced situation awareness technology for retrofit and advanced cockpit design; Proceedings of the SAE Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Warrendale, PA Society of Automotive Engineers, Inc. 1992 p. 27-31.
(SAE PAPER 921929) Copyright
The use of millimeter wave (MMW) radar technology to provide pilots with enhanced vision and enhanced situation awareness is examined. The development of the Enhanced Vision System (EVS) and its use of MMW is reviewed. The EVS MMW system requirements are listed and discussed. AIAA

A94-11722* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COCKPIT DATA LINK DISPLAYS - AN EVALUATION OF TEXTUAL FORMATS
ALISON MCGANN (Sterling Software, Moffett Field, CA), SANDRA LOZITO (San Jose State Univ., CA), and KEVIN CORKER (NASA, Ames Research Center, Moffett Field, CA) *In* Enhanced situation awareness technology for retrofit and advanced cockpit design; Proceedings of the SAE Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Warrendale, PA Society of Automotive Engineers, Inc. 1992 p. 155-160. refs
(SAE PAPER 922025) Copyright
Data link technologies are being investigated for air/ground information transfer for commercial aircraft operation. This study was designed to measure which of four alpha-numeric display formats for display of data link information would lead to the quickest and most accurate memory retrieval in a part-task simulation environment. Pilots viewed a clearance for 10-15 seconds and were subsequently queried about the content of that clearance. Speed and accuracy of responses were measured across three retention tasks. The three retention tasks included free recall of a particular clearance. recognition of a previous clearance, and the comparison of element values between a previously displayed and current clearance. Each format was tested with and without a distraction task. Subjective ratings of each format were also collected. The analyses revealed no significant differences for reaction time or accuracy among the four formats. Explanations for these results as well as alternative methodologies are discussed.

A94-11971
FUTURE CONCEPTS FOR MAINTENANCE AND THE INCREASING ROLE OF ON-BOARD MAINTENANCE
ROGER S. GOLDBERG (Aeronautical Radio, Inc., Annapolis, MD) and PAT M. WINDHAM (Delta Air Lines, Inc., Atlanta, GA) Oct. 1992 7 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921921) Copyright
As things stand, in a typical troubleshooting scenario, the cockpit centralized fault-display system is reviewed together with pilot reports from flight deck-observed effects. Built-in test equipment codes from the various reporting systems are reviewed; numerous faults may appear in the case of a power failure which are related to an initial fault. Maintenance efforts will then likely proceed in rather trial-and-error fashion until all faults on the display vanish. Recommendations are here presented for next-generation onboard maintenance systems capable of circumventing these problems.
AIAA

A94-12035
DATA, DECISIONS, AND COCKPIT TECHNOLOGY
NEIL C. KREY Oct. 1992 8 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922049) Copyright
This paper presents an operational philosophy proposing the design of automated cockpit systems whose capabilities are organized into 'levels-of-service' that may be 'ordered' by the crew. Service-based training would encourage the crew to 'purchase' required automation services using workload as a medium of exchange, with the goal of 'earning a profit' from the transaction.
Author (revised)

A94-12227
THE NIGHT VISION CAPABILITY OF THE TIGER HELICOPTER
O. PRAT (Societe Anonyme de Telecommunications, Div. Optronique et Defense, Paris, France) 1992 12 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by Ministere de la Defense and BMVg
Condor 2 is the IR-detecting CCD sensor-based thermal camera of the Tiger helicopter pilot's avionics, and is designed to allow the helicopter to safely perform low-altitude flights both in nocturnal and poor-weather conditions. An account is here given of the

operational principles of the Condor 2 system, and to test results indicative of the fulfilment of thermal sensitivity requirements. Plausible courses to improvement of field-of-view and elevation range are noted. AIAA

A94-12229
AVIONICS FOR NEW GENERATION HELICOPTERS
D. POULACHON and F. HEBERT (Sextant Avionique, Valence, France) 1992 9 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

Some new concepts and architectural and design principles proposed for new-generation helicopter avionics are outlined. In particular, attention is given to the principle of modularity, easy fault isolation, and reduction in the number of items to be managed and kept in maintenance stocks. The modules can be standalone items with their own resources and capacities, including power supply; computing and memory; mechanical protection, filtering, and lightning strike protection; safeties (e.g., redundancy, comparison, and identification); input/outputs; and connections. Each module can also be based on a standardized common model. A component design example is included. AIAA

A94-12231
HELICOPTER NVG COMPATIBLE COCKPIT ILLUMINATION ASSESSMENTS
H.-D. V. BOEHM, J. FRANK, and S. HAISCH (Eurocopter Deutschland GmbH, Munich, Germany) 1992 22 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

Measurements of NVG (Night Vision Goggles) radiance, luminance, chromaticity coordinates, colors, and contrasts are presented for different illumination techniques in helicopter cockpits. In particular, attention is given to the problems involved and improvements made after assessments on the Primary Integration Rig. The discussion covers visual aids and night levels, NVG compatibility requirements, the Night Vision Laboratory, resolution measurements of image intensifier tubes, and helicopter cockpit illumination technologies. AIAA

A94-12266
AN EXPLORATION OF THREE DIMENSIONAL COMPUTER GRAPHICS IN COCKPIT AVIONICS
PETER W. PRUYN and DONALD P. GREENBERG (Cornell Univ., Ithaca, NY) *In* Electroluminescent materials, devices, and large-screen displays; Proceedings of the Meeting, San Jose, CA, Feb. 1, 2, 1993 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1993 p. 244-258. refs
(Contract NSF DCR-82-03979)
Copyright

The use of 3D computer graphics as a basis for the integration and visualization of flight information in next-generation cockpits is investigated. An effort is made to visually represent information that was previously representable only by numerical means, such as airport wind conditions (directions and magnitudes); this is presently shown in the form of a 'windsock'. The feedback symbols used in the display should mimic the mental model that is being used by the pilot to present task-components pictorially. AIAA

A94-12554
SIGNAL ACQUISITION AND TRACKING IN THE DOD STANDARD MINIATURIZED AIRBORNE GPS RECEIVER
JEFF L. KACIREK and REDGE G. BARTHOLOMEW (Rockwell International Corp., Cedar Rapids, IA) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 53-62. refs
Copyright

This paper presents the signal acquisition and tracking capabilities and performance of the DOD standard Miniaturized Airborne GPS Receiver (MAGR) produced by the Collins Avionics and Communications Division, Rockwell International. This includes a presentation of signal acquisition, tracking, and reacquisition strategies; a discussion of how these strategies are affected by the MAGR's rapid acquisition and enhanced anti-jamming assets; consideration of the effect on these strategies of handling multiple codes and frequencies, handling jamming, off-nominal signal strength, and spoofing (unclassified); and a presentation of satellite selection methods, data collection strategies, and signal delay determination and calibration methods. Performance data captured during the government's qualification tests is included; they identify acquisition and reacquisition speeds, and tracking reliability statistics under both benign as well as worst case conditions. Author (revised)

A94-12555
FLIGHT TEST OF THE EXPLORATORY GIMBALLED AIRBORNE ESG SYSTEM
WILLIAM G. MILLER and PALMER O. HANSON (Honeywell, Inc., Clearwater, FL) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 81-89. Research supported by USAF refs
Copyright

Flight testing of the USAF exploratory gimballed inertial navigation system using electrically suspended gyros (ESGs) is discussed. For 12 test flights the system demonstrated 0.15 nmi/hr performance, at a time when the accepted state-of-the-art performance for airborne inertial navigation systems was at the 1.0 nmi/hr level and the emphasis in further development was on cost reduction rather than performance improvement. Other significant flight test accomplishments included demonstration of powerful performance analysis techniques which relied on the absence of physical gyro compensation such that the accelerometer outputs were independent of computer software. This permitted the simultaneous, on-line operation of multiple independent navigation solutions from a single inertial platform. An extension of the concept involved the recording of the accelerometer outputs for later playback into a navigation computer. The resulting navigation solutions are as valid a measure of system performance as if the solution had been obtained on-line. AIAA

A94-12565
DEVELOPMENT OF A GPS-AIDED MOTION MEASUREMENT, POINTING AND STABILIZATION SYSTEM FOR A SYNTHETIC APERTURE RADAR
JOHN R. FELLERHOFF and STEWART M. KOHLER (Sandia National Labs., Albuquerque, NM) *In* Inst. of Navigation, Annual Meeting, 48th, Washington, June 29-July 1, 1992, Proceedings Alexandria, VA Institute of Navigation 1992 p. 291-296. Previously announced in STAR as N93-11152
(Contract DE-AC04-76DP-00789)
Copyright

An advanced Synthetic Aperture Radar Motion Compensation System has been developed by Sandia National Laboratories (SNL). The system includes a miniaturized high accuracy ring laser gyro inertial measurement unit, a three axis gimbal pointing and stabilization assembly, a differential Global Positioning System (GPS) navigation aiding system, and a pilot guidance system. The system provides several improvements over previous SNL motion compensation systems and is capable of antenna stabilization to less than 0.01 degrees RMS and absolute position measurement to less than 5.0 meters RMS. These accuracies have been demonstrated in recent flight testing aboard a DHC-6-300 'Twin Otter' aircraft.

A94-12598
METHOD FOR INFERRING SENSOR ATTITUDE THROUGH MULTI-FEATURE TRACKING
W. C. CHOATE (Texas Instruments, Inc., Dallas) *In* Acquisition, tracking, and pointing VI; Proceedings of the Meeting, Orlando, FL, Apr. 22-24, 1992 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1992 p. 414-423. refs
Copyright

An algorithm for determining the attitude of an imaging sensors relative to its attitude at a reference time is described. The algorithm was developed to meet the needs of passive ranging where accurate estimates of attitude are crucial to performance and are difficult to obtain, especially when the sensor and INS are not colocated. Using the algorithm, it is not difficult to obtain estimates of relative motion to the required accuracy. AIAA

A94-12621
TECHNOLOGY INTEGRATION IN ADVANCED COMMERCIAL AIRCRAFT COCKPITS AND OPERATIONAL SYSTEMS
JEAN GROSSIN (Aerospatiale, Toulouse, France) *In* Control and dynamic systems. Vol. 52 - Integrated technology methods and applications in aerospace systems design San Diego, CA Academic Press, Inc. 1992 p. 435-451.
Copyright

The paper discusses the technology integration concepts for advanced commercial aircraft, with particular consideration given to applications on the Airbus aircraft. The main integrated systems on the latest aircraft of the Airbus family are the primary air data/inertial references, instrument display systems, radio systems, engine control, flight controls, and the autoflight systems. The evolution of these systems is described. AIAA

A94-12622* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
DEVELOPMENT OF A PNEUMATIC HIGH-ANGLE-OF-ATTACK FLUSH AIRDATA SENSING (HI-FADS) SYSTEM
STEPHEN A. WHITMORE, TIMOTHY R. MOES (NASA, Flight Research Facility, Edwards, CA), and CORNELIUS T. LEONDES (California Univ., La Jolla) *In* Control and dynamic systems. Vol. 52 - Integrated technology methods and applications in aerospace systems design San Diego, CA Academic Press, Inc. 1992 p. 453-511. refs
Copyright

The HI-FADS system design is an evolution of the FADS systems (e.g., Larson et al., 1980, 1987), which emphasizes the entire airdata system development. This paper describes the HI-FADS measurement system, with particular consideration given to the basic measurement hardware and the development of the HI-FADS aerodynamic model and the basic nonlinear regression algorithm. Algorithm initialization techniques are developed, and potential algorithm divergence problems are discussed. Data derived from HI-FADS flight tests are used to demonstrate the system accuracies and to illustrate the developed concepts and methods. AIAA

N94-13256*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PERSPECTIVE ON THE NATIONAL AERO-SPACE PLANE PROGRAM INSTRUMENTATION DEVELOPMENT
RODNEY K. BOGUE and PETER ERBLAND (Air Force Systems Command, Wright-Patterson AFB, OH.) May 1993 22 p
Presented at the Aero Space Planes Conference, Orlando, FL, 1-3 Dec. 1992 Previously announced in IAA as A93-22356
Sponsored by NASA, Washington
(Contract RTOP 763-21-41)
(NASA-TM-4505; H-1916; NAS 1.15:4505) Copyright Avail: CASI HC A03/MF A01

A review of the requirement for, and development of, advanced measurement technology for the National Aerospace Plane program is presented. The objective is to discuss the technical need and the program commitment required to ensure that adequate and timely measurement capabilities are provided for ground and flight testing in the NASP program. The scope of the measurement problem is presented, the measurement process is described, how instrumentation technology development has been affected by NASP program evolution is examined, the national effort to define measurement requirements and assess the adequacy of current technology to support the NASP program is discussed, and the measurement requirements are summarized. The unique features of the NASP program that complicate the understanding of requirements and the development of viable solutions are illustrated. Author (revised)

N94-13316*# Boeing Defense and Space Group, Philadelphia, PA.
HANDLING QUALITIES EFFECTS OF DISPLAY LATENCY
DAVID W. KING *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 329-340 Jul. 1993
Avail: CASI HC A03/MF A04

Display latency is the time delay between aircraft response and the corresponding response of the cockpit displays. Currently, there is no explicit specification for allowable display lags to ensure acceptable aircraft handling qualities in instrument flight conditions. This paper examines the handling qualities effects of display latency between 70 and 400 milliseconds for precision instrument flight tasks of the V-22 Tiltrotor aircraft. Display delay effects on the pilot control loop are analytically predicted through a second order pilot crossover model of the V-22 lateral axis, and handling qualities trends are evaluated through a series of fixed-base piloted simulation tests. The results show that the effects of display latency for flight path tracking tasks are driven by the stability characteristics of the attitude control loop. The data indicate that the loss of control damping due to latency can be simply predicted from knowledge of the aircraft's stability margins, control system lags, and required control bandwidths. Based on the relationship between attitude control damping and handling qualities ratings, latency design guidelines are presented. In addition, this paper presents a design philosophy, supported by simulation data, for using flight director display augmentation to suppress the effects of display latency for delays up to 300 milliseconds. Author

N94-13323*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EVALUATION OF TWO COCKPIT DISPLAY CONCEPTS FOR CIVIL TILTROTOR INSTRUMENT OPERATIONS ON STEEP APPROACHES
WILLIAM A. DECKER, RICHARD S. BRAY, RICKEY C. SIMMONS, and GEORGE E. TUCKER *In its* Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 433-452 Jul. 1993
Avail: CASI HC A03/MF A04

A piloted simulation experiment was conducted using the NASA Ames Research Center Vertical Motion Simulator to evaluate two cockpit display formats designed for manual control on steep instrument approaches for a civil transport tiltrotor aircraft. The first display included a four-cue (pitch, roll, power lever position, and nacelle angle movement prompt) flight director. The second display format provided instantaneous flight path angle information together with other symbols for terminal area guidance. Pilots evaluated these display formats for an instrument approach task which required a level flight conversion from airplane-mode flight to helicopter-mode flight while decelerating to the nominal approach airspeed. Pilots tracked glide slopes of 6, 9, 15 and 25 degrees, terminating in a hover for a vertical landing on a 150 feet square vertipad. Approaches were conducted with low visibility and ceilings and with crosswinds and turbulence, with all aircraft systems functioning normally and were carried through to a landing. Desired approach and tracking performance was achieved with generally satisfactory handling qualities using either display format on glide slopes up through 15 degrees. Evaluations with both display formats for a 25 degree glide slope revealed serious problems with glide slope tracking at low airspeeds in crosswinds and the loss of the intended landing spot from the cockpit field of view. Author

N94-13451# National Aerospace Lab., Tokyo (Japan). Short Take-Off and Landing Research Aircraft Group.
POSITION ERROR DETERMINATION FOR THE SPEEDOMETER AND ALTIMETER OF THE NAL QSTOL EXPERIMENTAL AIRCRAFT ASKA [TEISOUON SHORT TAKE-OFF AND LANDING JIKKENKI ASUKA NO SOKUDOKEI *OYOBI KOUDOKEI NO ICHI GOSA*]
KAZUYA MASUI, HAMAKI INOKUCHI, and KENJI YAZAWA Mar. 1992 69 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1144; JTN-93-80482) Avail: CASI HC A04/MF A01

The position error is reported for three different pitot-static systems used in the National Aerospace Laboratory (NAL) Quiet Short Take-Off and Landing (QSTOL) experimental aircraft, ASKA, being determined using only the static pressure error, and assuming that the total pressure error is negligible. It was found that a continuous reference altitude and a correction for pressure propagation lag, realized the determination of the position error during speed and altitude transition. The continuous reference altitude was obtained precisely by the combination of a radar altimeter and an aircraft tracking radar. The ground effect on the position error before touchdown is also reported. In addition, the position error in high angle of attack cases was discussed. The resultant position error correction was used for various analyses of flight test data. Furthermore, it was incorporated into the Digital Air Data Computer to indicate the calibrated airspeed and altitude to the pilots. Author (NASDA)

N94-13791*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
RECENT FLIGHT-TEST RESULTS OF OPTICAL AIRDATA TECHNIQUES
RODNEY K. BOGUE Washington May 1993 22 p Presented at the SAE Aerotech 1992, Anaheim, CA, 5-8 Oct. 1992
(Contract RTOP 505-68-50)
(NASA-TM-4504; H-1915; NAS 1.15:4504; SAE-92-1997) Avail: CASI HC A03/MF A01

Optical techniques for measuring airdata parameters were demonstrated with promising results on high performance fighter aircraft. These systems can measure the airspeed vector, and some are not as dependent on special in-flight calibration processes as current systems. Optical concepts for measuring freestream static temperature and density are feasible for in-flight applications. The best feature of these concepts is that the air data measurements are obtained nonintrusively, and for the most part well into the freestream region of the flow field about the aircraft. Current requirements for measuring air data at high angle of attack, and future need to measure the same information at hypersonic flight conditions place strains on existing techniques. Optical technology advances show outstanding potential for application in future programs and promise to make common use of optical concepts a reality. Results from several flight-test programs are summarized, and the technology advances required to make optical airdata techniques practical are identified. Author (revised)

N94-15187*# Alabama Univ., Huntsville. Coll. of Science.
TESTING AND MANAGEMENT OF FLIGHT INSTRUMENTS AND THEIR DATA Final Report, 1 Dec. 1988 - 30 Nov. 1991
RICHARD H. COMFORT Dec. 1991 4 p
(Contract NAG8-122)
(NASA-CR-194332; NAS 1.26:194332) Avail: CASI HC A01/MF A01

Hardware activities were concentrated on the Low Energy Ion Facility (LEIF), which is used for testing and calibration of most of the flight instruments for near-Earth observations. The ion beam generated by the ion source in the LEIF has been required for the proper testing and calibration of the primary components of the Thermal Ion Dynamics Experiment (TIDE) to be flown on the POLAR spacecraft of the Global Geospace Science (GGS) flight program. Additional work has been done on equipment and techniques for diagnosing and testing microchannel plates. These plates are used in the imager as well as the flight instruments. CASI

N94-18536# Naval Postgraduate School, Monterey, CA.
PRELIMINARY DESIGN OF A WATER COOLED AVIONICS COOLING RACK M.S. Thesis
COLLEEN L. ELLIS 25 Mar. 1993 47 p
(AD-A268826) Avail: CASI HC A03/MF A01

Military electronics are frequently operated in excessively confined spaces aboard ships and aircraft. This limited space impacts significantly on the space available for cooling equipment. The optimal solution is the development of one universal, modular rack for shipboard and aviation use. With a modular design, upgrades to equipment could also be accompanied by an upgrade to the cooling rack itself with very little additional cost or difficulty. A water cooled avionics rack can provide sufficient cooling for any piece or combination of avionics equipment if enough water flow paths are used, the water is at the appropriate temperature, and the water is properly distributed within the passages. To determine if the cooling medium, water, is properly distributed within a modular cooling rack, an analysis of the flow and pressure distribution of the coolant is required. This thesis presents a computer code that has been developed as an initial step in the total design of a modular cooling rack for avionics equipment. In itself, the code details a specific design technique and allows for the determination of whether a proposed configuration, including source location, characteristics of the cooling water, and the size and shape of the proposed flow passages will indeed provide a proper distribution of the coolant. DTIC

N94-18658# Naval Air Warfare Center, Indianapolis, IN. Aircraft Div.
EMBEDDED COMPUTER PERFORMANCE MEASUREMENT (ECPM). ADVANCED AVIONICS SUBSYSTEMS AND TECHNOLOGY MULTIPROCESSOR ECPM SOFTWARE DOCUMENTATION Final Report, Oct. 1990 - Jun. 1993
DIANE KOHALMI, JOHN NEWPORT, CHUCK ROARK, DIANE PAUL, and DAVE STRUBLE Jun. 1993 118 p
(AD-A269921) Avail: CASI HC A06/MF A02

The report consists of software documentation for a new computer performance measurement tool written in Ada. The tool is designed for easy portability between computer systems. Included are a MIL-STD-1553B Interface Definition, a DoD-STD-2167 Systems Requirements Specification, and a DoD-STD-2167 Interface Requirements Specification. DTIC

N94-20053# Galaxy Scientific Corp., Pleasantville, NJ.
HANDBOOK. VOLUME 3: DIGITAL SYSTEMS VALIDATION BOOK PLAN Final Report
JOAN JANOWITZ Jul. 1993 16 p
(Contract DTFA03-89-C-00043)
(DOT/FAA/CT-93/16-VOL-3) Avail: CASI HC A03/MF A01

The Digital Systems Validation Handbook is a tutorial series designed to provide certification engineers information on current topics related to digital avionics. The book plan lays the foundation for volume 3 of this series. The purpose of the handbook book plan is to identify technology and related issues that certification engineers are likely to encounter. Volume 3 of the handbook series will consist of approximately 20 chapters. Sixteen chapters are described in the book plan. Four were reserved for technologies or issues that might emerge during the course of the volume 3 life cycle. A list of potential handbook topics was derived from a survey of the literature, conference and seminar attendance, results of an informal questionnaire, and interviews with Federal Aviation Administration (FAA) National Resource Specialists, experts in the field of certification and digital avionics, National Aeronautics and Space Administration (NASA) officials, and persons in private industry. From this input, the list of potential topics was developed and refined into handbook chapters. In addition to the chapter list and descriptions, the handbook purpose, scope, and use is discussed. The unabridged list of topics is included in the book plan appendix. Author

N94-20343# Computer Resource Management, Inc., Pleasantville, NJ.
HANDBOOK. VOLUME 2: DIGITAL SYSTEMS VALIDATION. CHAPTER 18: AVIONIC DATA BUS INTEGRATION TECHNOLOGY
D. ELWELL, L. HARRISON, J. HENSYL, and N. VANSUETENDAEL Nov. 1993 179 p
(Contract DTFA03-86-C-00042)
(DOT/FAA/CT-88/10-VOL-2) Avail: CASI HC A09/MF A02

As multiple digital avionic systems were introduced into aircraft, there arose a need for digital communications between systems. In the early 1970s, many different digital data bus designs were used to provide this communication. Because these digital systems proved to be reliable and cost effective, their popularity increased. Proliferation led to standardization, particularly in the air transport category of aircraft, which allowed communications between line replaceable units (LRU's) to become more complex. The LRU's began to rely more heavily on each other to reduce the amount of equipment required. Sensor data and systems data could be shared among multiple systems, rather than each system requiring its own private source. Integrated digital avionics are increasingly being used to implement essential and critical functions that cannot be sufficiently reproduced by conventional means. The safety of such aircraft is highly dependent upon the computer software, hardware, and data buses connecting the systems. The newest concerns relate to the problems that are unique to highly integrated systems. There is no standard with which to assess the possible impact of these bus-based systems on aircraft safety. These and other advanced avionic systems will result in specific safety assessment problems when the appropriate data packages are submitted to the Federal Aviation Administration during the certification process. 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.

A94-10283* *National Aeronautics and Space Administration.* Lewis Research Center, Cleveland, OH.
PARTITIONING OF CENTRALIZED INTEGRATED FLIGHT/PROPULSION CONTROL DESIGN FOR DECENTRALIZED IMPLEMENTATION
SANJAY GARG (NASA, Lewis Research Center, Cleveland, OH) IEEE Transactions on Control Systems Technology (ISSN 1063-6536) vol. 1, no. 2 June 1993 p. 93-100. refs
Copyright
The notion of partitioning a centralized controller into a decentralized, hierarchical structure suitable for integrated flight/propulsion control (IFPC) implementation is discussed. A systematic procedure is developed for determining partitioned airframe and engine subsystem controllers (subcontrollers), with the desired interconnection structure, that approximate the closed-loop performance and robustness characteristics of a given centralized controller. The procedure is demonstrated by application to IFPC design for a short take-off and vertical landing (STOVL) aircraft in the landing-approach-to-hover-transition flight phase.

A94-10318
THREE-DIMENSIONAL NON-REACTING TURBULENT MIXING PHENOMENA IN A SIDE-DUMP COMBUSTOR WITH DUAL OPPOSITE INLETS
TZU-HSIANG KO (Lunghwa Junior College of Technology and Commerce, Taoyuan, Taiwan) and RUEY-HOR YEN (National Taiwan Univ., Taipei) Chinese Society of Mechanical Engineers, Journal (ISSN 0257-9731) vol. 14, no. 4 Aug. 1993 p. 350-359. refs
The nonreacting turbulent mixing in a 3D side-dump combustor with dual opposite jets is investigated numerically, with attention to the effects of the side-inlet angle and the overall inlet fuel/air mixture equivalent ratio on the fuel distribution and the mixing process. For the fuel injector configuration simulated, the axial recirculation structure, other than the spiral vortex motion in the flowfield, plays the dominant role in the fuel/air mixing process. The smaller side-inlet angle cases which contain wide axial recirculation zones are found to be beneficial for the mixing process. By contrast, the strong spiral vortex motion induced by the violent impact of one jet flow upon another, and the large radial momentum in the larger side-inlet angle cases trap the fuel in the combustor's dome region, impeding fuel/air mixing as the flow develops downstream. The optimum control of the overall inlet fuel/air mixture equivalent ratio according to the side-inlet angle, to get the stoichiometric mixing state in the dome region, and the effects of the side-inlet angle on the total pressure loss, are also discussed. Author (revised)

A94-10347
HSCT ENGINE RESEARCH MAKES STEADY GAINS
STANLEY W. KANDEBO Aviation Week & Space Technology (ISSN 0005-2175) vol. 139, no. 11 Sept. 13, 1993 p. 46, 47, 50.
Copyright
Gains made in the development of lightweight, low-noise engine inlets and nozzles and low-emission combustors are reviewed. Successful testing of these technologies are described along with that of a variable-diameter centerbody inlet. AIAA

A94-10702
EXPERIMENTAL INVESTIGATION ON SUPERSONIC COMBUSTION. II
XINGZHOU LIU, JINGHUA LIU, YUREN WANG, YUNQI GE, LIXING YANG, and YULI HU (31st Research Inst., China) Journal of Propulsion Technology (ISSN 1001-4055) no. 4 Aug. 1993 p. 1-7. In CHINESE refs
The experimental investigation with a model supersonic combustor which consists of a rearward-facing step and a diverging duct was carried out by using electric arc-heated air to simulate combustor inlet Mach numbers of 2.1 and 3.0. Comparisons were made with comnbustors of two different lengths by burning kerosene or hydrogen fuel injected either parallel or perpendicular to the airstream. Author (revised)

A94-10709
COMBUSTION PERFORMANCE OF DUMP COMBUSTOR IN RAMJET ENGINE USING LIQUID HYDROGEN FUEL
SHAOQING WANG (31st Research Inst., China) Journal of Propulsion Technology (ISSN 1001-4055) no. 4 Aug. 1993 p. 42-46. In CHINESE refs
The combustion performance of an aerospace plane ramjet dump combustor is discussed, giving attention to ramjet characteristics deriving from the use of LH2. The results show that the ramjet performance meets aerospaceplane propulsion system criteria in the range of Mach number range from 1.5 to 6.0 and 40-km altitude. The calculated results for dump and normal combustors were compared. At low altitude and small Mach number, the results show that the performance of the dump combustor is superior due to higher thrust and greater resistance to overflow. At higher altitude and Mach number, the differences in performance are very small. The problem of flow matching is partially solved. Author (revised)

A94-10745
STRATO 2C PROPULSION SYSTEM - INTEGRAL PART OF A BALANCED DESIGN [ANTRIEB DER STRATO 2C - INTEGRALER BESTANDTEIL EINER SYSTEMLOESUNG]
H. KUENKLER (Industrieanlagen-Betriebsgesellschaft mbH, Ottobrunn, Germany) *Zeitschrift fuer Flugwissenschaften und* Weltraumforschung (ISSN 0342-068X) vol. 17, no. 4 Aug. 1993 p. 239-244. In GERMAN refs
Copyright
The propulsion system of the STRATO 2C research aircraft, under development since Spring 1992, is designed for an operational flight altitude of 24 km. Due to time and cost it has to be realized using existing components to the most possible extent. Therefore, available hardware, technologies and experience are adapted to the unconventional mission task rather then being especially developed for operation at extreme flight altitude. Though the scope for the propulsion configuration was thereby restricted, the propulsion system has been harmonized with the concept of airframe and equipment as an integral part of a balanced design tailored consequently to the relevant tasks.

A94-10857
CFD-BASED THREE-DIMENSIONAL TURBOFAN EXHAUST NOZZLE ANALYSIS SYSTEM
B. D. KEITH, K. UENISHI, and D. A. DIETRICH (GE Aircraft Engines, Cincinnati, OH) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 6 Nov.-Dec. 1993 p. 840-846. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991, AIAA Paper 91-2478. Previously cited in issue 18, p. 3069, Accession no. A91-44261 refs
Copyright

A94-10860
CONCEPTUAL STUDY OF SEPARATED CORE ULTRAHIGH BYPASS ENGINE
Y. SAITO, N. SUGIYAMA, M. ENDOH, and Y. MATSUDA (National Aerospace Lab., Chofu, Japan) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 6 Nov.-Dec. 1993 p. 867-873. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992, AIAA Paper 92-3775. Previously cited in issue 20, p. 3482, Accession no. A92-49119 Research supported by Ishikawa-Harima Heavy Industries Co., Ltd. and Kawasaki Heavy Industries, Ltd
Copyright

A94-10931
NONSTATIONARY GASDYNAMIC PROCESSES IN RAMJET ENGINES [NESTATSIONARNYE GAZODINAMICHESKIE PROTSESSY V PRYAMOTOCHNYKH VOZDUSHNO-REAKTIVNYKH DVIGATELYAKH]
S. A. EGORUSHKIN and F. A. SLOBODKINA Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281) no. 4 July-Aug. 1993 p. 140-144. In RUSSIAN refs
Copyright

Nonstationary processes in the duct of a ramjet engine is modeled by using nonstationary quasi-one-dimensional Euler equations containing 'source' terms which describe the sources and sinks of mass, momentum, and energy. The quasi-one-dimensional approximation from ramjet ducts is valid since the l/d ratio in this case is about 20 (l and d are the length and the width of the duct, respectively). The moving medium is assumed to be a two-component mixture of chemically active compounds, which makes it possible to use realistic thermodynamic characteristics of the fuel and combustion products. AIAA

A94-11675
PARALLEL PROCESSING FOR JET ENGINE CONTROL
HAYDN A. THOMPSON (Marconi Radar and Control Systems, Ltd., Chelmsford, United Kingdom) London and New York Springer-Verlag 1992 289 p. refs
(ISBN 0-387-19747-8) Copyright

Topics addressed include controller and engine simulation implementation; controller and engine simulation on the Inmos transputer; alternative approaches to parallel processing based on the Butterfly Plus and Helios systems; formal methods and system specifications; and failure management and its application in gas turbine engine control. Particular attention is given to requirements and current trends in engine and controller design, engine modeling, normal operation, reheat and nozzle control, Occam simulation of engine model, the Helios operating system, programming in Helios, the Butterfly Plus computer, GIST analysis, and task length modification. Also discussed are formal methods for hardware specification, application of formal methods in fault tolerant systems, specifications for gas turbine systems, fault tolerant processor topologies, and a review of fault tolerant designs, a method of overlapping triads. AIAA

A94-11849
CERAMIC BLANKET REDUCES MAINTENANCE COSTS
PAUL ROMNES (United Airlines, Engine Technical Services Maintenance Operations, San Francisco, CA) Aerospace Engineering (ISSN 0736-2536) vol. 13, no. 9 Sept. 1993 p. 11, 12.
Copyright

FAA fireproofing regulations require that commercial aircraft engine cowlings withstand 2000 F for 15 min without flame propagation, especially around the thrust reverser structure. An account is given of a tightly woven but very lightweight insulating blanket design for such cowling-insulation purposes that is based on the Nextel 312 ceramic fiber. AIAA

A94-11967
LIQUID TIGHT INSULATION FOR HIGH TEMPERATURE AIRCRAFT DUCTING
DAVID A. WORCESTER (Rockwell International Corp., Los Angeles, CA) Oct. 1992 10 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921914) Copyright

Existing hot line insulation failed to provide an adequate barrier to liquid leakage penetration to the hot surfaces beneath the insulation. As a result, combustible fluid leakage posed an unacceptable safety problem to the B-1 B aircraft. An existing polyimide and Min-K insulation design was adapted, through the use of leakproof coupling covers, component covers and standoff mount covers, that is highly resistant to fluid leakage penetration. This paper describes the design and testing of a leak resistant insulation suitable for use on heated lines where isolation from external flammable fluid leakage cannot be otherwise provided.

A94-11992
GYROSCOPIC TEST FOR THE T800-LHT-800 TURBOSHAFT ENGINE
MARK D. BECKER (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) and BRIAN FROUNFELKER (U.S. Navy, Naval Air Warfare Center, Warminster, PA) Oct. 1992 12 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992
(SAE PAPER 921955) Copyright

The 1300 shp-class T800 turboshaft engine has been designed for such highly maneuverable vehicles as the Comanche helicopter, which will exert high gyroscopic loads on its rotating components. Attention is presently given to the development of the engine's gyroscopic testing facility and the results thus obtained. The engine design underwent several design modifications over the course of this test program, reducing costs and enhancing producibility. AIAA

A94-11993
RECENT ADVANCES IN NO-BREAK POWER TRANSFER (NBPT)
S. IDEN and D. CUNNINGHAM (Sundstrand Aerospace, Rockford, IL) Oct. 1992 9 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921964) Copyright

No-break power transfer (NBPT) has been used in the 400 Hz aircraft electrical power business for over 30 years. Initially, NBPT was performed on military aircraft or large commercial jets where the interest was to maintain availability of critical equipment during dispatch. Recent-NBPT equipped aircraft such as the 747-400 and MD-11 have demonstrated the desirability of this feature in commercial airline service. Some compatibility issues with solid-state ground power units (GPUs) have also been uncovered. Author (revised)

A94-11996
TRENDS IN AIR TURBINE STARTERS FOR LARGE TURBOFAN ENGINES
A. J. KASAK (GE Aircraft Engines, Cincinnati, OH) Oct. 1992 11 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921975) Copyright

The development of future air turbine starters for large turbofans can be approached via the present analysis of starter parameter trends and characteristic features. Previously unsuspected componential and systemic advancements are revealed by this trends-analysis. It is noted that starter durability has increased fourfold, and that air supply pressure levels could be increased to reduce the weight and volume of aircraft pneumatic ducts and components. AIAA

A94-12001 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

OVERVIEW OF HIGH PERFORMANCE AIRCRAFT PROPULSION RESEARCH

THOMAS J. BIESIADNY (NASA, Lewis Research Center, Cleveland, OH) Oct. 1992 17 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Previously announced in STAR as N93-11530

(Contract RTOP 505-68-32)

(SAE PAPER 921983) Copyright

The overall scope of the NASA Lewis High Performance Aircraft Propulsion Research Program is presented. High performance fighter aircraft of interest include supersonic flights with such capabilities as short take off and vertical landing (STOVL) and/or high maneuverability. The NASA Lewis effort involving STOVL propulsion systems is focused primarily on component-level experimental and analytical research. The high-maneuverability portion of this effort, called the High Alpha Technology Program (HATP), is part of a cooperative program among NASA's Lewis, Langley, Ames, and Dryden facilities. The overall objective of the NASA Inlet Experiments portion of the HATP, which NASA Lewis leads, is to develop and enhance inlet technology that will ensure high performance and stability of the propulsion system during aircraft maneuvers at high angles of attack. To accomplish this objective, both wind-tunnel and flight experiments are used to obtain steady-state and dynamic data, and computational fluid dynamics (CFD) codes are used for analyses. This overview of the High Performance Aircraft Propulsion Research Program includes a sampling of the results obtained thus far and plans for the future.

A94-12034

MATHEMATICAL METHODS OF RELATIVE ENGINE PERFORMANCE DIAGNOSTICS

LOUIS A. URBAN and ALLAN J. VOLPONI (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) Oct. 1992 28 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs

(SAE PAPER 922048) Copyright

The basic concepts and mathematics of a methodology that allows successful relative assessment of simultaneously occurring multiple faults in gas turbine engine modules and sensors, are presented in detail. Included are a detailed exposition of a thermodynamic/differential equation based model of a representative type of gas turbine engine; discussion of correction methods to minimize data scatter; the mathematical design aspects of a demonstratedly successful approach to data filtering to deal with residual scatter caused by large or small sensor errors, data correction errors, or engine system modelling errors.

A94-12048

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF DYNAMIC CHARACTERISTICS OF AN ADVANCED ATTACK HELICOPTER SHAFT DRIVEN COMPRESSOR

HIEU T. NGO (McDonnell Douglas Helicopter Co., Mesa, AZ) Sep. 1992 10 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

To improve the reliability of the Shaft Driven Compressor (SDC) on an advanced attack helicopter, the failure modes were investigated. The primary purpose of this paper is to address the theoretical analysis and experimental tests, plus lessons learned and the outcome of this investigation. Studies from the current production design to the flight test validation of the redesigned component are discussed with a description of the finite difference model used. Finally, flight test and bench test results are presented. These results indicate a 9 to 1 reduction in the SDC vibration and incorporate revision of the Endurance Test and the Acceptance Test Procedure in the manufacturing process. A secondary purpose of this paper is to illustrate the advantage of employing both analytical predictions and experimental data as a practical means of solving engineering problems. Author (revised)

A94-12096

FLIGHT TESTS OF THE DIGITALLY CONTROLLED TURBOMECA ARRIUS 1B ENGINES ON EC BO 108

MICHAEL VON GERSDORFF (Eurocopter Deutschland GmbH, Munich, Germany) and CHANTAL LORDON (Turbomeca, Bordes, France) Sep. 1992 12 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

In October 1988 the first BO 108 prototype equipped with two Allison 250 C20R engines made its maiden flight. The second prototype (V2), equipped with two TURBOMECA ARRIUS 1B engines and Digital Engine Control Unit (DECU) has provided successful flight test results since June 1991. A brief description of the engine and engine control will be given together with information about the different DECU functions and mode of operation. The ground and flight test program together with the aircraft test equipment and instrumentation are presented. Results focus on the most important tests related to the use of a digital engine control system and the main advantages of those systems over conventional (hydro-mechanic/pneumatic) engine control systems. Finally the definition and initial flight testing of a variable rotorspeed adapted to the flight conditions are presented.

A94-12115

LIFE PREDICTION OF HELICOPTER ENGINES FITTED WITH DUST FILTERS

JOHANNES P. VAN DER WALT (Potchefstroom Univ. for Christian Higher Education, South Africa) and ALAN NURICK (Univ. of the Witwatersrand, Johannesburg, South Africa) Sep. 1992 12 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by Atlas Aviation refs

The incorporation of an engine air inlet dust-filtration feature by helicopters often subjected to highly erosive environments reduces the diameter of particles encountered by the first compressor stage to less than 100 microns. The dependence of engine performance on the erosion of the first compressor stage by such a sparse dust concentration may be statistically extended to yield service life predictions for typical flights through a specific dust environment. This life-prediction methodology is here presented in detail. AIAA

A94-12695* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AEROELASTIC PROBLEMS IN TURBOMACHINES

ODDVAR O. BENDIKSEN (California Univ., Los Angeles) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 5 - Structural dynamics and aeroelasticity New York American Society of Mechanical Engineers 1993 p. 241-297. Research supported by NSF refs

(Contract NAG3-308; NAS3-25574)

Copyright

An overview is given of aeroelastic problems in turbomachines, emphasizing recent research. Unsteady flow in cascade and turbomachinery rotors is discussed, including supersonic and transonic linearized potential flow and nonlinear flow models. Computational and modeling aspects of the flutter of fan and compressor blades are examined. The correlation of the findings with experimental data is considered. Future directions in turbomachinery aeroelasticity are addressed. AIAA

A94-12953

CONTRIBUTION OF PHOTOELASTICITY TO THE DESIGN OF JET TURBO ENGINE PARTS

M. TARONI (SNECMA, Evry, France) and D. PARASKEVAS (PK-Lab. Co., Senlis, France) *In* International Congress on Experimental Mechanics, 7th, Las Vegas, NV, June 8-11, 1992, Proceedings. Vol. 2 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 884-891. refs

Copyright

The study shows how photoelasticity is used to design aircraft engines, as well as technical developments to supply the industry-specific equipment and methods capable of yielding the individual stress values throughout an investigation line using an automated method. The goal of this method is to obtain more information than is usually obtained from photoelasticity, in particular, the equivalent stress of Von Mises. Results are presented of analyses carried out in the median plane of an original disk and blade, together with a view of the mesh calculated using the FEM. Four borderline cases which illustrate the complementarity between calculations and photoelasticity are shown. It is argued that the most complex studies can be carried out if photoelastic analysis is used to map out the stresses identified in all the complex zones of a resin mock-up. AIAA

N94-10370# National Aerospace Lab., Tokyo (Japan). Computational Sciences Div.
NUMERICAL CALCULATION OF SCRAMJET INLET FLOW
TOMIKO ISHIGURO, SATORU OGAWA, and YASUHIRO WADA Jul. 1992 31 p
(ISSN 0389-4010)
(NAL-TR-1174T; JTN-93-80447; DE93-793626) Avail: CASI HC A03/MF A01

A numerical procedure to analyze flowfields through and around the Langley-type scramjet engine inlet is proposed. To accurately treat boundary conditions (walls, edges, etc.), all boundaries are mapped onto certain parts of the faces of three rectangular parallelepipeds. A computational space is made by connecting them. The three dimensional full Navier-Stokes equations which include the Baldwin-Lomax algebraic turbulent model are solved by applying the TVD (Total Variation Diminishing) scheme to the uniform mesh points of the space. To exhibit capability of the numerical procedure, parametric studies on flow simulations were carried out by fixing freestream Reynolds number Re = rho(sub infinity) x c(sub infinity) x L/mu(sub infinity) = 5.3 x 10(exp 5) under various trios of a freestream Mach number M(sub infinity), a sweep angle of leading edge of side plate beta and an entrance/throat contraction ratio R (M(sub infinity) approximately equals 2 to 10, beta approximately equals 0 deg to 60 deg, R approximately equals 3 to 10). The influence of the parameters on inlet performances (a mass capture ratio, a total pressure recovery ratio, and possibility of starting) is discussed. The results are in good agreements with the experiments under M(sub infinity) = 4 in starting cases, where iterated reflective oblique shock waves made by wedges of side panels decelerate and compress air. Unstarting phenomenon was analyzed in cases either of low M(sub infinity) or high R. Author (NASDA)

N94-10425# Alenia Aeronautica, Torino (Italy).
NUMERICAL SIMULATION OF THE FLOW THROUGH A SCRAMJET ENGINE
V. SELMIN *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 13 p Apr. 1993
Copyright Avail: CASI HC A03/MF A04

An inviscid numerical method was developed to simulate the flow through each component of a scramjet engine. Emphasis is on the effects due to non-ideal gas assumption and to H(sub 2)/air chemistry on the performance of air intakes and nozzles. Author (revised)

N94-11022# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
A RECOMMENDED METHODOLOGY FOR QUANTIFYING NDE/NDI BASED ON AIRCRAFT ENGINE EXPERIENCE [LE PROJET DE METHODOLOGIE POUR L'EVALUATION DU CONTROLE NON-DESTRUCTIF FONDE SUR L'EXPERIENCE ACQUISE SUR LES MOTEURS D'AVIONS]
Apr. 1993 97 p Lectures held in Ankara, Turkey, 26-27 Apr. 1993, in Lisbon, Portugal, 29-30 Apr. 1993, in Patras, Greece, 4 May 1993, and in Ottawa, Canada, 3-4 Jun. 1993
(AGARD-LS-190; ISBN-92-835-0707-X) Copyright Avail: CASI HC A05/MF A01

Methods to quantify nondestructive inspection (NDI) reliability and capability have been evolving for over twenty-five years. Initial attempts were qualitative rather than quantitative. With the advent of damage tolerance methodologies, it has become imperative to express more accurately probability of detection for a given inspection method and inspection system. This Lecture Series is aimed at providing a methodology to quantify probability of detection. This methodology includes, but is not limited to, design of experiments, specimen generation and maintenance, statistical analyses, data reduction and presentation, evaluation of inspection results in retirement for cause decisions, and the procedure required to establish a reliable probability based inspection for detecting anomalies in engine parts. The material to be presented is applicable to civil as well as military aircraft and turbine engine manufacturing and maintenance organizations. The lectures will examine the detection capabilities of fluorescent penetrant inspection, eddy current, ultrasonic, and magnetic particle inspection. This Lecture Series incorporates lessons learned in the design of experiments to validate nondestructive evaluation (NDE)/NDI systems and in the interpretation of the results of these experiments. Samples of specimens used in NDE/NDI reliability programs will be available for inspection by attendees. The Lecture Series also includes examples to help with the understanding of design of experiments and the statistical modeling for probability of detection analyses. This Lecture Series, sponsored by the Structures and Materials Panel of AGARD, was implemented by the Consultant and Exchange Program. Author (revised)

N94-11205*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PRELIMINARY SUPERSONIC FLIGHT TEST EVALUATION OF PERFORMANCE SEEKING CONTROL
JOHN S. ORME and GLENN B. GILYARD Washington Jun. 1993 20 p Presented at the 29th AIAA/SAE/ASME/ASEE Joint Propulsion Conference, Monterey, CA, 28-30 Jun. 1993
(Contract RTOP 533-02-34)
(NASA-TM-4494; H-1909; NAS 1.15:4494; AIAA PAPER 93-1821) Avail: CASI HC A03/MF A01

Digital flight and engine control, powerful onboard computers, and sophisticated controls techniques may improve aircraft performance by maximizing fuel efficiency, maximizing thrust, and extending engine life. An adaptive performance seeking control system for optimizing the quasi-steady state performance of an F-15 aircraft was developed and flight tested. This system has three optimization modes: minimum fuel, maximum thrust, and minimum fan turbine inlet temperature. Tests of the minimum fuel and fan turbine inlet temperature modes were performed at a constant thrust. Supersonic single-engine flight tests of the three modes were conducted using varied after burning power settings. At supersonic conditions, the performance seeking control law optimizes the integrated airframe, inlet, and engine. At subsonic conditions, only the engine is optimized. Supersonic flight tests showed improvements in thrust of 9 percent, increases in fuel savings of 8 percent, and reductions of up to 85 deg R in turbine temperatures for all three modes. The supersonic performance seeking control structure is described and preliminary results of supersonic performance seeking control tests are given. These findings have implications for improving performance of civilian and military aircraft. Author (revised)

N94-11255*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A COMPARISON BETWEEN NUMERICALLY MODELLED AND EXPERIMENTALLY MEASURED LOSS MECHANISMS IN WAVE ROTORS
DANIEL E. PAXSON Jun. 1993 13 p Presented at the 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-20 Jun. 1993; sponsored by AIAA, SAE, ASME, and ASEE
(Contract RTOP 505-62-50)
(NASA-TM-106279; AIAA PAPER 93-2522; E-8018; NAS 1.15:106279) Avail: CASI HC A03/MF A01

A numerical model has been developed which is capable of predicting the performance of a wave rotor (pressure exchanger) of specified geometry over a wide range of operating conditions. The model can account for the major loss mechanisms of leakage from the tube ends, fluid viscosity, heat transfer to the tube walls, finite tube opening time, shock waves, and non-uniform port flows. It is a one dimensional flow model which follows a single tube as it rotates past the various stationary ports. Since the model is relatively simple (i.e. one dimensional) it uses little computer time. This makes it suitable for design as well as analytical purposes. This paper will present a brief description of the model then discuss a comparison between the model predictions and several wave rotor experiments. Author (revised)

N94-12270*# United Technologies Corp., West Palm Beach, FL. Pratt and Whitney.
ADVANCED CONTROL FOR AIRBREATHING ENGINES, VOLUME 1: PRATT AND WHITNEY
J. A. RALPH Jul. 1993 83 p
(Contract NAS3-25952; RTOP 505-62-61)
(NASA-CR-189203; E-8006; NAS 1.26:189203) Avail: CASI HC A05/MF A01

The application of advanced control concepts to air breathing engines may yield significant improvements in aircraft/engine performance and operability. Screening studies of advanced control concepts for air breathing engines were conducted by three major domestic aircraft engine manufacturers to determine the potential impact of concepts on turbine engine performance and operability. The purpose of the studies was to identify concepts which offered high potential yet may incur high research and development risk. A target suite of proposed advanced control concepts was formulated and evaluated in a two phase study to quantify each concept's impact on desired engine characteristics. To aid in the evaluation specific aircraft/engine combinations were considered: a Military High Performance Fighter mission, a High Speed Civil Transport mission, and a Civil Tiltrotor mission. Each of the advanced control concepts considered in the study are defined and described. The concept potential impact on engine performance was determined. Relevant figures of merit on which to evaluate the concepts are determined. Finally, the concepts are ranked with respect to the target aircraft/engine missions. A final report describing the screening studies was prepared by each engine manufacturer. Volume 1 of these reports describes the studies performed by Pratt & Whitney. Author (revised)

N94-12271*# General Electric Co., Cincinnati, OH. Aircraft Engines.
ADVANCED CONTROL FOR AIRBREATHING ENGINES, VOLUME 2: GENERAL ELECTRIC AIRCRAFT ENGINES
INDAR BANSAL Jul. 1993 112 p
(Contract NAS3-25951; RTOP 505-62-41)
(NASA-CR-189204; E-8005; NAS 1.26:189204) Avail: CASI HC A06/MF A02

The application of advanced control concepts to air breathing engines may yield significant improvements in aircraft/engine performance and operability. Screening studies of advanced control concepts for air breathing engines were conducted by three major domestic aircraft engine manufacturers to determine the potential impact of concepts on turbine engine performance and operability. The purpose of the studies was to identify concepts which offered high potential yet may incur high research and development risk. A target suite of proposed advanced control concepts was formulated and evaluated in a two phase study to quantify each concept's impact on desired engine characteristics. To aid in the evaluation specific aircraft/engine combinations were considered: a Military High Performance Fighter mission, a High Speed Civil Transport mission, and a Civil Tiltrotor mission. Each of the advanced control concepts considered in the study are defined and described. The concept potential impact on engine performance was determined. Relevant figures of merit on which to evaluate the concepts are determined. Finally, the concepts are ranked with respect to the target aircraft/engine missions. A final report describing the screening studies was prepared by each engine manufacturer. Volume 2 of these reports describes the studies performed by GE Aircraft Engines. Author (revised)

N94-12272*# General Motors Corp., Indianapolis, IN. Allison Gas Turbine Div.
ADVANCED CONTROLS FOR AIRBREATHING ENGINES, VOLUME 3: ALLISON GAS TURBINE
R. M. BOUGH Jul. 1993 43 p
(Contract NAS3-25459; RTOP 505-62-41)
(NASA-CR-189205; E-8007; NAS 1.26:189205) Avail: CASI HC A03/MF A01

The application of advanced control concepts to airbreathing engines may yield significant improvements in aircraft/engine performance and operability. Screening studies of advanced control concepts for airbreathing engines were conducted by three major domestic aircraft engine manufacturers to determine the potential impact of concepts on turbine engine performance and operability. The purpose of the studies was to identify concepts which offered high potential yet may incur high research and development risk. A target suite of proposed advanced control concepts was formulated and evaluated in a two-phase study to quantify each concept's impact on desired engine characteristics. To aid in the evaluation specific aircraft/engine combinations were considered: a Military High Performance Fighter mission, a High Speed Civil Transport mission, and a Civil Tiltrotor mission. Each of the advanced control concepts considered in the study are defined and described. The concept potential impact on engine performance was determined. Relevant figures of merit on which to evaluate the concepts are determined. Finally, the concepts are ranked with respect to the target aircraft/engine missions. A final report describing the screening studies was prepared by each engine manufacturer. Volume 3 of these reports describes the studies performed by the Allison Gas Turbine Division. Author (revised)

N94-12274# Army Cold Regions Research and Engineering Lab., Hanover, NH.
ICING OF TURBINE INTAKE LOUVERS Special Report
MICHAEL R. WALSH, DONALD E. GARFIELD, JAMES S. MORSE, KURT V. KNUTH, and NATHAN D. MULHERIN Apr. 1993 43 p
(AD-A265714; CRREL-SR-93-4) Avail: CASI HC A03/MF A01

Superstructure icing is a phenomenon that can have debilitating effects on the operation of any ship. When designing ships that will operate in environments where icing may occur, careful consideration must be given to minimizing the accumulation and effect of superstructure icing. Such consideration was given to the U.S. Navy DDG-51-class destroyer when new turbine intake louvers were proposed. To ensure that sufficient air would be available to the vessel's gas turbines and ventilation system during an icing event, the Navy asked the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), through Advanced Marine Enterprises, Inc., (AME) of Arlington, Virginia, to conduct a series of comparative icing tests between standard intake louvers and a new louver design. DTIC

N94-13142*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
COMBUSTOR TECHNOLOGY FOR FUTURE SMALL GAS TURBINE AIRCRAFT
VALERIE J. LYONS and RICHARD W. NIEDZWIECKI Aug. 1993 18 p Proposed for presentation at the Propulsion and Energetics Panel 82nd Meeting, Montreal, Ottawa, 4-8 Oct. 1993; sponsored by the Advisory Group for Aerospace Research and Development
(Contract RTOP 535-05-10)
(NASA-TM-106312; E-8052; NAS 1.15:106312) Avail: CASI HC A03/MF A01

Future engine cycles proposed for advanced small gas turbine engines will increase the severity of the operating conditions of the combustor. These cycles call for increased overall engine pressure ratios which increase combustor inlet pressure and temperature. Further, the temperature rise through the combustor and the corresponding exit temperature also increase. Future combustor technology needs for small gas turbine engines is described. New fuel injectors with large turndown ratios which produce uniform circumferential and radial temperature patterns will be required. Uniform burning will be of greater importance because hot gas temperatures will approach turbine material limits. The higher combustion temperatures and increased radiation at high pressures will put a greater heat load on the combustor liners. At the same time, less cooling air will be available as more of the air will be used for combustion. Thus, improved cooling concepts and/or materials requiring little or no direct cooling will be required. Although presently there are no requirements for emissions levels from small gas turbine engines, regulation is expected in the near future. This will require the development of low emission combustors. In particular, nitrogen oxides will increase substantially if new technologies limiting their formation are not evolved and implemented. For example, staged combustion employing lean, premixed/prevaporized, lean direct injection, or rich burn-quick quench-lean burn concepts could replace conventional single stage combustors. Author

N94-13143*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ANALYSIS OF GAS TURBINE ENGINES USING WATER AND OXYGEN INJECTION TO ACHIEVE HIGH MACH NUMBERS AND HIGH THRUST
HUGH M. HENNEBERRY (Analex Corp., Brook Park, OH.) and CHRISTOPHER A. SNYDER Jul. 1993 20 p
(Contract RTOP 505-70-00)
(NASA-TM-106270; E-7998; NAS 1.15:106270) Avail: CASI HC A03/MF A01

An analysis of gas turbine engines using water and oxygen injection to enhance performance by increasing Mach number capability and by increasing thrust is described. The liquids are injected, either separately or together, into the subsonic diffuser ahead of the engine compressor. A turbojet engine and a mixed-flow turbofan engine (MFTF) are examined, and in pursuit of maximum thrust, both engines are fitted with afterburners. The results indicate that water injection alone can extend the performance envelope of both engine types by one and one-half Mach numbers at which point water-air ratios reach 17 or 18 percent and liquid specific impulse is reduced to some 390 to 470 seconds, a level about equal to the impulse of a high energy rocket engine. The envelope can be further extended, but only with increasing sacrifices in liquid specific impulse. Oxygen-airflow ratios as high as 15 percent were investigated for increasing thrust. Using 15 percent oxygen in combination with water injection at high supersonic Mach numbers resulted in thrust augmentation as high as 76 percent without any significant decrease in liquid specific impulse. The stoichiometric afterburner exit temperature increased with increasing oxygen flow, reaching 4822 deg R in the turbojet engine at a Mach number of 3.5. At the transonic Mach number of 0.95 where no water injection is needed, an oxygen-air ratio of 15 percent increased thrust by some 55 percent in both engines, along with a decrease in liquid specific impulse of 62 percent. Afterburner temperature was approximately 4700 deg R at this high thrust condition. Water and/or oxygen injection are simple and straightforward strategies to improve engine performance and they will add little to engine weight. However, if large Mach number and thrust increases are required, liquid flows become significant, so that operation at these conditions will necessarily be of short duration. Author (revised)

N94-13252# Federal Aviation Administration, Washington, DC.
AIRCRAFT ENGINE TYPE CERTIFICATION HANDBOOK: ADVISORY CIRCULAR
30 Jun. 1993 125 p Supersedes AC-33-2A
(AC-33-2B; ANE-110) Avail: CASI HC A06/MF A02

This advisory circular (AC) provides methods acceptable to the Administrator for showing compliance with the type certification requirements of aircraft engines in Part 33, inclusive through amendment 12, of the Federal Aviation Regulations (FAR). The procedures and guidance material provided in this AC may be used by an applicant seeking issuance of a type certificate, an amended type certificate, or a supplemental type certificate for the initial approval of a new type design, or a change in the type design. Consideration will be given to any other method of compliance the applicant elects to present. This information is not in itself mandatory, but serves as a guide to engine manufacturers, engine modifiers, and Federal Aviation Administration (FAA) engine type certification engineers. Individuals should be guided by the intent of the methods provided in this AC. Author

N94-13608* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ROTOR STATOR CGI (Videotape)
Apr. 1988 Videotape: 5 min. playing time, in color, with sound
(NASA-TM-109313; NONP-VT-93-185320) Avail: CASI VHS A01/BETA A22

This video contains computer graphics of numerous kinds of flow within jet engines. Analyses include pressure contours (shock waves), fluid pressures, etc. The video also contains dramatic views of jet engine manufacturing. Author (revised)

N94-13623* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FUTUREPATH 2 (Videotape)
Apr. 1989 Videotape: 28 min. 48 sec. playing time, in color, with sound
(NASA-TM-109285; NONP-VT-93-185301) Avail: CASI VHS A01/BETA A22

This covers advanced turboprop tests, the diesel engine as an aircraft propulsion system in helicopters, and the development of the Stirling engine as a space power system. Author

N94-14036*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NOISE LEVELS FROM A MODEL TURBOFAN ENGINE WITH SIMULATED NOISE CONTROL MEASURES APPLIED
DAVID G. HALL (Sverdrup Technology, Inc., Brook Park, OH.) and RICHARD P. WOODWARD Oct. 1993 15 p Proposed for presentation at the 15th AIAA Aeroacoustics Conference, Long Beach, CA, 25-27 Oct. 1993; sponsored by AIAA
(Contract RTOP 535-03-10)
(NASA-TM-106318; E-8063; NAS 1.15:106318; AIAA PAPER 93-4401) Avail: CASI HC A03/MF A01

A study of estimated full-scale noise levels based on measured levels from the Advanced Ducted Propeller (ADP) sub-scale model is presented. Testing of this model was performed in the NASA Lewis Low Speed Anechoic Wind Tunnel at a simulated takeoff condition of Mach 0.2. Effective Perceived Noise Level (EPNL) estimates for the baseline configuration are documented, and also used as the control case in a study of the potential benefits of two categories of noise control. The effect of active noise control is evaluated by artificially removing various rotor-stator interaction tones. Passive noise control is simulated by applying a notch filter to the wind tunnel data. Cases with both techniques are included to evaluate hybrid active-passive noise control. The results for EPNL values are approximate because the original source data was limited in bandwidth and in sideline angular coverage. The main emphasis is on comparisons between the baseline and configurations with simulated noise control measures. Author (revised)

N94-14165# Sverdrup Technology, Inc., Arnold AFS, TN. Facility Enhancements.
AEROPROPULSION TEST AND EVALUATION METHODS
BRIAN WETTLAUFER *In* VKI, Methodology of Hypersonic Testing 18 p 1993 Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
Copyright Avail: CASI HC A03/MF A03

Methods used for propulsion test and evaluation for both ground and flight testing, which are very important when the engine systems under consideration are supporting hypersonic vehicles, are considered. The propulsion systems of these vehicles are highly integrated within the airframe of the vehicle with many supporting systems being shared by both. To ground test an engine system such as this, it must first be separated from the vehicle. An approach to accomplish this through the use of reference planes is discussed. Both direct connect and free jet testing methods are discussed and some of the advantages, disadvantages, challenges, and issues associated with these testing techniques and approaches as they apply to hypersonic propulsion are addressed. ESA

N94-14168# Sverdrup Technology, Inc., Arnold AFS, TN.
HYPERSONIC FLIGHT TEST. PART 1: PROPULSION FLIGHT TESTING
VIRGIL K. SMITH, III (Arnold Engineering Development Center, Arnold AFS, TN.) *In* VKI, Methodology of Hypersonic Testing 10 p 1993 Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
Copyright Avail: CASI HC A02/MF A03

The challenges of hypersonic system development, which require a combination of integrated ground testing, flight testing, and computational/simulation approaches, are considered. The role of flight testing in the triad of development approaches is addressed, and the reasons for hypersonic propulsion flight test is focused upon. Each reason is illustrated by specific mini-case studies, including the Lockheed X-7, North American X-15/Hypersonic Research Engine (HRE) combination, Russian Hypersonic Flying Laboratory (HFL), National Aeronautics and Space Administration (NASA) SR-71 External Burning Experiment, NASA Space Shuttle, and the German HYTEX Flying Prototype. Three types of hypersonic flight test systems are reviewed. The traditional and proposed propulsion flight test reasons and traditional/proposed approaches are reviewed. ESA

N94-14169# Calspan Corp., Arnold AFS, TN.
HYPERSONIC FLIGHT TESTING. PART 2: AEROTHERMAL FLIGHT TESTING
R. K. MATTHEWS *In* VKI, Methodology of Hypersonic Testing 6 p 1993 Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
Copyright Avail: CASI HC A02/MF A03

Some of the fundamentals of hypersonic flight testing, which provides the only true environment to demonstrate that a vehicle has the material/structural integrity to survive hypersonic flight, are reviewed. An overview of aerothermal techniques is provided. Heat transfer gage measurements in particular are considered and some common problems encountered are discussed. ESA

N94-14448*# Wisconsin Univ., Madison. Engine Research Center.
THREE-DIMENSIONAL MODELING OF DIESEL ENGINE INTAKE FLOW, COMBUSTION AND EMISSIONS-2 Final Report
R. D. REITZ and C. J. RUTLAND Sep. 1993 64 p
(Contract NAG3-1087; DE-AI01-91CE-50306; RTOP 778-34-2A)
(NASA-CR-191189; E-8103; NAS 1.26:191189; DOE/NASA/1087-2) Avail: CASI HC A04/MF A01

A three-dimensional computer code, KIVA, is being modified to include state-of-the-art submodels for diesel engine flow and combustion. Improved and/or new submodels which have already been implemented and previously reported are: wall heat transfer with unsteadiness and compressibility, laminar-turbulent characteristic time combustion with unburned HC and Zeldo'vich NO(x), and spray/wall impingement with rebounding and sliding drops. Progress on the implementation of improved spray drop drag and drop breakup models, the formulation and testing of a multistep kinetics ignition model, and preliminary soot modeling results are described. In addition, the use of a block structured version of KIVA to model the intake flow process is described. A grid generation scheme was developed for modeling realistic (complex) engine geometries, and computations were made of intake flow in the ports and combustion chamber of a two-intake-value engine. The research also involves the use of the code to assess the effects of subprocesses on diesel engine performance. The accuracy of the predictions is being tested by comparisons with engine experiments. To date, comparisons were made with measured engine cylinder pressure, temperature and heat flux data, and the model results are in good agreement with the experiments. Work is in progress that will allow validation of in-cylinder flow and soot formation predictions. An engine test facility is described that is being used to provide the needed validation data. Test results were obtained showing the effect of injection rate and split injections on engine performance and emissions. Author (revised)

N94-14450# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
PERFORMANCE OF GAS TURBINE COMPRESSOR CLEANERS [WASMIDDELEN VOOR GASTURBINES VALLEN VIES TEGEN]
H. J. KOLKMAN 23 Jul. 1991 15 p In DUTCH Submitted for publication
(NLR-TP-91291-U; ETN-93-94068) Avail: CASI HC A03/MF A01

The cleaning efficiency of compressor cleaners was studied. Recently developed cleaners are claimed to be ecologically sound. In addition, many new compressor cleaners contain a corrosion inhibitor. The cleaning efficiency of eight (old and new) compressor cleaners was determined by simulated compressor washing of compressor blades that had become foul in service. For the situation simulated, the cleaning efficiency of new, ecologically sound cleaners turned out to be poor as compared with old cleaners. ESA

N94-14855*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PERFORMANCE SEEKING CONTROL: PROGRAM OVERVIEW AND FUTURE DIRECTIONS
GLENN B. GILYARD and JOHN S. ORME Aug. 1993 19 p Presented at the Guidance, Navigation, and Control Conference, Monterey, CA, 9-11 Aug. 1993; sponsored by AIAA See also A93-51360
(Contract RTOP 533-02-39)
(NASA-TM-4531; H-1920; NAS 1.15:4531; AIAA PAPER 93-3765)
Copyright Avail: CASI HC A03/MF A01

A flight test evaluation of the performance-seeking control (PSC) algorithm on the NASA F-15 highly integrated digital electronic control research aircraft was conducted for single-engine operation at subsonic and supersonic speeds. The model-based PSC system was developed with three optimization modes: minimum fuel flow at constant thrust, minimum turbine temperature at constant thrust, and maximum thrust at maximum dry and full afterburner throttle settings. Subsonic and supersonic flight testing were conducted at the NASA Dryden Flight Research Facility covering the three PSC optimization modes and over the full throttle range. Flight results show substantial benefits. In the maximum thrust mode, thrust increased up to 15 percent at subsonic and 10 percent at supersonic flight conditions. The minimum fan turbine inlet temperature mode reduced temperatures by more than 100 F at high altitudes. The minimum fuel flow mode results decreased fuel consumption up to 2 percent in the subsonic regime and almost 10 percent supersonically. These results demonstrate that PSC technology can benefit the next generation of fighter or transport aircraft. NASA Dryden is developing an adaptive aircraft performance technology system that is measurement based and uses feedback to ensure optimality. This program will address the technical weaknesses identified in the PSC program and will increase performance gains. Author (revised)

N94-14964 Air Force Inst. of Tech., Wright-Patterson AFB, OH.
TURBINE BLADE TIP FILM COOLING MEASUREMENTS M.S. Thesis
DEAN A. WARD Dec. 1992 186 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A267686; AFIT/CI/CIA-93-011) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

In the design of gas turbine engines, the need to accurately know the heat transfer characteristics of the turbine blade tip is of extreme importance. The pressure differential between the pressure and suction side of the blade induces a strong secondary flow of hot combustion gases through the clearance gap between the turbine blade tip and shroud. This leakage flow is detrimental to the tip of the blade. In order to minimize this leakage flow, designers need to accurately know the heat transfer characteristics of the blade and blade tip so that dimensional changes may be accurately predicted. If dimensional changes are accurately known, the clearance gap and the secondary flow may be minimized and the overall thermal efficiency of the gas turbine engine increased. In addition, increased blade life is often achieved by cooling of the blade and blade tip. DTIC

N94-15141*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT-DETERMINED ENGINE EXHAUST CHARACTERISTICS OF AN F404 ENGINE IN AN F-18 AIRPLANE
KIMBERLY A. ENNIX, FRANK W. BURCHAM, JR., and LANNIE D. WEBB Oct. 1993 15 p Presented at the AIAA/SAE/ASME/ASEE 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993 See also A93-50267
(Contract RTOP 537-03-20)
(NASA-TM-4538; H-1910; NAS 1.15:4538; AIAA PAPER 93-2543) Copyright Avail: CASI HC A03/MF A01

Personnel at the NASA Langley Research Center (NASA-Langley) and the NASA Dryden Flight Research Facility (NASA-Dryden) recently completed a joint acoustic flight test program. Several types of aircraft with high nozzle pressure ratio engines were flown to satisfy a twofold objective. First, assessments were made of subsonic climb-to-cruise noise from flights conducted at varying altitudes in a Mach 0.30 to 0.90 range. Second, using data from flights conducted at constant altitude in a Mach 0.30 to 0.95 range, engineers obtained a high quality noise database. This database was desired to validate the Aircraft Noise Prediction Program and other system noise prediction codes. NASA-Dryden personnel analyzed the engine data from several aircraft that were flown in the test program to determine the exhaust characteristics. The analysis of the exhaust characteristics from the F-18 aircraft are reported. An overview of the flight test planning, instrumentation, test procedures, data analysis, engine modeling codes, and results are presented. Author (revised)

N94-15192*# Sverdrup Technology, Inc., Brook Park, OH. Lewis Research Center Group.
ROTARY ENGINE PERFORMANCE COMPUTER PROGRAM (RCEMAP AND RCEMAPPC): USER'S GUIDE Final Report
TIMOTHY A. BARTRAND and EDWARD A. WILLIS Oct. 1993 240 p
(Contract NAS3-25266; RTOP 505-62-11)
(NASA-CR-191192; E-8133; NAS 1.26:191192) Avail: CASI HC A11/MF A03

This report is a user's guide for a computer code that simulates the performance of several rotary combustion engine configurations. It is intended to assist prospective users in getting started with RCEMAP and/or RCEMAPPC. RCEMAP (Rotary Combustion Engine performance MAP generating code) is the mainframe version, while RCEMAPPC is a simplified subset designed for the personal computer, or PC, environment. Both versions are based on an open, zero-dimensional combustion system model for the prediction of instantaneous pressures, temperature, chemical composition and other in-chamber thermodynamic properties. Both versions predict overall engine performance and thermal characteristics, including bmep, bsfc, exhaust gas temperature, average material temperatures, and turbocharger operating conditions. Required inputs include engine geometry, materials, constants for use in the combustion heat release model, and turbomachinery maps. Illustrative examples and sample input files for both versions are included. Author (revised)

N94-15344* National Aeronautics and Space Administration, Washington, DC.
BACK TO PROPELLERS (Videotape)
Jun. 1987 Videotape: 2 min. 50 sec. playing time, in color, with sound
(NASA-TM-109445; NONP-VT-93-190242) Avail: CASI VHS A01/BETA A22

The videotape shows the unique propfan design. The propfan is designed to achieve the speeds and altitudes of jets while only using half the normal amount of fuel. CASI

N94-15866*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EFFECT OF WIND TUNNEL ACOUSTIC MODES ON LINEAR OSCILLATING CASCADE AERODYNAMICS
DANIEL H. BUFFUM and SANFORD FLEETER (Purdue Univ., West Lafayette, IN.) May 1993 43 p Presented at the 38th ASME International Gas Turbine and Aeroengine Congress and Exposition, Cincinnati, OH, 24-27 May 1993; sponsored by ASME
(Contract RTOP 505-62-10)
(NASA-TM-106367; E-8171; NAS 1.15:106367) Avail: CASI HC A03/MF A01

The aerodynamics of a biconvex airfoil cascade oscillating in torsion is investigated using the unsteady aerodynamic influence coefficient technique. For subsonic flow and reduced frequencies as large as 0.9, airfoil surface unsteady pressures resulting from oscillation of one of the airfoils are measured using flush-mounted high-frequency-response pressure transducers. The influence coefficient data are examined in detail and then used to predict the unsteady aerodynamics of a cascade oscillating at various interblade phase angles. These results are correlated with experimental data obtained in the traveling-wave mode of oscillation and linearized analysis predictions. It is found that the unsteady pressure disturbances created by an oscillating airfoil excite wind tunnel acoustic modes which have detrimental effects on the experimental data. Acoustic treatment is proposed to rectify this problem. Author

N94-16157# Army Missile Command, Redstone Arsenal, AL.
WIND TUNNEL INVESTIGATION WITH AN OPERATIONAL TURBOJET ENGINE
LAMAR M. AUMAN *In* Huntsville Association of Technical Societies, TABES 1993: 9th Annual Technical and Business Exhibition and Symposium 6 p 1993
(TABES PAPER 93-662) Avail: CASI HC A02/MF A03

A wind tunnel test of a turbojet powered missile with the engine installed and operating was conducted in Calspan's Transonic Wind Tunnel in Buffalo, New York from 20 May to 3 June 1991. The primary model configuration consisted of a bifurcated inlet and exhaust which was sting mounted. Instrumentation consisted of a six-component main balance, four fin balances, 39 thermocouples, 10 heat flow gages and several base pressure ports. The purpose of this test was to investigate stability and control, installed engine performance at flight conditions, and plume interactions or aft heating problems. The investigation obtained data at Mach numbers from 0.05 to 0.80, with the majority of the data collected at Mach 0.33, 0.50 and 0.60. Angle of attack was swept from -16 deg to +16 deg, with engine throttle setting, fin deflection angle and Mach number held constant. Missile stability data indicates that the operational mid-body turbojet engine has no adverse effect on missile stability or control authority. Aftbody thermal data indicates that the worst case occurs during a low Mach number (static) high engine throttle setting condition. Author (revised)

N94-17386*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF THE NASA LOW-SPEED CENTRIFUGAL COMPRESSOR FLOW FIELD
MICHAEL D. HATHAWAY, RANDALL M. CHRISS, JERRY R. WOOD, and ANTHONY J. STRAZISAR Washington Sep. 1993 21 p Presented at the 37th International Gas Turbine and Aero Engine Congress and Exposition, Cologne, Germany, 1-4 Jun. 1992; sponsored by ASME See also A93-19436 Prepared in cooperation with Army Research Lab., Cleveland, OH
(Contract RTOP 505-62-52)
(NASA-TM-4481; E-7651; NAS 1.15:4481; AVSCOM-TR-91-C-052) Avail: CASI HC A03/MF A01

An experimental and computational investigation of the NASA

Lewis Research Center's low-speed centrifugal compressor (LSCC) flow field was conducted using laser anemometry and Dawes' three-dimensional viscous code. The experimental configuration consisted of a backswept impeller followed by a vaneless diffuser. Measurements of the three-dimensional velocity field were acquired at several measurement planes through the compressor. The measurements describe both the throughflow and secondary velocity field along each measurement plane. In several cases the measurements provide details of the flow within the blade boundary layers. Insight into the complex flow physics within centrifugal compressors is provided by the computational fluid dynamics analysis (CFD), and assessment of the CFD predictions is provided by comparison with the measurements. Five-hole probe and hot-wire surveys at the inlet and exit to the impeller as well as surface flow visualization along the impeller blade surfaces provided independent confirmation of the laser measurement technique. The results clearly document the development of the throughflow velocity wake that is characteristic of unshrouded centrifugal compressors. Derived from text

N94-17470*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
JET ENGINE PERFORMANCE ENHANCEMENT THROUGH USE OF A WAVE-ROTOR TOPPING CYCLE
JACK WILSON (Sverdrup Technology, Inc., Brook Park, OH.) and DANIEL E. PAXSON Washington Oct. 1993 12 p
(Contract RTOP 505-62-10)
(NASA-TM-4486; E-7836; NAS 1.15:4486) Avail: CASI HC A03/MF A01

A simple model is used to calculate the thermal efficiency and specific power of simple jet engines and jet engines with a wave-rotor topping cycle. The performance of the wave rotor is based on measurements from a previous experiment. Applied to the case of an aircraft flying at Mach 0.8, the calculations show that an engine with a wave rotor topping cycle may have gains in thermal efficiency of approximately 1 to 2 percent and gains in specific power of approximately 10 to 16 percent over a simple jet engine with the same overall compression ratio. Even greater gains are possible if the wave rotor's performance can be improved. Author

N94-18333 Analytic Sciences Corp., Midwest City, OK.
THE J85 COST/BENEFIT ENGINE STUDY Final Report
LAWRENCE E. MACHADO, JOHN M. PFALZ, and PAUL R. WETZEL 28 May 1993 53 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract F33657-92-D-2055)
(AD-A269280) Avail: CASI HC A04

This report documents the results of an independent evaluation of J85 maintenance practices and the data reporting system used for parts life tracking (PLT) of selected life limited components. A major requirement of the study was to quantify the costs/benefits associated with using the D042 Comprehensive Engine Management System (CEMS) for J85 PLT versus the system now in use. The techniques and methodologies used in the analysis are compatible with the philosophy of Reliability-Centered Maintenance (RCM). DTIC

N94-18748 Army Research Lab., Aberdeen Proving Ground, MD.
NUMERICAL SIMULATION OF FLUID DYNAMICS AND COMBUSTION FOR RAM ACCELERATOR PROJECTILE/OBTURATOR INTERACTION Final Report, Jan. - Dec. 1992
MICHAEL J. NUSCA Sep. 1993 44 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A269715; ARL-TR-198) Avail: CASI HC A03

Computational fluid dynamics solutions of the Navier-Stokes equations have been applied to both nonreacting and reacting in-bore flowfields for a ram accelerator projectile launch system. In this system, a projectile is injected at supersonic velocity into a stationary tube filled with a pressurized mixture of hydrocarbon, oxidizer, and inert gases. After ignition, the shock system generated by the projectile can result in sustained combustion around and aft of the projectile. This energy release process, which travels with the projectile, also generates high pressures and imparts thrust to the projectile. Experimental observations indicate that the porous obturator may play a significant role in the initiation of combustion after projectile injection. Numerical simulations have been used to investigate the role of the obturator in both the 38mm and 120mm (bore diameter) systems. DTIC

N94-18907 Wright Lab., Wright-Patterson AFB, OH.
VANE OPTIMIZATION FOR MAXIMUM EFFICIENCY USING DESIGN OF EXPERIMENTS (DOX) Final Report, Apr. 1992 - Mar. 1993
PAUL T. KERNEY Mar. 1993 47 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract AF PROJ. 681B)
(AD-A270270; WL-TR-93-2055) Avail: CASI HC A03

Optimization of vane and bleed settings in a multistage axial compressor undergoing development can be a difficult, time-consuming, and expensive process. This project optimized seven variable vanes and one variable bleed on the five-stage Pratt & Whitney XTC66 compressor at the aerodynamic design point (ADP) for maximum efficiency using Design of Experiments (DOX). The DOX are statistical methods for changing process inputs in a systematic way, and analyzing the resulting outputs in order to improve a response to an acceptable or optimum value, find a less expensive design, material, or method providing equivalent results, or understand process sensitivities. Along with developing a model for maximum efficiency, the project also developed models for predicting pressure ratio and mass flow. Results show the number of Steady State Data Points (SSDP's) to be reduced, as well as, the total test time without sacrificing data integrity. DTIC

N94-19353*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OVERVIEW OF STOVL AIRCRAFT PROPULSION RESEARCH OFFTAKES AND VERTICAL LIFT SYSTEMS
THOMAS J. BIESIADNY, JACK G. MCARDLE, and BARBARA S. ESKER Dec. 1993 14 p Presented at the International Powered Lift Conference, Santa Clara, CA, 1-3 Dec. 1993; sponsored by AIAA
(Contract RTOP 505-68-32)
(NASA-TM-106387; E-8207; NAS 1.15:106387; AIAA PAPER 93-4865) Avail: CASI HC A03/MF A01

The overall Short Takeoff and Vertical Landing (STOVL) Aircraft Propulsion Research program includes key technologies involving offtake systems, vertical lift systems, hot gas ingestion, STOVL augmentors, and integrated flight propulsion controls. A part of the NASA Lewis work involving STOVL aircraft propulsion systems is presented with the emphasis on component-level experiments and analysis related to offtakes and vertical lift systems. Author (revised)

N94-20042# Naval Academy, Annapolis, MD.
DESIGN OF A STATE-SPACE CONTROLLER FOR AN ADVANCED GAS TURBINE ENGINE
KARL F. PRIGGE 17 May 1993 50 p
(AD-A270859; USNA-TSPR-207) Avail: CASI HC A03/MF A01

A multi-input, multi-output (MIMO) controller for an advanced gas turbine has been developed and tested using a computer simulation. The engine modeled is a two-and-one-half spool gas turbine with both an intercooler and a regenerator. In addition, variable stator vanes are present in the free-power turbine. This advanced engine is proposed for future naval propulsion for both mechanical drive and electrical drive. The designed controller controls free-power turbine speed and turbine inlet temperature using fuel flow and angle of the stator vanes. The controller will also have four modes of operation to deal with over temperature and over speed conditions. An eight state reduced order controller was used with pole placement and LQR to arrive at control gains.

Both these methods required considerable insight into the problem. This insight was provided by previous experience with controller design for a less complicated engine, and also by use of a polyhedral search model of the gas turbine engine. The difficulty with a MIMO controller was that both inputs affect both of the control variables. The classical resolution this problem is to have one input control one variable at a fast time constant and the other input control the other variable at a slow time constant. The 'optimal' resolution of this problem is analyzed using the transient curves and basic control theory. DTIC

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A94-10115
MINIMUM TIME 3-D FLIGHT TRAJECTORY COMPUTATION
CHUAN LU (Beijing Univ. of Aeronautics and Astronautics, China) Beijing University of Aeronautics and Astronautics, Journal (ISSN 1001-5965) no. 1 Jan. 1992 p. 112-119. In CHINESE refs

Miele et al. (1970) developed the SGRA method for optimal flight trajectory computation, but there are some shortcomings in determining the time weighting, controlling the integral precision, and requiring a numerical differential. This article presents a modifying gradient method, and the fastest 3D turning trajectory from subsonic to supersonic is calculated. This method is shown to be stable and efficient. This method provides an efficient algorithm for optimizing the flight trajectory. Author (revised)

A94-10118
A PREDICTION FOR LANDING FLYING QUALITIES OF AIRCRAFT USING LOOP SEPARATION PARAMETER METHOD
YACHANG FENG and YONG WANG (Beijing Univ. of Aeronautics and Astronautics, China) Beijing University of Aeronautics and Astronautics, Journal (ISSN 1001-5965) no. 2 April 1993 p. 36-42. In CHINESE refs

The physical meaning and calculation method of loop separation parameter are introduced in this paper. This method is applied to a test aircraft with a longitudinal digital fly-by-wire system and it can predict the landing flying quality of the aircraft, the control frequency of critical instability, and the control frequency of pilot induced oscillation, so that some useful conclusions can be worked out. Author (revised)

A94-10281
GAIN SCHEDULING FOR H-INFINITY CONTROLLERS - A FLIGHT CONTROL EXAMPLE
ROBERT A. NICHOLS, ROBERT T. REICHERT (Johns Hopkins Univ., Laurel, MD), and WILSON J. RUGH (Johns Hopkins Univ., Baltimore, MD) IEEE Transactions on Control Systems Technology (ISSN 1063-6536) vol. 1, no. 2 June 1993 p. 69-79. refs (Contract AF-AFOSR-90-0138)
Copyright

A new approach to gain scheduling linear dynamic controllers is illustrated for a pitch-axis autopilot design problem. In this application the linear controllers are designed at distinct operating conditions by H(infinity) methods. The gain scheduling procedure uses particular features of both the linear dynamic controllers and the controller configuration to remove so-called hidden coupling terms that can occur in scheduled controllers. Potential performance improvement is demonstrated by comparing simulation results to those for a naive gain scheduled controller that ignores the coupling terms.

A94-10282
ROBUST FLIGHT CONTROL DESIGN USING DYNAMIC INVERSION AND STRUCTURED SINGULAR VALUE SYNTHESIS
RICHARD J. ADAMS and SIVA S. BANDA (USAF, Wright Lab., Wright-Patterson AFB, OH) IEEE Transactions on Control Systems Technology (ISSN 1063-6536) vol. 1, no. 2 June 1993 p. 80-92. refs
Copyright

A direct methodology for the design of flight control systems is introduced. The design approach uses a control selector and an inner/outer loop structure to achieve robustness and performance across the flight envelope. A control selector normalizes control effectiveness with respect to generalized inputs. An inner loop uses dynamic inversion to equalize plant dynamics across the flight envelope. An outer loop is designed around this equalized plant, using mu-synthesis to achieve performance and robustness goals. The methodology is applied to the design of a manual flight control system for the lateral axis of a fighter aircraft. Analysis shows that the inner/outer loop approach produces designs with excellent performance and robustness for a broad range of operating conditions. The direct incorporation of design goals such as flying qualities requirements and the elimination of gain scheduling make this direct methodology an effective and efficient alternative to traditional flight control design approaches.

A94-10328
F-16 UNCOMMANDED PITCH OSCILLATION
W. A. FLYNN and K. L. KELLER (USAF, Edwards AFB, CA) Cockpit (ISSN 0742-1508) Apr.-June 1993 p. 4-12.
Copyright

Simulation tests to investigate an uncommanded pitch oscillation in an F-16 aircraft are reported. The flight control anomaly was characterized and a control law modification was developed to eliminate the problem. It was demonstrated that a software fix terminated pitch oscillations induced with the original control laws, once a modified control law path was selected. Flight test results demonstrated that the fix was effective throughout the entire flight envelope in all types of Digital Flight Control system modes and aircraft configurations. Aircraft performance did not deteriorate due to the modified control laws. AIAA

A94-10744
IDENTIFICATION OF THRUST VECTOR EFFECTIVENESS FROM X-31A FLIGHT TEST DATA
E. PLAETSCHKE and S. WEISS (DLR, Inst. fuer Flugmechanik, Braunschweig, Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X) vol. 17, no. 4 Aug. 1993 p. 235-238. refs
Copyright

The effectiveness of the thrust vectoring system of X-31A, the U.S./German post-stall demonstrator aircraft, is evaluated from the flight test data. The evaluation technique is briefly described, and preliminary results are presented. In particular, it is found that the effectiveness in pitch in general follows the thrust model predictions while the effectiveness in yaw seems to be lower than predicted. It is noted, however, that the results are affected by the uncertainty in the gross weight thrust, as calculated from the thrust model. AIAA

A94-10798
EFFECTS OF PROPELLER ON THE TURNING FLIGHT OF OLD FIGHTERS
TADASHI SATO (Iwate Univ., Morioka, Japan), HIROBUMI OHTA (Nagoya Univ., Japan), SHOKICHI KANNO (Ichinoseki National College of Technology, Japan), and TATSUO CHUBACHI (Iwate Univ., Morioka, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811) vol. 36, no. 112 Aug. 1993 p. 72-91. refs

This paper is concerned with the effects of propeller on the turning flight of old fighters. The effects of propeller are composed of three elements. One of them is the aerodynamic moments induced by the vortex. The second is the gyro moments and the third is the torque reaction due to propeller. The curves of trailing vortices are spiral. Exact analysis is very difficult. Therefore the vortices are decomposed into the axial and circumferential components in this paper. The latter gives almost no effect. Approximate analyses of aerodynamic moments and stability derivatives were performed. The results were applied to the simulations of turning flight of old fighters. Considerable effects are shown in the figures.

A94-10800
STATIC AND DYNAMIC FLIGHT-PATH STABILITY OF AIRPLANES
OSAMU KOBAYASHI (Kawasaki Heavy Industries, Ltd., Kakamigahara, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811) vol. 36, no. 112 Aug. 1993 p. 107-120. Translation. refs
The concept of flight-path stability, which is today in use, is based on the characteristics of airplanes in equilibrium, or steady unaccelerated flight conditions, and so can be called 'static flight-path stability'. After summarizing the studies on static flight-path stability from several points of view, the concept of 'dynamic flight-path stability' for accelerated/decelerated flight conditions is introduced, and the elevator compensation necessary to provide an airplane with a desired dynamic flight-path stability is obtained. Furthermore, through analysis of the time history and the root-locus characteristics of an airplane's motion, it is shown that an airplane with compensation can stably control the flight-path via the elevator in the backside region. Author (revised)

A94-10801* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DESIGN AND PILOTED SIMULATION OF INTEGRATED FLIGHT/PROPULSION CONTROLS FOR STOVL AIRCRAFT
JAMES A. FRANKLIN and SHAWN A. ENGELLAND (NASA, Ames Research Center, Moffett Field, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 6 Nov.-Dec. 1993 p. 993-998. AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Baltimore, MD, Sept. 23-25, 1991, AIAA Paper 91-3108. Previously cited in issue 23, p. 4021, Accession no. A91-54032 refs
Copyright

A94-10803 National Aeronautics and Space Administration, Washington, DC.
OPTIMAL RECOVERY FROM MICROBURST WIND SHEAR
SANDEEP S. MULGUND and ROBERT F. STENGEL (Princeton Univ., NJ) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 6 Nov.-Dec. 1993 p. 1010-1017. AIAA Atmospheric Flight Mechanics Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1, p. 1-8. Previously cited in issue 23, p. 4067, Accession no. A92-55327 Research supported by FAA refs
(Contract NGL-31-001-252)
Copyright

A94-10805* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT-DETERMINED MULTIVARIABLE STABILITY ANALYSIS AND COMPARISON OF A CONTROL SYSTEM
JOHN J. BURKEN (NASA, Flight Research Center, Edwards, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 6 Nov.-Dec. 1993 p. 1026-1031. AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1, p. 439-453. Previously cited in issue 23, p. 4064, Accession no. A92-55196 refs
Copyright

A94-10833
COMMENT ON 'GENERALIZED TECHNIQUE FOR INVERSE SIMULATION APPLIED TO AIRCRAFT MANEUVERS'
KUO-CHI LIN (Central Florida Univ., Orlando, FL) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 6 Nov.-Dec. 1993 p. 1196-1199. refs
Copyright
With reference to the integration reverse method introduced by Hess et al. (1991), it is demonstrated through an analysis and an example that the solution exhibits high-frequency oscillations when the discretization interval T is less than 0.005, leading to an erratic and unstable result. In their response, the authors of the original paper point out that the filtering procedure mentioned in their study makes it possible to approximate the true control inputs with sufficient accuracy for engineering analysis AIAA

A94-11974
INVESTIGATION OF THE LONGITUDINAL STABILITY OF THE T-45A WITH COMPUTATIONAL FLUID DYNAMICS
K. BLACKBURN, S. AGRAWAL, and D. JASPER (McDonnell Aircraft Co., Saint Louis, MO) Oct. 1992 12 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921925) Copyright
Wind tunnel and flight tests of the T-45A aircraft have identified a transonic region of reduced longitudinal stability. Wind tunnel results established the phenomenon as a flow interaction between the wing-body and the horizontal tail; however, insufficient data existed to determine the mechanism causing the reduced stability. Computational Fluid Dynamics (CFD) analysis of the T-45A in the transonic region identified the source of the reduced stability to be an increase in downwash on the horizontal tail caused by mid-span vorticity shed from the wing.

A94-12002* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MANEUVERING TECHNOLOGY FOR ADVANCED FIGHTER AIRCRAFT
MICHAEL G. ALEXANDER (USAF, Wright-Patterson AFB, OH), SCOTT H. HARRIS (NASA, Ames Research Center, Moffett Field, CA), and RICHARD H. BYERS (USAF, Wright-Patterson AFB, OH) Oct. 1992 12 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921984) Copyright
The need for increased maneuverability has its genesis from the first aerial combat engagement when two adversaries entangled themselves in a deadly aerial dance trying to gain the advantage over the other. It has only been in the past two decades that technologies have been investigated to increase aircraft control at maneuver attitudes that are typically dominated by highly separated flows. These separated flow regions are aggravated by advanced fighter aircraft shapes required to defeat an electronic enemy. This paper discusses passive and active devices that can be used to enhance the maneuverability of advanced fighter aircraft through vortex flow control, boundary layer control, and innovative flow manipulation.

A94-12009
SPOILER ACTUATOR - PROBLEM INVESTIGATION
WILLEM D. WOLDA (Boeing Commercial Airplane Group, Seattle, WA) Oct. 1992 11 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992
(SAE PAPER 922005) Copyright
The Boeing 757 commercial jet transport experienced a series of uncommanded roll events requiring pilot action to maintain wings-level flight. Investigation revealed failures within the spoiler control actuator that allowed excessive internal leakage. This significantly reduced the capability of the actuator to hold the spoiler surface down against aerodynamic forces, and allowed the panel to float.

A94-12090
HELICOPTER FLYING QUALITIES IN CRITICAL MISSION TASK ELEMENTS - INITIAL EXPERIENCE WITH THE DRA (BEDFORD) LARGE MOTION SIMULATOR
GARETH D. PADFIELD, MALCOLM T. CHARLTON, and ANDY M. KIMBERLEY (Defence Research Agency, Flight Dynamics and Simulation Div., Bedford, United Kingdom) Sep. 1992 43 p.

AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by Ministry of Defence of United Kingdom refs

The first experiences are reported with the Large Motion Simulator at DRA Bedford for simulating the flying qualities of helicopters in NoE mission task elements. A framework for defining flying qualities in terms of an aircraft's response characteristics and the key external environmental influences is described. The simulation facility is described along with special developments in modeling, motion, and visual cueing undertaken to support the trials. Comparisons with other current helicopter simulation efforts are made. AIAA

A94-12091

HANDLING QUALITIES AND PERFORMANCE ASPECTS OF THE SIMULATION OF HELICOPTERS FLYING MISSION TASK ELEMENTS

R. BRADLEY and D. G. THOMSON (Glasgow Univ., United Kingdom) Sep. 1992 16 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by Royal Society refs

As part of demonstrations of compliance with U.S. Handling Qualities for Military Rotorcraft, a set of standard maneuvers designated Mission Task Elements (MTEs) has been defined and criteria for performance and handling have been specified. Attention has been given to inverse simulation as a basis for objective evaluation of both the performance and handling qualities of helicopters flying aggressive MTEs. Inverse simulation is here demonstrated for the cases of agility rating, design evaluation, and control strategy. AIAA

A94-12092

MANEUVERABILITY ASPECTS FOR HELICOPTER TAKEOFF AND LANDING

N. TRAENAPP, G. REICHERT, and H. HEPP (Braunschweig, Technische Univ., Germany) Sep. 1992 15 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs
(Contract DFG-SFB-212)

During takeoff and landing, often a helicopter has to operate within a wind-induced ground boundary layer. For safety reasons, adequate maneuverability and power available is essential for such flight conditions. The investigation is based on a six-body DOF simulation with consideration of the blade-flapping degree. A simple approximation of the wind-induced ground boundary, which is validated by measurements, is applied for the variation of the horizontal wind-velocity. Wind influence on the ground vortex is described and verified by flight test measurements. Based on energy-method considerations, safety for the incidence of an engine-failure during takeoff and landing maneuvers can be estimated using the height-velocity diagram. Simulation investigations consider the influence of the ground boundary on this diagram. Simulations for typical flight paths for takeoff and landing procedures are investigated, providing insight into maneuverability and decisive variables of state. Flight conditions with small distance to maneuverability limits are presented for proposed modification of current rules. Author (revised)

A94-12093* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

INVESTIGATION OF THE EFFECTS OF BANDWIDTH AND TIME DELAY ON HELICOPTER ROLL-AXIS HANDLING QUALITIES

HEINZ-JUERGEN PAUSDER (DLR, Inst. fuer Flugmechanik, Braunschweig, Germany) and CHRIS L. BLANKEN (U.S. Army, Aviation and Troop Command; NASA, Ames Research Center, Moffett Field, CA) Sep. 1992 18 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

Several years of cooperative research conducted under the U.S./German Memorandum of Understanding (MOU) in helicopter flight control has recently resulted in a successful handling qualities study. The focus of this cooperative research has been the effects on handling qualities due to time delays in combination with a high bandwidth vehicle. The jointly performed study included the use of U.S. ground-based simulation and German in-flight simulation facilities. The NASA-Ames Vertical Motion Simulator (VMS) was used to develop a high bandwidth slalom tracking task which took into consideration the constraints of the facilities. The VMS was also used to define a range of the test parameters and to perform initial handling qualities evaluations. The flight tests were conducted using DLR's variable-stability BO 105 S3 Advanced Technology Testing Helicopter System (ATTHeS). Configurations included a rate command and an attitude command response system with added time delays up to 160 milliseconds over the baseline and bandwidth values between 1.5 and 4.5 rad/sec. Sixty-six evaluations were performed in about 25 hr of flight time during 10 days of testing. The results indicate a need to more tightly constrain the allowable roll axis phase delay for the Level 1 and Level 2 requirements in the U.S. Army's specification for helicopter handling qualities, ADS-33C.

A94-12099

DEVELOPMENT OF ACTIVE CONTROL TECHNOLOGY IN THE ROTATING SYSTEM, FLIGHT TESTING AND THEORETICAL INVESTIGATIONS

D. TEVES, V. KLOEPPEL (Eurocopter Deutschland GmbH, Munich, Germany), and P. RICHTER (Henschel Flugzeug-Werke, Kassel, Germany) Sep. 1992 14 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The extension of the conventional rotor control system to individual control of the single rotor blades (IBC) implements a vast potential of enhancing helicopter flight performance. In order to test this system, new flight tests on a BO105 equipped with IBC were performed. The control system has been realized utilizing pitch link actuators, replacing the control rods in the rotating system between swashplate and rotor blades. This represents the first flying four-bladed helicopter with the blades individually controlled. In order to reduce the number of free control parameters the IBC technology was tested in the harmonic mode. Compared to former flight tests, reported in ERF 1900, the control authority has been increased in order to better address vibration and noise reduction effects. These effects are discussed in comparison with theoretical results. Author (revised)

A94-12102

THE EUROPEAN ACT PROGRAMME - COMPLEMENTARY USE OF GROUND BASED SIMULATION FACILITIES AND EXPERIMENTAL 'FLY BY WIRE/LIGHT' HELICOPTERS

D. SCHIMKE (Eurocopter Deutschland GmbH, Munich, Germany), C. GUYOMARD (Eurocopter France, Marignane), R. M. T. LANE (Westland Helicopters, Ltd., Yeovil, United Kingdom), A. BELLAZZI (Gruppo Agusta, Milan, Italy), M. T. CHARLTON (Defence Research Agency, Farnborough, United Kingdom), and H.-J. PAUSDER (DLR, Oberpfaffenhofen, Germany) Sep. 1992 18 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

A status evaluation is presented for aspects of Europe's Active Control Technology (ACT) development program applicable to helicopter flight control systems. These developmental activities have been apportioned to two working teams, which respectively deal with handling qualities and control laws, and with interceptors. The comprehensive groundwork of the ACT program involves the definition of task elements, the selection of rate-response parameters, the definition of test configurations, and the definition of assessment methods. AIAA

A94-12108

CONCEPTUAL DESIGN OF A STOPPED ROTOR WITH FLAP CONTROLS

E. KISLI (Undersecretariat for Defence Industries, Ankara, Turkey), J. V. R. PRASAD (Georgia Inst. of Technology, Atlanta), and Y. K. YILLIKCI (Undersecretariat for Defence Industries, Ankara, Turkey) Sep. 1992 11 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

A set of helicopter equations for a unique configuration of trailing edge flap controlled rotor blades are derived and solved both for different forward velocities and various blade stopping conditions. New aerodynamic environment due to flap control is formulated based on Theodorsen's unsteady oscillating airfoil aerodynamics representation including unsteady trailing edge flap motions. A simplified procedure is used to calculate the trim settings for the flap and corresponding pitch controls. Flap control input settings are calculated by an iterative procedure and control inputs for blades with flap and pitch controls are compared and rotor stopping conditions for different blade configurations with variable chord and flap configurations are analyzed.

A94-12111
A TRANSLATIONAL RATE COMMAND CONTROL LAW FOR HOVER ASSIST
REINER SUIKAT (DLR, Braunschweig, Germany) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

Future helicopters will rely heavily on advanced flight control systems to extend bad weather operations and to fully utilize the operational envelope of the vehicle. Especially in hover the pilot workload can be significantly reduced by providing advanced command and stability augmentation functions. This paper documents the design and flight testing of a translational rate command control law including position/altitude/heading hold functions which completely stabilizes the helicopter and dccouples the inputs. Without pilot inputs the control law switches into hold modes so that precision hover is done automatically. The control law has been validated in nonlinear simulations as well as flight tests on the BO105-S3 fly-by-wire/fly-by-light research helicopter of DLR. Discrete-time multivariable control design techniques have been used to derive the new control law demonstrating the applicability of such techniques to complex nonlinear systems.

A94-12112
ACTIVE CONTROL OF VIBRATIONS IN HELICOPTERS - FROM HHC TO OBC
SERGIO BITTANTI, FABRIZIO LORITO, LUCA MOIRAGHI, and SILVIA STRADA (Milano, Politecnico, Milan, Italy) Sep. 1992 11 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by MURST and CNR refs

The limitations of helicopter rotor vibration higher-harmonic control (HHC) are presently characterized in view of a critical analysis conducted in a continuous time setting. A continuous time-controller based on observer concepts is proposed in which a dynamic model describes the effect of swash plate commands on the hub force. The state of such a model is enlarged by including a state-space model of the disturbance; this observer-based controller is more robust, time-responsive, and frequency-constrained in its compensation for vibrations. AIAA

A94-12113
CONTRIBUTION TO PERFORMANCE ASSESSMENT OF HELICOPTER ROTOR SPEED CONTROL BY NUMERICAL OPTIMIZATION
M. A. GARNOT-DAO (ONERA, Ecole de l'Air, Salon-de-Provence-Air, France) Sep. 1992 11 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

This paper is concerned with the improvement to helicopter maneuverability and agility by control of a continuous, variable rotor speed. The maneuver considered here consists in jumping in a vertical plane and returning to level flight at the same initial altitude; the end time is fixed. The helicopter model is a point-mass, and a new control related to rotor speed is considered in addition to the classic control variables. Optimal control strategies are obtained by two numerical optimization techniques, respectively, from first-order (projected gradient) and second-order (quasi-linearization) algorithm. In comparison with a constant rotor speed vehicle, a 10 percent increase of rotor speed allows thus, in some flight conditions, more than 60 percent improvement in the maximum altitude variation. This illustrates the potential of variable rotor speed control to extend maneuverability of helicopters. Author (revised)

A94-12118* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
RESEARCH ON MEASUREMENT AND CONTROL OF HELICOPTER ROTOR RESPONSE USING BLADE-MOUNTED ACCELEROMETERS 1991-92
NORMAN D. HAM (MIT, Cambridge, MA) and ROBERT M. MCKILLIP, JR. (Continuum Dynamics, Inc., Princeton, NJ) Sep. 1992 6 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs
(Contract NCC2-366)

Preliminary wind tunnel tests of the hill-size Model 412/IBC rotor at the Ames Research Center, NASA, are described. Blade flapping motion was excited by swash plate oscillation, and the flapping response was measured using blade-mounted accelerometers and compared with flapping motion inferred form blade strain measurements. The recorded open-loop accelerometer signals were used as input to the flapping-IBC system in the laboratory. The resulting controller cyclic pitch outputs are compared with the original cyclic pitch excitation inputs, and the potential effectiveness of the controller in suppressing the original excitation is evaluated. Control of blade flapping excites blade lagging, and vice versa; the paper describes a theoretical investigation of these coupling effects.

A94-12233
EVALUATION OF ADVANCED CONTROL LAWS USING A SIDESTICK ON THE EXPERIMENTAL FLY-BY-WIRE DAUPHIN HELICOPTER
S. DAMOTTE and S. MEZAN (Eurocopter France, Marignane) 1992 10 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

The objectives and results of the experimental evaluation of the fly-by-wire (FBW) Dauphin 6001 helicopter are summarized. In particular, attention is given to the evaluation of the impact of sidestick on control and piloting in terms of workload and performance. It is noted that direct law piloting is degraded by the use of the sidestick, as compared with the classical stick. It is shown, however, that this degradation of the control accuracy can be compensated by advanced control laws. The law by angular rate objective is evaluated. However, the deficiency in control margin restitution and the transition problems on landing prevent this law from being applied in an operational context without any improvement. It is then shown that the conventional law provides easy control with the sidestick throughout the flight envelope. AIAA

A94-12243
INVESTIGATION OF INDIVIDUAL BLADE PITCH CONTROL IN TIME DOMAIN
JANUSZ NARKIEWICZ and WIESLAW LUCJANEK (Warsaw Univ. of Technology, Poland) 1992 11 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by Polish State Committee for Scientific Research refs

An algorithm is developed of the stabilization of blade motion through active control of the pitch angle. The algorithm performs control of individual rotor blades in time domain. Optimal controls are obtained by solving differential Riccatti equations for the conditions given at the end of a selected time period. The convergence and efficiency of the algorithm are demonstrated. AIAA

A94-12247
PARAMETRIC IDENTIFICATION OF A MODEL FOR THE DYNAMICS OF HELICOPTER MOTION USING OPTIMAL CONTROL THEORY METHODS
L. N. NIKIFOROVA (Kamov Helicopter Scientific and Technology Co., Russia) 1992 11 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

A series of experiments has been conducted with a view to the identification of a system model having its basis in optimal control theory. This method is then used to solve the dual, model identification/control optimization problem. The illustrative case thus treated is the model identification of a coaxial helicopter rotor's motion during a maneuver in a vertical plane. AIAA

A94-12488* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
DEVELOPMENT OF AN ON-LINE PARAMETER ESTIMATION SYSTEM USING THE DISCRETE MODAL FILTER
S. J. SHELLEY (Cincinnati Univ., OH), L. C. FREUDINGER (NASA, Flight Research Facility, Edwards, CA), and R. J. ALLEMANG (Cincinnati Univ., OH) *In* International Modal Analysis Conference, 10th, San Diego, CA, Feb. 3-7, 1992, Proceedings. Vol. 1 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 173-183. refs
Copyright

Ongoing development of an automated system for monitoring the frequency and damping of time varying structural systems is discussed. A spatial filtering technique called the discrete modal filter is used to uncouple multiple response measurements into modal coordinate responses. Since the modal coordinate responses are the responses of single-degree-of-freedom systems, the frequency and damping may be accurately estimated with short data records. An on-line monitoring system is discussed which may be useful in a variety of applications. The focus in this paper is on the application to aircraft flight flutter testing.

A94-12613
ACTIVE FLUTTER SUPPRESSION TECHNIQUES IN AIRCRAFT WINGS
GIAN L. GHIRINGHELLI, MASSIMILIANO LANZ, PAOLO MANTEGAZZA, and SERGIO RICCI (Milano, Politecnico, Milan, Italy) *In* Control and dynamic systems. Vol. 52 - Integrated technology methods and applications in aerospace systems design San Diego, CA Academic Press, Inc. 1992 p. 57-115. refs
Copyright

The paper illustrates the facets and tools required to design an active flutter suppression system (AFSS), including aerodynamics, coupling of the aeroelastic system to arbitrary actuators, and design of AFSSs with methods that can include the determination of sensors/actuators locations and combine the design of structurally constrained active controllers with passive structural components. The aerodynamic and open loop modeling of aeroservoelastic systems are extensively treated and established in a general form for the classical and the modern formulations. It is emphasized that it is possible to adopt design methods that, irrespective of the aeroservoelastic formulation used, allow the designer to integrate active and passive control, include sensors/actuators locations as design parameters, assign a simplified controller structure, and directly take into account a large variety of specifications. AIAA

A94-12615
NEW TECHNIQUES FOR AIRCRAFT FLIGHT CONTROL RECONFIGURATION
MARCELLO R. NAPOLITANO (West Virginia Univ., Morgantown) and ROBERT L. SWAIM (Oklahoma State Univ., Stillwater) *In* Control and dynamic systems. Vol. 52 - Integrated technology methods and applications in aerospace systems design San Diego, CA Academic Press, Inc. 1992 p. 155-228. refs
Copyright

The need for a flight control system with a reconfiguration capability would arise folowing battle damage and/or generic failure of a component of the flight control system. This paper introduces new techniques for all phases of the overall flight control reconfiguration problem, starting with the implementation of a neural network for failure detection and identification and a new multiple modal Kalman filtering technique for the correct determination of the mathematical model of the damaged aircraft. A very simple algorithm is proposed for the calculation of the deflection for the other control surfaces to compensate for the damage. Finally, an eigenstructure assignment technique is proposed for the recalculation of the feedback gains of the flight control system with the goal of restoring acceptable handling qualities and to remove the unavoidable damage-induced coupling between the longitudinal and the lateral-direction dynamics. AIAA

A94-12617
APPLICATION OF MULTIPLE MODEL ADAPTIVE ALGORITHMS TO RECONFIGURABLE FLIGHT CONTROL
PETER S. MAYBECK (USAF, Inst. of Technology, Wright-Patterson AFB, OH) *In* Control and dynamic systems. Vol. 52 - Integrated technology methods and applications in aerospace systems design San Diego, CA Academic Press, Inc. 1992 p. 291-320. refs
Copyright

The paper describes a multiple model adaptive control (MMAC) algorithm developed for the STOL F-15 aircraft to provide for reconfiguration in response to sensor and/or actuator failures. The algorithm contains seven elemental controllers, based on a command generator tracker/proportional plus integral/Kalman filter design employing reduced order models. Each elemental controller assumes a particular system status (e.g., no failures or a single failed surface or sensor, or any second such failure, once a first failure is declared). The entire MMAC is evaluated against a higher order 'truth model' with a selected failure, repeating the process for all failure modes of interest. It is shown that the MMAC is capable of providing effective reconfigurability when subjected to single and double failures of sensors and/or actuators. AIAA

A94-12618
TECHNIQUES FOR ON-BOARD AUTOMATIC AID AND ADVISORY FOR PILOTS OF CONTROL-IMPAIRED AIRCRAFT
ELAINE A. WAGNER (General Dynamics Corp., Fort Worth, TX) *In* Control and dynamic systems. Vol. 52 - Integrated technology methods and applications in aerospace systems design San Diego, CA Academic Press, Inc. 1992 p. 321-358. refs
Copyright

The paper describes the types of postfailure operating and performance constraints and discusses the explicit determination of postfailure operating points. Various techniques for postfailure emergency control are examined, including the solution of the problem of control loop reconfiguration, manual recovery, and recovery piloting as expert behavior. Particular attention is given to an expert system for postfailure recovery control, the extensions and use of the expert-type recovery-finding system, and an integrated recovery and advisory system. AIAA

A94-12693* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AEROSERVOELASTICITY
THOMAS E. NOLL (NASA, Langley Research Center, Hampton, VA) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 5 - Structural dynamics and aeroelasticity New York American Society of Mechanical Engineers 1993 p. 179-212. refs
Copyright

An overview of some research activities being conducted on aeroservoelasticity (ASE) in flight vehicles is given. Modeling procedures involving rational functions for approximating unsteady aerodynamics are briefly examined along with analysis methods using the ISAC and ADAM codes. The use of ASE in integrated structure/control law design methodology, control design using constrained optimization/singular value constraints, and adaptive structures is addressed. Test demonstrations of aeroelastic wind-tunnel models or full-scale flight vehicles with active control concepts are described which have significantly enhanced the state of the art in active control technology. The Active Flexible Wing wind-tunnel test project is discussed in detail to emphasize today's activities and accomplishments. Finally, recent activities illustrating the state of the art of ASE in high-speed aircraft are examined. AIAA

A94-12696 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ROTARY-WING AEROELASTICITY WITH APPLICATION TO VTOL VEHICLES
PERETZ P. FRIEDMANN (California Univ., Los Angeles) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 5 - Structural dynamics and aeroelasticity New York American Society of Mechanical Engineers 1993 p. 299-391. refs
(Contract NAG2-477; NAG1-833; DAAL03-88-C-0003; DAAL03-89-K-0007)
Copyright
A concise assessment is presented of the state of the art in the field of rotary-wing aeroelasticity (RWE). The basic ingredients of RWE are reviewed, including structural modeling, unsteady aerodynamic modeling, formulation of the equations of motion, and solution methods. Results illustrating these methods are presented for isolated blades and coupled rotor-fuselage problems. The application of active controls to suppress aeromechanical and aeroelastic instabilities and to reduce vibration in rotorcraft is discussed. Structural optimization with aeroelastic constraints, gust response analysis of helicopters, and aeroelastic problems in special VTOL vehicles are briefly examined. AIAA

A94-12697* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL AEROELASTICITY
JOHN W. EDWARDS (NASA, Langley Research Center, Hampton, VA) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 5 - Structural dynamics and aeroelasticity New York American Society of Mechanical Engineers 1993 p. 393-436. refs
Copyright
Recent large-scale studies of computational unsteady aerodynamics for aeroelastic applications are reviewed. The variety of fluid dynamic flow models available to address such computations are illustrated in two cases: (1) 2D Navier-Stokes (NS) equations illustrating the highest level of modeling usually employed and (2) the transonic small-disturbance potential equation representing the entry level for nonlinear flow modeling. Estimates of computer resources necessary to produce accurate converged results are given. Application of potential and NS equation codes for flows which are generally at lower angles and high speeds are addressed, including (1) the treatment of wings and configuration details using potential equation codes and (2) recent NS code calculations of complete vehicle configurations. Attention is given to high-angle conditions involving separated vortex-dominated flows. Accuracy requirements for vortex shedding over airfoils is discussed and the calculation of vorticity convected over significant distances is addressed. Steady CFD computations about delta wings at high angles are given, including a discussion of the required level of fluid dynamic flow modeling. Recent results on unsteady 'buffetlike flow' about complete vehicle models are reviewed. AIAA

A94-12704
KNOWLEDGE-BASED SYSTEM TECHNIQUES FOR PILOT AIDING
HUBERT H. CHIN (Grumman Corp., Aircraft Systems Div., Bethpage, NY) *In* Control and dynamic systems. Vol. 54 - System performance improvement and optimization techniques and their applications in aerospace systems San Diego, CA Academic Press, Inc. 1992 p. 69-174. refs
Copyright
The state of the art in 'reasonable-to-assist' application of knowledge-based system techniques as applied to pilot aiding is introduced. The design phases, software development techniques, system architecture, and knowledge-based construction techniques required to develop, test, and deploy a pilot aiding system are covered. The proposed system architecture consists of an executive system, an intelligent component system, and a knowledge base management system. The knowledge base construction methodologies are outlined. AIAA

A94-12707* National Aeronautics and Space Administration, Washington, DC.
SIZE-REDUCTION TECHNIQUES FOR THE DETERMINATION OF EFFICIENT AEROSERVOELASTIC MODELS
MORDECHAY KARPEL (Technion - Israel Inst. of Technology, Haifa) *In* Control and dynamic systems. Vol. 54 - System performance improvement and optimization techniques and their applications in aerospace systems San Diego, CA Academic Press, Inc. 1992 p. 263-295. refs
(Contract NAGW-1708)
Copyright
Size-reduction techniques for determining efficient time-domain state-space aeroservoelastic models are presented. Various rational function approximation methods of the unsteady aerodynamic force coefficients are brought to a common motion, emphasizing their differences. Among these, the classic Roger's method is the easier to apply but its resulting number of aerodynamic states is typically equal to or larger than the number of structural states. On the other hand, the minimum-state (MS) method, which typically reduces the number of aerodynamic states by 70 percent or more, requires the solution of an iterative nonlinear least-square solution. The MS computational efforts are reduced significantly when three approximation constraints are applied. AIAA

A94-12708
SENSITIVITY ANALYSIS OF EIGENDATA OF AEROELASTIC SYSTEMS
V. R. MURTHY and YI LU (Syracuse Univ., NY) *In* Control and dynamic systems. Vol. 54 - System performance improvement and optimization techniques and their applications in aerospace systems San Diego, CA Academic Press, Inc. 1992 p. 297-340. refs
Copyright
Methods to determine the derivatives of eigendata for time-invariant and periodic systems with stability constraints are presented. The methods are applied to determine the sensitivity derivatives of the stability eigenvalues of three rotary-wing aeroelastic problems. The first example demonstrates the application of the nonlinear eigenvalue derivative formulation to a complex aeroelastic system. The second examples address the isolated rotor-blade flapping in forward flight, bringing out important features of the formulation for periodic systems. Finally, the coupled rotor-body problem is used to demonstrate the validation of the formulation. AIAA

N94-10424# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany).
EXPERIMENTAL RESULTS IN AERODYNAMIC STABILITY AND CONTROL OF A TSTO CONFIGURATION
T. GOTTMANN and G. CUCINELLI *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 14 p Apr. 1993
Copyright Avail: CASI HC A03/MF A04
A Winged Launcher Configuration (WLC) in a Two Stage To Orbit (TSTO) version has to fly through a wide range of angles-of-attack and Mach numbers (roughly -3 deg is less than or equal to alpha is less than or equal to 20 deg and 0.2 is less than or equal to Ma is less than or equal to 7.0). This and the requirements for horizontal take-off and landing in Central Europe, and the special separation maneuver at a hypersonic Mach number, causes a wide range of new aerodynamic and aerothermodynamic problems. Especially the problem of stability and control is increased by the wide alpha-Mach range and possibly strong engine effects. The main tasks of the experimental investigations of a TSTO configuration are to establish a data base to support the whole design process of Winged Launcher Configurations, to provide a validation base for CFD codes and to understand the very complicated problems which dominate stability, control, and stage separation aerodynamics. A generic baseline configuration of a TSTO was developed at MBB (lower and upper stage), which satisfies all requirements so far. To be able to test this configuration in all occurring speed regimes, a titanium model (size 1:160) was manufactured with an acceptable size to fit into most wind tunnels

for sub-, super-, and hypersonic Mach numbers, especially at DLR in Germany and FFA in Sweden. The main part of the presentation deals with trends of the TSTO configuration in aerodynamic stability and control over the entire Mach regime, showing that some aerodynamic characteristics change significantly with increasing Mach number. Because all aerodynamic forces and moments must be balanced by the engine or aerodynamic controls to obtain reasonable flight conditions, statements regarding absolute stability and control features cannot be set up within this investigation, but tendencies can be given. Major emphasis is placed on the flap efficiency at high Mach numbers which exhibits a strongly nonlinear behavior. The separation of the upper stage was investigated in a special test phase, which shows the enormous changes in longitudinal characteristics caused by interference effects in close proximities between upper and lower stage.
Author (revised)

N94-10426# Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
CONTROL EFFECTIVENESS AT HYPERSONIC SPEEDS
J. L. STOLLERY, D. KUMAR, P. A. ATCLIFFE, and H. BABINSKY *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 10 p Apr. 1993
Copyright Avail: CASI HC A02/MF A04

Two models equipped with trailing edge flaps were tested at a Mach number of 8.2. A simple flat plate model was used to understand how control effectiveness is influenced by transition, bluntness, and incidence, while a cropped-delta-wing spaceplane configuration has emphasized the important three-dimensional effects arising from the geometry chosen. Schlieren photographs were used to visualize the flow, and pressure measurements on the windward surface of the spaceplane model showed any regions of separation. Encapsulated liquid crystals were used to obtain an overall picture of the heat transfer distribution and to highlight the three-dimensional structure of the flow. Author (revised)

N94-10734# National Aerospace Lab., Tokyo (Japan). Flight Research Div.
IN-FLIGHT SIMULATION OF BACKSIDE OPERATING MODELS USING DIRECT LIFT CONTROLLER [DLC WO MOCHIITA BAKKUSAIDO MODERU NO IN FURAITO SHIMYURESHON]
YUUKICHI TSUKANO and TOSHIHARU INAGAKI Apr. 1992 18 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1152; JTN-93-80433; DE93-767976) Avail: CASI HC A03/MF A01

Effectiveness of a Direct Lift Controller (DLC) for in-flight simulation is discussed. A DLC device has been shown to be indispensable for in-flight simulation of backside operating models, hence quick-moving flaps were installed on the Variable Stability and Response Airplane (VSRA) of the National Aerospace Laboratory (NAL) of Japan. After tailoring feedback and feed-forward gains, a model-following system was constructed to simulate backside operating mother aircraft. Flight verification test results are included and indicate that a DLC is helpful but not required for simulating frontside operating models, whereas it is mandatory to obtain acceptable model following errors necessary to simulate backside operating models. Flight test results for a simulated landing approach in the backside region are also presented. Author (NASDA)

N94-10895*# Purdue Univ., West Lafayette, IN. School of Aeronautics and Astronautics.
A FEASIBILITY STUDY REGARDING THE ADDITION OF A FIFTH CONTROL TO A ROTORCRAFT IN-FLIGHT SIMULATOR Final Report, 1 Jun. 1990 - 31 May 1991
SIMON TURNER and DOMINICK ANDRISANI, II Jul. 1992 143 p
(Contract NCC2-671)
(NASA-CR-193240; NAS 1.26:193240) Avail: CASI HC A07/MF A02

The addition of a large movable horizontal tail surface to the control system of a rotorcraft in-flight simulator being developed from a Sikorsky UH-60A Black Hawk Helicopter is evaluated. The capabilities of the control surface as a trim control and as an active control are explored. The helicopter dynamics are modeled using the Generic Helicopter simulation program developed by Sikorsky Aircraft. The effect of the horizontal tail on the helicopter trim envelope is examined by plotting trim maps of the aircraft attitude and controls as a function of the flight speed and horizontal tail incidence. The control power of the tail surface relative to that of the other controls is examined by comparing control derivatives extracted from the simulation program over the flight speed envelope. The horizontal tail's contribution as an active control is evaluated using an explicit model following control synthesis involving a linear model of the helicopter in steady, level flight at a flight speed of eighty knots. The horizontal tail is found to provide additional control flexibility in the longitudinal axis. As a trim control, it provides effective control of the trim pitch attitude at mid to high forward speeds. As an active control, the horizontal tail provides useful pitching moment generating capabilities at mid to high forward speeds. Author (revised)

N94-11134*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CRITERIA FOR DESIGN OF INTEGRATED FLIGHT/PROPULSION CONTROL SYSTEMS FOR STOVL FIGHTER AIRCRAFT
JAMES A. FRANKLIN Apr. 1993 34 p Sponsored by NASA. Washington
(Contract RTOP 533-02-37)
(NASA-TP-3356; A-93038; NAS 1.60:3356) Avail: CASI HC A03/MF A01

As part of NASA's program to develop technology for short takeoff and vertical landing (STOVL) fighter aircraft, control system designs have been developed for a conceptual STOVL aircraft. This aircraft is representative of the class of mixed-flow remote-lift concepts that was identified as the preferred design approach by the U.S./U.K. STOVL Joint Assessment and Ranking Team. The control system designs have been evaluated throughout the powered-lift flight envelope on the Vertical Motion Simulator (VMS) at Ames Research Center. Items assessed in the control system evaluation were: maximum control power used in transition and vertical flight, control system dynamic response associated with thrust transfer for attitude control, thrust margin in the presence of ground effect and hot-gas ingestion, and dynamic thrust response for the engine core. Effects of wind, turbulence, and ship airwake disturbances are incorporated in the evaluation. Results provide the basis for a reassessment of existing flying-qualities design criteria applied to STOVL aircraft. Author

N94-11251*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
APPLICATION OF CONTROLLER PARTITIONING OPTIMIZATION PROCEDURE TO INTEGRATED FLIGHT/PROPULSION CONTROL DESIGN FOR A STOVL AIRCRAFT
SANJAY GARG and PHILLIP H. SCHMIDT (Akron Univ., OH.) Jul. 1993 11 p Prepared for presentation at the AIAA Guidance, Navigation, and Control Conference, Monterey, CA, 9-11 Aug. 1993; sponsored by AIAA
(Contract RTOP 505-62-50)
(NASA-TM-106265; AIAA PAPER 93-3766; E-7992; NAS 1.15:106265) Avail: CASI HC A03/MF A01

A parameter optimization framework has earlier been developed to solve the problem of partitioning a centralized controller into a decentralized, hierarchical structure suitable for integrated flight/propulsion control implementation. This paper presents results from the application of the controller partitioning optimization procedure to IFPC design for a Short Take-Off and Vertical Landing (STOVL) aircraft in transition flight. The controller partitioning problem and the parameter optimization algorithm are briefly described. Insight is provided into choosing various 'user' selected parameters in the optimization cost function such that the resulting optimized subcontrollers will meet the characteristics of the centralized controller that are crucial to achieving the desired closed-loop performance and robustness, while maintaining the desired subcontroller structure constraints that are crucial for IFPC implementation. The optimization procedure is shown to improve upon the initial partitioned subcontrollers and lead to performance comparable to that achieved with the centralized controller. This application also provides insight into the issues that should be addressed at the centralized control design level in order to obtain implementable partitioned subcontrollers. Author (revised)

N94-11259*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MOVING-BASE SIMULATION EVALUATION OF THRUST MARGINS FOR VERTICAL LANDING FOR THE NASA YAV-8B HARRIER AIRCRAFT
JAMES A. FRANKLIN and MICHAEL W. STORTZ Mar. 1993 26 p
(Contract RTOP 505-59-36)
(NASA-TM-104008; A-93051; NAS 1.15:104008) Avail: CASI HC A03/MF A01

A simulation experiment was conducted on Ames Research Center's Vertical Motion Simulator to evaluate the thrust margin for vertical landing required for the YAV-8B Harrier. Two different levels of ground effect were employed, representing the aircraft with or without lift improvement devices installed. In addition, two different inlet temperature profiles were included to cover a wide range of hot gas ingestion. For each ground effect and hot gas ingestion variant, vertical landings were performed at successively heavier weights, with the pilot assessing the acceptability of the operation in each case. Results are presented as a function of hover weight ratio and a metric of the mean ground effect and ingestion that reflect the increase in thrust margin required to provide acceptable control of sink rate during the descent to touchdown with increasing suck down and hot gas ingestion. Author (revised)

N94-11489# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
STABILITY IN AEROSPACE SYSTEMS [LA STABILITE DANS LES SYSTEMES AEROSPATIAUX]
Feb. 1993 233 p Workshop held in Toulouse, France, 23-25 Jun. 1992
(AGARD-R-789; ISBN-92-835-0702-9) Copyright Avail: CASI HC A11/MF A03

This volume contains the 18 unclassified papers presented at the Guidance and Control Panel Workshop. The presented papers cover topics under the following headings: fundamental aspects of stability with examples; basic theoretical aspects and chaos; and applications of aerospace techniques.

N94-11491# Universite Catholique de Louvain (Belgium).
STABILITY ANALYSIS AND AEROSPACE VEHICLE DYNAMICS
PIERRE Y. WILLEMS *In* AGARD, Stability in Aerospace Systems 10 p Feb. 1993 Sponsored by Belgian State Science Policy Programming Office
Copyright Avail: CASI HC A02/MF A03

This paper presents stability analysis results which can be used to analyze the behavior of aerospace vehicles. A certain number of definitions are recalled. Liapunov stability criteria are given for autonomous systems described by ordinary differential equations and discrete-time equations. Particular attention is paid to the stability of mechanical systems around equilibrium configurations. Derived from text

N94-11492# Max-Planck-Inst. fuer Aeronomie, Katlenburg-Lindau (Germany).
ON NON-LINEAR LONGITUDINAL STABILITY OF AN AIRCRAFT IN A DIVE IN THE PRESENCE OF ATMOSPHERIC DISTURBANCES
L. M. B. C. CAMPOS (Instituto Superior Tecnico, Lisbon, Portugal.) and A. A. FONSECA (Instituto Superior Tecnico, Lisbon, Portugal.) *In* AGARD, Stability in Aerospace Systems 19 p Feb. 1993
Copyright Avail: CASI HC A03/MF A03

We consider the nonlinear longitudinal stability problem of aircraft starting a dive from an initial velocity far removed from the steady dive speeds: the aim is to find a pitch control law, which will keep the aircraft in a constant glide slope, compensating for the phugoid mode. The problem is extended to account for the presence of arbitrary atmospheric winds, e.g., windshears. The theoretical stability curves are compared with flight test data, obtained using the BAFR (Basic aircraft for flight research) in Portugal. The model includes a number of effects, and has also some restrictions, which do not affect its suitability for the present application: (1) it includes compensation of the phugoid, but not short-period, mode i.e., neglects rotational inertia; (2) it accounts for boundary-layer and induced drag, but not wave drag, i.e., applies at low Mach numbers, typical of approach to land; (3) it neglects lateral motion, but allows for non-linear effects on longitudinal motion; and (4) it leads to a free-flying control law, in stall free conditions, and in the absence of autopilot or active control. These additional effects would be relevant to other applications, and would require extension or modification of the present model. Derived from text

N94-11496# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
NONLINEAR AND DYNAMIC ANALYSIS OF FLIGHT [ANALYSE NON LINEAIRE ET DYNAMIQUE DU VOL]
P. GUICHETEAU *In* AGARD, Stability in Aerospace Systems 12 p Feb. 1993 In FRENCH
Copyright Avail: CASI HC A03/MF A03

In a rigorous manner, aircraft motion can be described by a set of nonlinear differential equations, depending of parameters, associating the state vector (angle of attack, sideslip angle, speed ...) with the control vector (motivators) through flight dynamics equations, aerodynamic aircraft model, and flight control system. The communication presents some works which aim at a better understanding and at the precise prediction of aircraft behavior in particular flight phases for which classical linearized analysis of differential equations is insufficient or not valid. Author

N94-11497# Wright Lab., Wright-Patterson AFB, OH.
DECOUPLING OF AIRCRAFT RESPONSES
DAVID J. MOORHOUSE *In* AGARD, Stability in Aerospace Systems 9 p Feb. 1993
Copyright Avail: CASI HC A02/MF A03

The theory of aircraft stability is at least as old as powered flight. The original impetus was to design the configuration to have acceptable characteristics. Flight control technology was next applied to tailor, i.e. improve, the classical response characteristics: a yaw damper being a simple example. More recent flight control technology has provided the means to change the character of the aircraft response so that it no longer exhibits the classical behavior of a short period, a phugoid, a Dutch roll, a roll mode, and a spiral. With additional control effectors and the use of feedback there is an infinite number of ways to change the basic stability and response characteristics. Pilot preferences are also well established, however, so that care is needed in implementing any theoretical improvements. The technology exists to provide the pilot with the capability to individually control all six degrees of freedom. Obviously, a requirement for a pilot to integrate six different control effectors would be likely to increase his workload. In that sense, decoupling all six axes would be detrimental. Conversely, any unwanted coupling that can be eliminated should reduce the pilot task. The Wright Laboratory has had a series of flight demonstration programs that have evaluated new technologies in the most realistic tasks. First, an F-16 was provided with the additional control effectors to allow independent control of all six degrees of freedom. A variety of control modes was mechanized, so that the pilot could evaluate both coupled and decoupled modes. Following a subjective in-flight assessment, a ground-based piloted simulation experiment was performed to evaluate all modes for both offensive and defensive combat use.

Second, an F-15 was modified to facilitate precise landing in adverse conditions. A special short landing mode was implemented to feature decoupling of airspeed and glideslope responses plus the integrated coupling of direct lift and sideforce control. This paper presents results from both these programs to illustrate the benefits of either decoupling or new coupling of aircraft responses. Derived from text

N94-11499# Wright Lab., Wright-Patterson AFB, OH.
MODELING NONLINEAR AERODYNAMIC LOADS FOR AIRCRAFT STABILITY AND CONTROL ANALYSIS
JERRY E. JENKINS and JAMES H. MYATT *In* AGARD, Stability in Aerospace Systems 10 p Feb. 1993 Sponsored by AFOSR and Dept. of National Defence
Copyright Avail: CASI HC A02/MF A03

Results from systematic wind tunnel tests of the dynamic roll behavior of a 65 degree swept delta wing at moderate (15 to 35 degree) angles of attack are reviewed. These tests, conducted in both the IAR 2 x 3 m low-speed wind tunnel and the 7 x 10 ft SARL facility at WPAFB, included static, forced oscillation and free-to-roll experiments with flow visualization. Multiple stable trim points (attractors) for body-axis rolling motions and other hard-to-explain dynamic behavior were observed. These data are examined in light of the nonlinear indicial response theory advanced by Tobak and his colleagues. The current analysis shows that force and moment, free-to-roll motion, and flow visualization data all confirm the existence of 'critical states' with respect to the static roll angle. When these singularities are encountered in a dynamic situation, large and persistent transients are induced. Conventional means of representing the nonlinear force and moments in the equations of motion are shown to be inadequate in these cases. Alternative approaches based on simplification of the nonlinear indicial model are briefly discussed.
Derived from text

N94-11501# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
UTILIZING QUANTITATIVE FEEDBACK THEORY DESIGN TECHNIQUE FOR FLIGHT CONTROL SYSTEM
CONSTANTINE H. HOUPIS *In* AGARD, Stability in Aerospace Systems 10 p Feb. 1993
Copyright Avail: CASI HC A02/MF A03

Quantitative feedback theory (QFT) has achieved the status as a very powerful design technique for the achievement of assigned performance tolerances over specific ranges of plant uncertainties without and with control effector failures. This paper presents a brief overview of QFT and its applications to advanced multi-input multi-output (MIMO) flight control systems. Desired performance over varied flight conditions may be achieved with fixed compensators (controllers), despite failures of effectors. QFT is the only design technique that has been able to make considerable progress in improving the design of an overall flight control system taking into account the man-in-the-loop specifications. Author

N94-11502# State Univ. of New York, Binghamton. Dept. of Electrical Engineering.
ADAPTIVE RECONFIGURABLE FLIGHT CONTROLS FOR HIGH ANGLE OF ATTACK AIRCRAFT AGILITY
T. SADEGHI, M. TASCILLO, A. SIMONS, and K. LAI *In* AGARD, Stability in Aerospace Systems 13 p Feb. 1993
Copyright Avail: CASI HC A03/MF A03

Two control technologies have been developed and integrated towards the definition of an Integrated Flight Control for the year 2000 (IFC2000) aircraft. The control technologies considered for IFC2000 are flight control reconfiguration and post stall maneuvering. The reconfiguration technique allows an aircraft to utilize the inherent redundancy among its control effectors for maintaining aircraft's controllability after loss (or degradation in effectiveness) of one or more of its control effectors. The reconfiguration technique used in this paper consisted of redistribution of control signals after identification of a control effector failure (first stage adaptation). This technique is based on utilizing a pseudo-inverse algorithm and minimizing a performance index to redistribute pilot's commands to the remaining control effectors. Two control laws were developed for controlling the aircraft in the post stall region where the aircraft is flying at high angle of attack (HAOA) while allowing reconfiguration in the event of surface damage or actuator failure. A self-tuning adaptive control law was developed for parameter estimation and control gain tuning (second stage adaptation). The control law utilizes the Bierman's algorithm for estimating aircraft parameters, and a linear quadratic regulator for tuning the gains. A neural net control law was developed to account for nonlinearity, parameter uncertainties, and disturbances in the flight control system. The reconfiguration, adaptive, and neural net control laws have been partially integrated; the results are reported in this paper. Post-stall maneuvering is configuration sensitive requiring a high performance aircraft with relaxed static stability, thrust vectoring, and/or additional surfaces (such as canard). A generic high performance aircraft model was modified to incorporate thrust vectoring for generating pitch and yaw moments. A control structure was developed to fly the aircraft with high angle of attack at low speed. The control structure can track alpha, phi, and beta commands from pilot's longitudinal and lateral sticks and rudder pedal, respectively. The control laws were designed to give steady state tracking for fuselage pointing. Thrust vectoring was used to produce pitch and yaw moments at HAOA. The control signal distribution function of the control laws was modified to facilitate aircraft transition from and to post-stall region. Author

N94-11503*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
TOWARD INTELLIGENT FLIGHT CONTROL
ROBERT F. STENGEL *In* AGARD, Stability in Aerospace Systems 22 p Feb. 1993 Sponsored in part by FAA
(Contract NGL-31-001-252; DAAL03-89-K-0092)
Copyright Avail: CASI HC A03/MF A03

Flight control systems can benefit by being designed to emulate functions of natural intelligence. Intelligent control functions fall in three categories: declarative, procedural, and reflexive. Declarative actions involve decision-making, providing models for system monitoring, goal planning, and system/scenario identification. Procedural actions concern skilled behavior and have parallels in guidance, navigation, and adaptation. Reflexive actions are more-or-less spontaneous and are similar to inner-loop control and estimation. Intelligent flight control systems will contain a hierarchy of expert systems, procedural algorithms, and computational neural networks, each expanding on prior functions to improve mission capability to increase the reliability and safety of flight and to ease pilot workload. Author

N94-11504# Wright Lab., Wright-Patterson AFB, OH.
X-29: LONGITUDINAL INSTABILITY AT HIGH ANGLE-OF-ATTACK
LAWRENCE A. WALCHLI *In* AGARD, Stability in Aerospace Systems 13 p Feb. 1993
Copyright Avail: CASI HC A03/MF A03

Relaxed static stability (RSS) was chosen as one of the primary technologies to be flight demonstrated on the forward swept wing X-29 aircraft. Development experiences and performance benefits of this technology in the high angle-of-attack (AOA) regime of flight are described. Flight test results validate the X-29's wind tunnel database and the updated piloted simulation is used for parameter variations to thoroughly explore the potential performance of an aircraft with high levels of static instability.
Author

N94-12799*# MCAT Inst., San Jose, CA.
TURBULENCE MODELING OF FREE SHEAR LAYERS FOR HIGH-PERFORMANCE AIRCRAFT Progress Report
DOUGLAS L. SONDAK Aug. 1993 9 p
(Contract NCC2-663)
(NASA-CR-193659; NAS 1.26:193659; MCAT-93-15) Avail: CASI HC A02/MF A01

The High Performance Aircraft (HPA) Grand Challenge of the

High Performance Computing and Communications (HPCC) program involves the computation of the flow over a high performance aircraft. A variety of free shear layers, including mixing layers over cavities, impinging jets, blown flaps, and exhaust plumes, may be encountered in such flowfields. Since these free shear layers are usually turbulent, appropriate turbulence models must be utilized in computations in order to accurately simulate these flow features. The HPCC program is relying heavily on parallel computers. A Navier-Stokes solver (POVERFLOW) utilizing the Baldwin-Lomax algebraic turbulence model was developed and tested on a 128-node Intel iPSC/860. Algebraic turbulence models run very fast, and give good results for many flowfields. For complex flowfields such as those mentioned above, however, they are often inadequate. It was therefore deemed that a two-equation turbulence model will be required for the HPA computations. The k-epsilon two-equation turbulence model was implemented on the Intel iPSC/860. Both the Chien low-Reynolds-number model and a generalized wall-function formulation were included.
Author (revised)

N94-12820*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
KINEMATICS AND CONSTRAINTS ASSOCIATED WITH SWASHPLATE BLADE PITCH CONTROL
JANE A. LEYLAND Mar. 1993 35 p
(Contract RTOP 505-61-51)
(NASA-TM-102265; A-90033; NAS 1.15:102265) Avail: CASI HC A03/MF A01

An important class of techniques to reduce helicopter vibration is based on using a Higher Harmonic controller to optimally define the Higher Harmonic blade pitch. These techniques typically require solution of a general optimization problem requiring the determination of a control vector which minimizes a performance index where functions of the control vector are subject to inequality constraints. Six possible constraint functions associated with swashplate blade pitch control were identified and defined. These functions constrain: (1) blade pitch Fourier Coefficients expressed in the Rotating System, (2) blade pitch Fourier Coefficients expressed in the Nonrotating System, (3) stroke of the individual actuators expressed in the Nonrotating System, (4) blade pitch expressed as a function of blade azimuth and actuator stroke, (5) time rate-of-change of the aforementioned parameters, and (6) required actuator power. The aforementioned constraints and the associated kinematics of swashplate blade pitch control by means of the strokes of the individual actuators are documented.
Author (revised)

N94-13254*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PRELIMINARY FLIGHT RESULTS OF A FLY-BY-THROTTLE EMERGENCY FLIGHT CONTROL SYSTEM ON AN F-15 AIRPLANE
FRANK W. BURCHAM, JR., TRINDEL A. MAINE, C. GORDON FULLERTON, and EDWARD A. WELLS (McDonnell-Douglas Automation Co., Saint Louis, MO.) Washington Jun. 1993 19 p Presented at the 29th AIAA/SAE/ASME Joint Propulsion Conference, Monterey, CA, 28-30 Jun. 1993
(Contract RTOP 533-02-34)
(NASA-TM-4503; H-1911; NAS 1.15:4503; AIAA PAPER 93-1820) Copyright Avail: CASI HC A03/MF A01

A multi-engine aircraft, with some or all of the flight control system inoperative, may use engine thrust for control. NASA Dryden has conducted a study of the capability and techniques for this emergency flight control method for the F-15 airplane. With an augmented control system, engine thrust, along with appropriate feedback parameters, is used to control flightpath and bank angle. Extensive simulation studies were followed by flight tests. The principles of throttles only control, the F-15 airplane, the augmented system, and the flight results including actual landings with throttles-only control are discussed. Author (revised)

N94-13255*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
ACTUATOR AND AERODYNAMIC MODELING FOR HIGH-ANGLE-OF-ATTACK AEROSERVOELASTICITY
MARTIN J. BRENNER Washington Jun. 1993 30 p Presented at the AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, LaJolla, CA, 19-22 Apr. 1993 Previously announced in IAA as A93-37433
(Contract RTOP 533-02-35)
(NASA-TM-4493; H-1904; NAS 1.15:4493; AIAA PAPER 93-1419) Copyright Avail: CASI HC A03/MF A01

Accurate prediction of airframe/actuation coupling is required by the imposing demands of modern flight control systems. In particular, for agility enhancement at high angle of attack and low dynamic pressure, structural integration characteristics such as hinge moments, effective actuator stiffness, and airframe/control surface damping can have a significant effect on stability predictions. Actuator responses are customarily represented with low-order transfer functions matched to actuator test data, and control surface stiffness is often modeled as a linear spring. The inclusion of the physical properties of actuation and its installation on the airframe is therefore addressed using detailed actuator models which consider the physical, electrical, and mechanical elements of actuation. The aeroservoelastic analysis procedure is described in which the actuators are modeled as detailed high-order transfer functions and as approximate low-order transfer functions. The impacts of unsteady aerodynamic modeling on aeroservoelastic stability are also investigated by varying the order of approximation, or number of aerodynamic lag states, in the analysis. Test data from a thrust-vectoring configuration of an F/A-18 aircraft are compared to predictions to determine the effects on accuracy as a function of modeling complexity.
Author (revised)

N94-13294*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PILOTING VERTICAL FLIGHT AIRCRAFT: A CONFERENCE ON FLYING QUALITIES AND HUMAN FACTORS
CHRISTOPHER L. BLANKEN, ed. and MATTHEW S. WHALLEY, ed. (Army Aviation Systems Command, Moffett Field, CA.) Jul. 1993 488 p Workshop held at San Francisco, CA, 20-22 Jan. 1993
(Contract RTOP 505-59-52)
(NASA-CP-3220; A-93074; NAS 1.55:3220) Avail: CASI HC A21/MF A04

This document contains papers from a specialists' meeting entitled 'Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors.' Vertical flight aircraft, including helicopters and a variety of Vertical Takeoff and Landing (VTOL) concepts, place unique requirements on human perception, control, and performance for the conduct of their design missions. The intent of this conference was to examine, for these vehicles, advances in: (1) design of flight control systems for ADS-33C standards; (2) assessment of human factors influences of cockpit displays and operational procedures; (3) development of VTOL design and operational criteria; and (4) development of theoretical methods or models for predicting pilot/vehicle performance and mission suitability. A secondary goal of the conference was to provide an initial venue for enhanced interaction between human factors and handling qualities specialists.

N94-13295*# National Research Council of Canada, Ottawa (Ontario). Flight Research Lab.
ADS-33C RELATED HANDLING QUALITIES RESEARCH PERFORMED USING THE NRC BELL 205 AIRBORNE SIMULATOR
J. MURRAY MORGAN and STEWART W. BAILLIE *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 3-15 Jul. 1993
Avail: CASI HC A03/MF A04

Over 10 years ago a project was initiated by the U.S. Army AVSCOM to update the military helicopter flying qualities specification MIL-8501-A. While not yet complete, the project reached a major milestone in 1989 with the publication of an Airworthiness Design Standard, ADS-33C. The 8501 update project initially set out to identify critical gaps in the requisite data base and then proceeded to fill them using a variety of directed research studies. The magnitude of the task required that it become an international effort: appropriate research studies were conducted in Germany, the UK and Canada as well as in the USA. Canadian participation was supported by the Department of National Defence (DND) through the Chief of Research and Development. Both ground based and in-flight simulation were used to study the defined areas and the Canadian Bell 205-A1 variable stability helicopter was used extensively as one of the primary research tools available for this effort. This paper reviews the involvement of the Flight Research Laboratory of the National Research Council of Canada in the update project, it describes the various experiments conducted on the Airborne Simulator, it notes significant results obtained and describes ongoing research associated with the project. Author

N94-13296*# Naval Air Warfare Center, Warminster, PA. Aircraft Div.

MIL-H-8501B: APPLICATION TO SHIPBOARD TERMINAL OPERATIONS

A. N. CAPPETTA and J. B. JOHNS (Army Aviation Systems Command, Moffett Field, CA.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 17-36 Jul. 1993

Avail: CASI HC A03/MF A04

The philosophy and structure of the proposed U.S. Military Specification for Handling Qualities Requirements for Military Rotorcraft, MIL-H-8501B, are presented with emphasis on shipboard terminal operations. The impact of current and future naval operational requirements on the selection of appropriate combinations of basic vehicle dynamics and usable cue environments are identified. An example 'walk through' of MIL-H-8501B is conducted from task identification to determination of stability and control requirements. For selected basic vehicle dynamics, criteria as a function of input/response magnitude are presented. Additionally, rotorcraft design development implications are discussed. Author

N94-13297*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

DESIGN CRITERIA FOR INTEGRATED FLIGHT/PROPULSION CONTROL SYSTEMS FOR STOVL FIGHTER AIRCRAFT

JAMES A. FRANKLIN *In its* Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 37-57 Jul. 1993

Avail: CASI HC A03/MF A04

As part of NASA's program to develop technology for short takeoff and vertical landing (STOVL) fighter aircraft, control system designs have been developed for a conceptual STOVL aircraft. This aircraft is representative of the class of mixed-flow remote-lift concepts that was identified as the preferred design approach by the US/UK STOVL Joint Assessment and Ranking Team. The control system designs have been evaluated throughout the powered-lift flight envelope on Ames Research Center's Vertical Motion Simulator. Items assessed in the control system evaluation were: maximum control power used in transition and vertical flight, control system dynamic response associated with thrust transfer for attitude control, thrust margin in the presence of ground effect and hot gas ingestion, and dynamic thrust response for the engine core. Effects of wind, turbulence, and ship airwake disturbances are incorporated in the evaluation. Results provide the basis for a reassessment of existing flying qualities design criteria applied to STOVL aircraft. Author

N94-13298*# Starmark Corp., Arlington, VA.

A PERSPECTIVE ON THE FAA APPROVAL PROCESS: INTEGRATING ROTORCRAFT DISPLAYS, CONTROLS AND WORKLOAD

DAVID L. GREEN, JAKE HART (American Eurocopter Corp., Grand Prarie, TX.), and PETER HWOSCHINSKY (Federal Aviation Administration, Washington, DC.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 59-68 Jul. 1993

Avail: CASI HC A02/MF A04

The FAA is responsible for making the determination that a helicopter is safe for IFR operations in the National Airspace System (NAS). This involves objective and subjective evaluations of cockpit displays, flying qualities, procedures and human factors as they affect performance and workload. After all of the objective evaluations are completed, and all Federal Regulations have been met, FAA pilots make the final subjective judgement as to suitability for use by civil pilots in the NAS. The paper uses the flying qualities and pilot workload characteristics of a small helicopter to help examine the FAA pilot's involvement in this process. The result highlights the strengths of the process and its importance to the approval of new aircraft and equipments for civil IFR helicopter applications. The paper also identifies opportunities for improvement. Author

N94-13299*# Army Aviation Systems Command, Moffett Field, CA. Aeroflightdynamics Directorate.

SOME LESSONS LEARNED IN THREE YEARS WITH ADS-33C

DAVID L. KEY, CHRIS L. BLANKEN, and ROGER H. HOH (Hoh Aeronautics, Inc., Lomita, CA.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 69-89 Jul. 1993

Avail: CASI HC A03/MF A04

Three years of using the U.S. Army's rotorcraft handling qualities specification, Aeronautical Design Standard - 33, has shown it to be surprisingly robust. It appears to provide an excellent basis for design and for assessment, however, as the subtleties become more well understood, several areas needing refinement became apparent. Three responses to these needs have been documented in this paper: (1) The yaw-axis attitude quickness for hover target acquisition and tracking can be relaxed slightly. (2) Understanding and application of criteria for degraded visual environments needed elaboration. This and some guidelines for testing to obtain visual cue ratings have been documented. (3) The flight test maneuvers were an innovation that turned out to be very valuable. Their extensive use has made it necessary to tighten definitions and testing guidance. This was accomplished for a good visual environment and is underway for degraded visual environments. Author

N94-13300*# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Institut feur Flugmechanik.

INVESTIGATION OF THE EFFECTS OF BANDWIDTH AND TIME DELAY ON HELICOPTER ROLL-AXIS HANDLING QUALITIES

HEINZ-JUERGEN PAUSDER and CHRIS L. BLANKEN (Army Aviation Systems Command, Moffett Field, CA.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 91-110 Jul. 1993

Avail: CASI HC A03/MF A04

Several years of cooperative research conducted under the U.S./German Memorandum of Understanding (MOU) in helicopter flight control has recently resulted in a successful handling qualities study. The focus of this cooperative research has been the effects on handling qualities due to time delays in combination with a high bandwidth vehicle. The jointly performed study included the use of U.S. ground-based simulation and German in-flight simulation facilities. The NASA-Ames Vertical Motion Simulator (VMS) was used to develop a high bandwidth slalom tracking task which took into consideration the constraints of the facilities. The VMS was also used to define a range of the test parameters and to perform initial handling qualities evaluations. The flight tests were conducted using DLR's variable-stability BO 105 S3 Advanced Technology Testing Helicopter System (ATTHeS). Configurations included a rate command and an attitude command response system with added time delays up to 160 milliseconds over the baseline and bandwidth values between 1.5 and 4.5 rad/sec. Sixty-six evaluations were performed in about 25 hours of flight time during ten days of testing. The results indicate a need to more tightly constrain the allowable roll axis phase delay for the Level 1 and Level 2 requirements in the U.S. Army's specification for helicopter handling qualities, ADS-33C. Author

N94-13302*# Eurocopter Deutschland G.m.b.H., Munich (Germany). Dept. Guidance and Control.

THE APPLICATION OF ACTIVE SIDE ARM CONTROLLERS IN HELICOPTERS

R. KNORR, C. MELZ, A. FAULKNER, and M. OBERMAYER *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 131-140 Jul. 1993

Avail: CASI HC A02/MF A04

Eurocopter Deutschland (ECD) started simulation trials to investigate the particular problems of Side Arm Controllers (SAC) applied to helicopters. Two simulation trials have been performed. In the first trial, the handling characteristics of a 'passive' SAC and the basic requirements for the application of an 'active' SAC were evaluated in pilot-in-the-loop simulations, performing the tasks in a realistic scenario representing typical phases of a transport mission. The second simulation trial investigated the general control characteristics of the 'active' in comparison to the 'passive' control principle. A description of the SACs developed by ECD and the principle of the 'passive' and 'active' control concept is given, as well as specific ratings for the investigated dynamic and ergonomic parameters effecting SAC characteristics. The experimental arrangements, as well as the trials procedures of both simulation phases, are described and the results achieved are discussed emphasizing the advantages of the 'active' as opposed to the 'passive' SAC concept. This also includes the presentation of some critical aspects still to be improved and proposals to solve them. Author (revised)

N94-13303*# Leicester Univ. (England). Dept. of Engineering.

ROTORCRAFT FLYING QUALITIES IMPROVEMENT USING ADVANCED CONTROL

D. WALKER, I. POSTLETHWAITE, J. HOWITT (Defence Research Agency, Bedford, England.), and N. FOSTER *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 141-155 Jul. 1993

Avail: CASI HC A03/MF A04

We report on recent experience gained when a multivariable helicopter flight control law was tested on the Large Motion Simulator (LMS) at DRA Bedford. This was part of a study into the application of multivariable control theory to the design of full-authority flight control systems for high-performance helicopters. In this paper, we present some of the results that were obtained during the piloted simulation trial and from subsequent off-line simulation and analysis. The performance provided by the control law led to level 1 handling quality ratings for almost all of the mission task elements assessed, both during the real-time and off-line analysis. Author

N94-13304*# Defence Research Agency, Bedford (England).

THE IMPACT OF FLYING QUALITIES ON HELICOPTER OPERATIONAL AGILITY

GARETH D. PADFIELD, NICK LAPPOS (Sikorsky Aircraft, Stratford, CT.), and JOHN HODGKINSON (McDonnell-Douglas Corp., Long Beach, CA.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 157-170 Jul. 1993

Avail: CASI HC A03/MF A04

Flying qualities standards are formally set to ensure safe flight and therefore reflect minimum, rather than optimum, requirements. Agility is a flying quality but relates to operations at high, if not maximum, performance. While the quality metrics and test procedures for flying, as covered for example in ADS33C, may provide an adequate structure to encompass agility, they do not currently address flight at high performance. This is also true in the fixed-wing world and a current concern in both communities is the absence of substantiated agility criteria and possible conflicts between flying qualities and high performance. AGARD is sponsoring a working group (WG19) title 'Operational Agility' that deals with these and a range of related issues. This paper is condensed from contributions by the three authors to WG19, relating to flying qualities. Novel perspectives on the subject are presented including the agility factor, that quantifies performance margins in flying qualities terms; a new parameter, based on maneuver acceleration is introduced as a potential candidate for defining upper limits to flying qualities. Finally, a probabilistic analysis of pilot handling qualities ratings is presented that suggests a powerful relationship between inherent airframe flying qualities and operational agility. Author

N94-13305*# McDonnell-Douglas Helicopter Co., Mesa, AZ.

A FOUR-AXIS HAND CONTROLLER FOR HELICOPTER FLIGHT CONTROL

JOE DEMAIO *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 171-175 Jul. 1993

Avail: CASI HC A01/MF A04

A proof-of-concept hand controller for controlling lateral and longitudinal cyclic pitch, collective pitch and tail rotor thrust was developed. The purpose of the work was to address problems of operator fatigue, poor proprioceptive feedback and cross-coupling of axes associated with many four-axis controller designs. The present design is an attempt to reduce cross-coupling to a level that can be controlled with breakout force, rather than to eliminate it entirely. The cascaded design placed lateral and longitudinal cyclic in their normal configuration. Tail rotor thrust was placed atop the cyclic controller. A left/right twisting motion with the wrist made the control input. The axis of rotation was canted outboard (clockwise) to minimize cross-coupling with the cyclic pitch axis. The collective control was a twist grip, like a motorcycle throttle. Measurement of the amount of cross-coupling involved in pure, single-axis inputs showed cross coupling under 10 percent of full deflection for all axes. This small amount of cross-coupling could be further reduced with better damping and force gradient control. Fatigue was not found to be a problem, and proprioceptive feedback was adequate for all flight tasks executed. Author

N94-13306*# Defence Research Agency, Bedford (England).

IN-FLIGHT SIMULATION OF HIGH AGILITY THROUGH ACTIVE CONTROL: TAMING COMPLEXITY BY DESIGN

GARETH D. PADFIELD and ROY BRADLEY (Caledonian Univ., Glasgow, Scotland.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 177-195 Jul. 1993

Avail: CASI HC A03/MF A04

The motivation for research into helicopter agility stems from the realization that marked improvements relative to current operational types are possible, yet there is a dearth of useful criteria for flying qualities at high performance levels. Several research laboratories are currently investing resources in developing second generation airborne rotorcraft simulators. The UK's focus has been the exploitation of agility through active control technology (ACT); this paper reviews the results of studies conducted to date. The conflict between safety and performance in flight research is highlighted and the various forms of safety net to protect against system failures are described. The role of the safety pilot, and the use of actuator and flight envelope limiting are discussed. It is argued that the deep complexity of a research ACT system can only be tamed through a requirement specification assembled using design principles and cast in an operational simulation form. Work along these lines conducted at DRA is described, including the use of the Jackson System Development method and associated Ada simulation. Author

N94-13307*# Canterbury Univ., Christchurch (New Zealand). Dept. of Psychology.

COMPATIBILITY OF INFORMATION AND MODE OF CONTROL: THE CASE FOR NATURAL CONTROL SYSTEMS

DEAN H. OWEN *In* NASA. Ames Research Center, Piloting

Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 199-204 Jul. 1993
Avail: CASI HC A02/MF A04

The operation of control systems has been determined largely by mechanical constraints. Compatibility with the characteristics of the operator is a secondary consideration, with the result that control may never be optimal, control workload may interfere with performance of secondary tasks, and learning may be more difficult and protracted than necessary. With the introduction of a computer in the control loop, the mode of operation can be adapted to the operator, rather than vice versa. The concept of natural control is introduced to describe a system that supports control of the information used by the operator in achieving an intended goal. As an example, control of speed during simulated approach to a pad by helicopter pilots is used to contrast path-speed control with direct control of global optical flow-pattern information. Differences are evidenced in the performance domains of control activity, speed, and global optical flow velocity.
Derived from text

N94-13308*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering and Aerospace Lab.
A MODEL FOR ROTORCRAFT FLYING QUALITIES STUDIES
MANOJ MITTAL and MARK F. COSTELLO *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 205-220 Jul. 1993
Avail: CASI HC A03/MF A04

This paper outlines the development of a mathematical model that is expected to be useful for rotorcraft flying qualities research. A computer model is presented that can be applied to a range of different rotorcraft configurations. The algorithm computes vehicle trim and a linear state-space model of the aircraft. The trim algorithm uses non linear optimization theory to solve the nonlinear algebraic trim equations. The linear aircraft equations consist of an airframe model and a flight control system dynamic model. The airframe model includes coupled rotor and fuselage rigid body dynamics and aerodynamics. The aerodynamic model for the rotors utilizes blade element theory and a three state dynamic inflow model. Aerodynamics of the fuselage and fuselage empennages are included. The linear state-space description for the flight control system is developed using standard block diagram data. Author

N94-13309*# Starmark Corp., Arlington, VA.
INTERPRETED COOPER-HARPER FOR BROADER USE
DAVID L. GREEN, HAL ANDREWS (Naval Air Systems Command, Washington, DC.), and DONALD W. GALLAGHER (Federal Aviation Administration, Atlantic City, NJ.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 221-234 Jul. 1993
Avail: CASI HC A03/MF A04

The current aircraft assessment process typically makes extensive use of operational personnel during simulations and operational evaluations, with increased emphasis on evaluating the many pilot and/or operator/aircraft control loops. The need for a crew assessment in this broader arena has produced a variety of rating scales. The Cooper-Harper Rating Scale is frequently misused and routinely overlooked in the process, for these applications often extend the scale's use beyond its originally intended application. This paper agrees with the broader application of the Cooper-Harper Rating Scale and presents a concept for the development of a 'use unique' Interpreted Cooper-Harper Scale to help achieve this objective. This interpreted scale concept was conceived during efforts to support an FAA evaluation of a night vision enhancement system. It includes descriptive extensions, which are faithful to the intent of the current Cooper-Harper Scale and should provide the kind of detail that has historically been provided by trained test pilots in their explanatory comments.
Author (revised)

N94-13310*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
IMPROVEMENTS IN HOVER DISPLAY DYNAMICS FOR A COMBAT HELICOPTER
JEFFREY A. SCHROEDER and MICHELLE M. ESHOW (Army Aviation Systems Command, Moffett Field, CA.) *In its* Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 235-250 Jul. 1993
Avail: CASI HC A03/MF A04

This paper describes a piloted simulation conducted on the NASA Ames Vertical Motion Simulator. The objective of the experiment was to investigate the handling qualities benefits attainable using new display law design methods for hover displays. The new display laws provide improved methods to specify the behavior of the display symbol that predicts the vehicle's ground velocity in the horizontal plane; it is the primary symbol that the pilot uses to control aircraft horizontal position. The display law design was applied to the Apache helmet-mounted display format, using the Apache vehicle dynamics to tailor the dynamics of the velocity predictor symbol. The representations of the Apache vehicle used in the display design process and in the simulation were derived from flight data. During the simulation, the new symbol dynamics were seen to improve the pilots' ability to maneuver about hover in poor visual cuing environments. The improvements were manifested in pilot handling qualities ratings and in measured task performance. The paper details the display design techniques, the experiment design and conduct, and the results. Author

N94-13311*# Glasgow Univ. (Scotland).
THE DEVELOPMENT AND POTENTIAL OF INVERSE SIMULATION FOR THE QUANTITATIVE ASSESSMENT OF HELICOPTER HANDLING QUALITIES
ROY BRADLEY and DOUGLAS G. THOMSON *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 251-263 Jul. 1993
Avail: CASI HC A03/MF A04

In this paper it is proposed that inverse simulation can make a positive contribution to the study of handling qualities. It is shown that mathematical descriptions of the MTEs (Mission Task Elements) defined in ADS-33C may be used to drive an inverse simulation thereby generating, from an appropriate mathematical model, the controls and states of a subject helicopter flying it. By presenting the results of such simulations it is shown that, in the context of inverse simulation, the attitude quickness parameters given in ADS-33C are independent of vehicle configuration. An alternative quickness parameter, associated with the control displacements required to fly the MTE is proposed, and some preliminary results are presented. Author

N94-13312*# United Technologies Research Center, East Hartford, CT.
AN ANALYTIC MODELING AND SYSTEM IDENTIFICATION STUDY OF ROTOR/FUSELAGE DYNAMICS AT HOVER
STEVEN W. HONG and H. C. CURTISS, JR. (Princeton Univ., NJ.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 265-286 Jul. 1993
Avail: CASI HC A03/MF A04

A combination of analytic modeling and system identification methods have been used to develop an improved dynamic model describing the response of articulated rotor helicopters to control inputs. A high-order linearized model of coupled rotor/body dynamics including flap and lag degrees of freedom and inflow dynamics with literal coefficients is compared to flight test data from single rotor helicopters in the near hover trim condition. The identification problem was formulated using the maximum likelihood function in the time domain. The dynamic model with literal coefficients was used to generate the model states, and the model was parametrized in terms of physical constants of the aircraft rather than the stability derivatives, resulting in a significant reduction in the number of quantities to be identified. The likelihood function was optimized using the genetic algorithm approach. This method proved highly effective in producing an estimated model from flight test data which included coupled fuselage/rotor dynamics. Using this approach it has been shown that blade flexibility is a significant contributing factor to the discrepancies between theory and experiment shown in previous studies. Addition of flexible modes, properly incorporating the constraint due to the lag dampers, results in excellent agreement between flight test and theory, especially in the high frequency range. Author

N94-13313*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VISUAL CUEING AIDS FOR ROTORCRAFT LANDINGS
WALTER W. JOHNSON and ANTHONY D. ANDRE *In its* Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 289-308 Jul. 1993
Avail: CASI HC A03/MF A04

The present study used a rotorcraft simulator to examine descents-to-hover at landing pads with one of three approach lighting configurations. The impact of simulator platform motion upon descents to hover was also examined. The results showed that the configuration with the most useful optical information led to the slowest final approach speeds, and that pilots found this configuration, together with the presence of simulator platform motion, most desirable. The results also showed that platform motion led to higher rates of approach to the landing pad in some cases. Implications of the results for the design of vertiport approach paths are discussed. Author

N94-13317*# Systems Technology, Inc., Hawthorne, CA.
EFFECTS OF SIMULATOR MOTION AND VISUAL CHARACTERISTICS ON ROTORCRAFT HANDLING QUALITIES EVALUATIONS
DAVID G. MITCHELL and DANIEL C. HART (Army Aviation Systems Command, Moffett Field, CA.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 341-359 Jul. 1993
Avail: CASI HC A03/MF A04

The pilot's perceptions of aircraft handling qualities are influenced by a combination of the aircraft dynamics, the task, and the environment under which the evaluation is performed. When the evaluation is performed in a groundbased simulator, the characteristics of the simulation facility also come into play. Two studies were conducted on NASA Ames Research Center's Vertical Motion Simulator to determine the effects of simulator characteristics on perceived handling qualities. Most evaluations were conducted with a baseline set of rotorcraft dynamics, using a simple transfer-function model of an uncoupled helicopter, under different conditions of visual time delays and motion command washout filters. Differences in pilot opinion were found as the visual and motion parameters were changed, reflecting a change in the pilots' perceptions of handling qualities, rather than changes in the aircraft model itself. The results indicate a need for tailoring the motion washout dynamics to suit the task. Visual-delay data are inconclusive but suggest that it may be better to allow some time delay in the visual path to minimize the mismatch between visual and motion, rather than eliminate the visual delay entirely through lead compensation. Author

N94-13318*# Naval Air Warfare Center, Warminster, PA. Aircraft Div.
PRIMARY DISPLAY LATENCY CRITERIA BASED ON FLYING QUALITIES AND PERFORMANCE DATA
JOHN D. FUNK, JR., CORIN P. BECK, and JOHN B. JOHNS (Army Aviation Systems Command, Moffett Field, CA.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 361-374 Jul. 1993
Avail: CASI HC A03/MF A04

With a pilots' increasing use of visual cue augmentation, much requiring extensive pre-processing, there is a need to establish criteria for new avionics/display design. The timeliness and synchronization of the augmented cues is vital to ensure the performance quality required for precision mission task elements (MTEs) where augmented cues are the primary source of information to the pilot. Processing delays incurred while transforming sensor-supplied flight information into visual cues are unavoidable. Relationships between maximum control system delays and associated flying qualities levels are documented in MIL-F-83300 and MIL-F-8785. While cues representing aircraft status may be just as vital to the pilot as prompt control response for operations in instrument meteorological conditions, presently, there are no specification requirements on avionics system latency. To produce data relating avionics system latency to degradations in flying qualities, the Navy conducted two simulation investigations. During the investigations, flying qualities and performance data were recorded as simulated avionics system latency was varied. Correlated results of the investigation indicates that there is a detrimental impact of latency on flying qualities. Analysis of these results and consideration of key factors influencing their application indicate that: (1) Task performance degrades and pilot workload increases as latency is increased. Inconsistency in task performance increases as latency increases. (2) Latency reduces the probability of achieving Level 1 handling qualities with avionics system latency as low as 70 ms. (3) The data suggest that the achievement of desired performance will be ensured only at display latency values below 120 ms. (4) These data also suggest that avoidance of inadequate performance will be ensured only at display latency values below 150 ms. Author

N94-13320*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PILOTING CONSIDERATIONS FOR TERMINAL AREA OPERATIONS OF CIVIL TILTWING AND TILTROTOR AIRCRAFT
WILLIAM S. HINDSON, GORDON H. HARDY, GEORGE E. TUCKER, and WILLIAM A. DECKER *In its* Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 393-410 Jul. 1993
Avail: CASI HC A03/MF A04

The existing body of research to investigate airworthiness, performance, handling, and operational requirements for STOL and V/STOL aircraft was reviewed for its applicability to the tiltrotor and tiltwing design concepts. The objective of this study was to help determine the needs for developing civil certification criteria for these aircraft concepts. Piloting tasks that were considered included configuration and thrust vector management, glidepath control, deceleration to hover, and engine failure procedures. Flight control and cockpit display systems that have been found necessary to exploit the low-speed operating characteristics of these aircraft are described, and beneficial future developments are proposed. Author

N94-13321*# Sikorsky Aircraft, Stratford, CT.
DESIGN AND PILOT EVALUATION OF THE RAH-66 COMANCHE CORE AFCS
DONALD L. FOGLER, JR. and JAMES F. KELLER (Boeing Defense and Space Group, Philadelphia, PA.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 411-418 Jul. 1993
Avail: CASI HC A02/MF A04

This paper addresses the design and pilot evaluation of the Core Automatic Flight Control System (AFCS) for the Reconnaissance/Attack Helicopter (RAH-66) Comanche. During the period from November 1991 through February 1992, the RAH-66 Comanche control laws were evaluated through a structured pilot acceptance test using a motion base simulator. Design requirements, descriptions of the control law design, and handling qualities data collected from ADS-33 maneuvers are presented. Author

N94-13322*# Sikorsky Aircraft, Stratford, CT.
DESIGN AND PILOT EVALUATION OF THE RAH-66 COMANCHE SELECTABLE CONTROL MODES
PHILLIP J. GOLD and JAMES B. DRYFOOS (Boeing Defense and Space Group, Philadelphia, PA.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 419-431 Jul. 1993
Avail: CASI HC A03/MF A04

The RAH-66 Comanche helicopter has been designed to possess superior handling qualities over a wide range of flight conditions. The control laws have been tailored to satisfy the requirements of ADS-33C and the Weapon System Specification (WSS). This paper addresses the design of the Comanche Selectable Mode control laws (Velocity Stabilization/Hover Hold and Altitude Hold), which provide the additional stabilization and control augmentation needed when flying in a Degraded Visual Environment (DVE). An overview of the RAH-66 control laws is presented, including a detailed description of the Selectable Modes design. The primary focus of this paper is the results of piloted evaluation of these control laws in the Boeing motionbase simulator. These tests substantiate the detailed design of the Comanche Selectable Mode control laws. All tested DVE tasks (ADS-33C, sections 4.4 and 4.5) were rated Level 1. Other evaluation tasks confirmed the mission suitability of the control system. These control laws are ready for formal ADS-33C compliance testing in the Sikorsky Full Mission Simulator (FMS). Author

N94-13324*# Army Aviation Technical Test Center, Fort Rucker, AL.
FLIGHT TESTING AND FREQUENCY DOMAIN ANALYSIS FOR ROTORCRAFT HANDLING QUALITIES CHARACTERISTICS
JOHNNIE A. HAM, CHARLES K. GARDNER, and MARK B. TISCHLER (Army Aviation Systems Command, Moffett Field, CA.) *In* NASA. Ames Research Center, Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 453-469 Jul. 1993
Avail: CASI HC A03/MF A04

A demonstration of frequency domain flight testing techniques and analyses was performed on a U.S. Army OH-58D helicopter in support of the OH-58D Airworthiness and Flight Characteristics Evaluation and the Army's development and ongoing review of Aeronautical Design Standard 33C, Handling Qualities Requirements for Military Rotorcraft. Hover and forward flight (60 knots) tests were conducted in 1 flight hour by Army experimental test pilots. Further processing of the hover data generated a complete database of velocity, angular rate, and acceleration frequency responses to control inputs. A joint effort was then undertaken by the Airworthiness Qualification Test Directorate (AQTD) and the U.S. Army Aeroflightdynamics Directorate (AFDD) to derive handling qualities information from the frequency response database. A significant amount of information could be extracted from the frequency domain database using a variety of approaches. This report documents numerous results that have been obtained from the simple frequency domain tests; in many areas, these results provide more insight into the aircraft dynamics that affect handling qualities than to traditional flight tests. The handling qualities results include ADS-33C bandwidth and phase delay calculations, vibration spectral determinations, transfer function models to examine single axis results, and a six degree of freedom fully coupled state space model. The ability of this model to accurately predict aircraft responses was verified using data from pulse inputs. This report also documents the frequency-sweep flight test technique and data analysis used to support the tests.
Author

N94-13347# National Aerospace Lab., Tokyo (Japan). Aircraft Aerodynamics Div.
ROLLING MOMENT CONTROL IN THE NAL 10 CM X 10 CM MAGNETIC SUSPENSION AND BALANCE SYSTEM [KOUGIKEN 10 CM X 10 CM JIRYOKU SHIJU TENBIN SOUCHI YOKOYURE SEIGYO NITSUITE]
HIDEO SAWADA, HISASHI SUENAGA, TAKAYUKI SUZUKI (Musashi Inst. of Tech., Tokyo, Japan.), and NOBUKAZU IKEDA (Musashi Inst. of Tech., Tokyo, Japan.) Jun. 1992 17 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1164; JTN-93-80494) Avail: CASI HC A03/MF A01

To have control the rolling moment acting on a model suspended in National Aerospace Laboratory (NAL) 10 cm x 10 cm Magnetic Suspension and Balance System (MSBS), two extra pairs of small magnets were attached perpendicular to the model axis at both the front and rear sides of it. Side force, yawing moment, and rolling moment acting on the model are controlled by the currents passing through the system's four side coils. Test results indicate the roll angle is suitably controlled using this method. An analytical approximation for estimating the rolling moment with the existing arrangement of magnetic moments and charges is described. This approximation correlates well with several experimental results. The NAL MSBS has the capability of controlling model motion with six degrees of freedom.
Author (NASDA)

N94-13469*# Texas A&M Univ., College Station. Dept. of Electrical Engineering.
KNOWLEDGE-BASED PROCESSING FOR AIRCRAFT FLIGHT CONTROL Final Report, period ending 17 Oct. 1991
JOHN H. PAINTER 17 Oct. 1991 8 p
(Contract NAG1-1066)
(NASA-CR-194074; NAS 1.26:194074) Avail: CASI HC A02/MF A01

The purpose is to develop algorithms and architectures for embedding artificial intelligence in aircraft guidance and control systems. With the approach adopted, AI-computing is used to create an outer guidance loop for driving the usual aircraft autopilot. That is, a symbolic processor monitors the operation and performance of the aircraft. Then, based on rules and other stored knowledge, commands are automatically formulated for driving the autopilot so as to accomplish desired flight operations. The focus is on developing a software system which can respond to linguistic instructions, input in a standard format, so as to formulate a sequence of simple commands to the autopilot. The instructions might be a fairly complex flight clearance, input either manually or by data-link. Emphasis is on a software system which responds much like a pilot would, employing not only precise computations, but, also, knowledge which is less precise, but more like common-sense. The approach is based on prior work to develop a generic 'shell' architecture for an AI-processor, which may be tailored to many applications by describing the application in appropriate processor data bases (libraries). Such descriptions include numerical models of the aircraft and flight control system, as well as symbolic (linguistic) descriptions of flight operations, rules, and tactics. Author (revised)

N94-13859# Institute for Aerospace Research, Ottawa (Ontario). Applied Aerodynamics Lab.
MEASUREMENTS OF WING AND FIN BUFFETING ON THE STANDARD DYNAMICS MODEL
S. J. ZAN May 1993 82 p
(IAR-AN-76; NRC-32158; CTN-93-60761) Avail: CASI HC A05/MF A01

A wind tunnel investigation was conducted on wing and fin buffeting measured on the Standard Dynamics Model, a generic fighter aircraft configuration. Buffeting was investigated for three modes: the fin bending mode and the wing symmetric and antisymmetric bending modes. Tests were performed at four wind speeds corresponding to reduced frequencies ranging from 0.6 to 1.5 for the wings and 0.9 to 1.8 for the fin. The angle of attack ranged from zero to 53 deg and the sideslip angle ranged from minus 10 deg to plus 10 deg. The model was tested with and without strakes. The data are presented in terms of the buffet excitation parameter. It was found that the level of fin buffeting exceeded that of wing buffeting by an order of magnitude. This severe fin buffeting arises from the immersion of the fin in the swirling wake of the burst strake and/or forebody vortices. The fin buffet excitation peaked near an angle of attack corresponding to the onset of asymmetrical forebody flow. This excitation was sensitive to the presence of sideslip and to the value of the reduced frequency parameter. The magnitude of the parameter did not exceed 0.003, a limit that was achieved for cases where the excitation arose from the interaction of the strake and wing vortices or simply from separated flow unsteadiness over the wing.
Author (CISTI)

N94-13906# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
INVESTIGATION OF AN AEROELASTIC OSCILLATOR: ANALYSIS OF ONE-DEGREE-OF-FREEDOM GALLOPING WITH COMBINED TRANSLATIONAL AND TORSIONAL EFFECTS
B. W. VANOUDHEUSDEN Dec. 1992 28 p
(LR-707; ETN-93-94424) Avail: CASI HC A03/MF A01

The investigation was carried out in the framework of a research project on aeroelastic oscillators. The results of literature investigations about the background and analysis of galloping and the construction of a test set up are summarized. Galloping is a type of flow induced vibration, which is caused by aerodynamic instability: the unsteady aerodynamic forces on the oscillating structure can amplify or sustain the vibration. The major assumptions underlying the theory with which galloping is described and an analysis of two types of one degree of freedom galloping are discussed. The purpose of the analysis is to give an insight into the relevant parameters of the phenomenon and the set up. ESA

N94-14322*# MCAT Inst., San Jose, CA.
NUMERICAL SIMULATION OF A POWERED-LIFT LANDING, TRACKING FLOW FEATURES USING OVERSET GRIDS, AND SIMULATION OF HIGH LIFT DEVICES ON A FIGHTER-LIFT-AND-CONTROL WING Final Report
KALPANA CHAWLA Aug. 1993 27 p Original contains color illustrations
(Contract NCC2-563)
(NASA-CR-194260; NAS 1.26:194260; MCAT-93-18) Avail: CASI HC A03/MF A01; 2 functional color pages

Attached as appendices to this report are documents describing work performed on the simulation of a landing powered-lift delta wing, the tracking of flow features using overset grids, and the simulation of flaps on the Wright Patterson Lab's fighter-lift-and-control (FLAC) wing. Numerical simulation of a powered-lift landing includes the computation of flow about a delta wing at four fixed heights as well as a simulated landing, in which the delta wing descends toward the ground. Comparison of computed and experimental lift coefficients indicates that the simulations capture the qualitative trends in lift-loss encountered by thrust-vectoring aircraft operating in ground effect. Power spectra of temporal variations of pressure indicate computed vortex shedding frequencies close to the jet exit are in the experimentally observed frequency range; the power spectra of pressure also provide insights into the mechanisms of lift oscillations. Also, a method for using overset grids to track dynamic flow features is described and the method is validated by tracking a moving shock and vortices shed behind a circular cylinder. Finally, Chimera gridding strategies were used to develop pressure coefficient contours for the FLAC wing for a Mach no. of 0.18 and Reynolds no. of 2.5 million. CASI

N94-14642*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
OPTIMIZATION-BASED CONTROLLER DESIGN FOR ROTORCRAFT
N.-K. TSING (Maryland Univ., College Park.), M. K. H. FAN (Georgia Inst. of Tech., Atlanta.), J. BARLOW (Maryland Univ., College Park.), A. L. TITS (Maryland Univ., College Park.), and M. B. TISCHLER *In* JPL, Proceedings of the Fifth NASA/NSF/DOD Workshop on Aerospace Computational Control p 379-393 15 Feb. 1993
Avail: CASI HC A03/MF A04

An optimization-based methodology for linear control system design is outlined by considering the design of a controller for a UH-60 rotorcraft in hover. A wide range of design specifications is taken into account: internal stability, decoupling between longitudinal and lateral motions, handling qualities, and rejection of windgusts. These specifications are investigated while taking into account physical limitations in the swashplate displacements and rates of displacement. The methodology crucially relies on user-machine interaction for tradeoff exploration. Author (revised)

N94-14646*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
CONTROL SYSTEM DESIGN FOR FLEXIBLE STRUCTURES USING DATA MODELS
R. DENNIS IRWIN (Ohio Univ., Athens.), W. GARTH FRAZIER (Ohio Univ., Athens.), JERREL R. MITCHELL (Ohio Univ., Athens.), ENRIQUE A. MEDINA (Ohio Univ., Athens.), and ANGELIA P. BUKLEY *In* JPL, Proceedings of the Fifth NASA/NSF/DOD Workshop on Aerospace Computational Control p 463-477 15 Feb. 1993
Avail: CASI HC A03/MF A04

The dynamics and control of flexible aerospace structures exercises many of the engineering disciplines. In recent years there has been considerable research in the developing and tailoring of control system design techniques for these structures. This problem involves designing a control system for a multi-input, multi-output (MIMO) system that satisfies various performance criteria, such as vibration suppression, disturbance and noise rejection, attitude control and slewing control. Considerable progress has been made and demonstrated in control system design techniques for these structures. The key to designing control systems for these structures that meet stringent performance requirements is an accurate model. It has become apparent that theoretically and finite-element generated models do not provide the needed accuracy; almost all successful demonstrations of control system design techniques have involved using test results for fine-tuning a model or for extracting a model using system ID techniques. This paper describes past and ongoing efforts at Ohio University and NASA MSFC to design controllers using 'data models.' The basic philosophy of this approach is to start with a stabilizing controller and frequency response data that describes the plant; then, iteratively vary the free parameters of the controller so that performance measures become closer to satisfying design specifications. The frequency response data can be either experimentally derived or analytically derived. One 'design-with-data' algorithm presented in this paper is called the Compensator Improvement Program (CIP). The current CIP designs controllers for MIMO systems so that classical gain, phase, and attenuation margins are achieved. The center-piece of the CIP algorithm is the constraint improvement technique which is used to calculate a parameter change vector that guarantees an improvement in all unsatisfied, feasible performance metrics from iteration to iteration. The paper also presents a recently demonstrated CIP-type algorithm, called the Model and Data Oriented Computer-Aided Design System (MADCADS), developed for achieving H(sub infinity) type design specifications using data models. Control system design for the NASA/MSFC Single Structure Control Facility are demonstrated for both CIP and MADCADS. Advantages of design-with-data algorithms over techniques that require analytical plant models are also presented. Author (revised)

N94-14650*# Phillips Lab., Edwards AFB, CA.
PACE: A TEST BED FOR THE DYNAMICS AND CONTROL OF FLEXIBLE MULTIBODY SYSTEMS
MOON K. KWAK, MONTY J. SMITH, and ALOK DAS *In* JPL, Proceedings of the Fifth NASA/NSF/DOD Workshop on Aerospace Computational Control p 525-533 15 Feb. 1993 See also A93-34231
Avail: CASI HC A02/MF A04

The Phillips Laboratory at Edwards AFB has constructed a test bed for the validation and comparison of modeling and control theories for the dynamics and control of flexible multibody systems. This project is called the Planar Articulating Controls Experiment (PACE). This paper presents the experimental apparatus for PACE and the problem formulation. An in-depth analysis on DC motor dynamics was also performed. Author

N94-15416*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
RESEARCH IN ROBUST CONTROL FOR HYPERSONIC AIRCRAFT Progress Report No. 2, 1 Dec. 1992 - 31 Aug. 1993
A. J. CALISE Oct. 1993 24 p

(Contract NAG1-1451)
(NASA-CR-194106; NAS 1.26:194106) Avail: CASI HC A03/MF A01

The research during the second reporting period has focused on robust control design for hypersonic vehicles. An already existing design for the Hypersonic Winged-Cone Configuration has been enhanced. Uncertainty models for the effects of propulsion system perturbations due to angle of attack variations, structural vibrations, and uncertainty in control effectiveness were developed. Using H(sub infinity) and mu-synthesis techniques, various control designs were performed in order to investigate the impact of these effects on achievable robust performance. Derived from text

N94-15730# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
DEVELOPMENT OF AN AIR-TO-AIR REFUELING AUTOMATIC FLIGHT CONTROL SYSTEM USING QUANTITATIVE FEEDBACK THEORY M.S. Thesis
DENNIS W. TROSEN Jun. 1993 127 p
(AD-A266718; AFIT/GE/ENG/93J-03) Avail: CASI HC A07/MF A02

Quantitative Feedback Theory and the improved method Quantitative Feedback Theory are enhanced to include the rejection of disturbance at the system output. The enhanced Quantitative Feedback Theory and improved method Quantitative Feedback Theory processes are applied to the design of an automatic flight control system to regulate position of the C-135B fuel receiving aircraft relative to the tanker during air-to-air refueling. A simple feedback control system is developed that will achieve stable position regulation. State-space aircraft models are generated. An inner loop autopilot is designed to reduce the plant cutoff frequency and provide the system inputs for the Quantitative Feedback Theory compensators. Disturbance models representing disturbance due to wind gusts and refueling are developed. The flight control system is designed using the enhanced Quantitative Feedback Theory equations. Linear simulations are performed on MATRIX, and nonlinear simulations are run on EASY5x. The results of the simulations show excellent results. The simulation results indicate that air-to-air automatic flight control system are technically achievable, and that implementation in USAF aircraft is possible. DTIC

N94-15793*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FIDELITY ASSESSMENT OF A UH-60A SIMULATION ON THE NASA AMES VERTICAL MOTION SIMULATOR
ADOLPH ATENCIO, JR. Sep. 1993 318 p Sponsored by NASA, Washington
(Contract RTOP 505-59-52)
(NASA-TM-104016; A-93071; NAS 1.15:104016; USAATC-TR-93-A-005) Avail: CASI HC A14/MF A03

Helicopter handling qualities research requires that a ground-based simulation be a high-fidelity representation of the actual helicopter, especially over the frequency range of the investigation. This experiment was performed to assess the current capability to simulate the UH-60A Black Hawk helicopter on the Vertical Motion Simulator (VMS) at NASA Ames, to develop a methodology for assessing the fidelity of a simulation, and to find the causes for lack of fidelity. The approach used was to compare the simulation to the flight vehicle for a series of tasks performed in flight and in the simulator. The results show that subjective handling qualities ratings from flight to simulator overlap, and the mathematical model matches the UH-60A helicopter very well over the range of frequencies critical to handling qualities evaluation. Pilot comments, however, indicate a need for improvement in the perceptual fidelity of the simulation in the areas of motion and visual cuing. The methodology used to make the fidelity assessment proved useful in showing differences in pilot work load and strategy, but additional work is needed to refine objective methods for determining causes of lack of fidelity. Author

N94-16107# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
AERODYNAMIC/DYNAMIC/CONTROL INTERACTION Final Report, 15 Oct. 1989 - 14 Oct. 1992
DEAN T. MOOK and ALI H. NAYFEH 22 Dec. 1992 22 p
(Contract AF-AFOSR-0032-90)
(AD-A266187; AFOSR-93-0443TR) Avail: CASI HC A03/MF A01

The present report attempts to present a comprehensive review of achievements made under the support of a continuing series of related AFOSR grants. The essence of all the work was to develop numerical simulations that capture the interactions among aerodynamics, rigid-body dynamics, structural dynamics, and control systems. All of these components of a flying airplane were viewed simply as elements of a single dynamic system. All the work led toward an end result in which a maneuvering aircraft could be simulated without resorting to wind-tunnel or flight tests. A major obstacle to this development is the fact that one must know the motion of the aircraft and its control-surface deflections in order to calculate the flowfield, and one must know the flowfield in order to calculate the aerodynamic forces and, from them, the motions. One cannot determine the flowfield unless one knows the motion of the airplane and one cannot determine the motion unless one knows the flowfield. In this work the PI's have made significant advances in the development of the needed methodology. By expanding the structural deflections in terms of the free-vibration modes, the principal investigators were able to covert the governing partial-differential equations of the structure into a system of ordinary-differential equations. The aerodynamic loads were obtained by refining and extending the vortex-lattice concept. However, it must be noted that both the aerodynamic model and the structural models used in the examples can be changed, by simply changing subroutines in the general code, without changing the general approach. DTIC

N94-17412# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
A COMPARATIVE STUDY OF ANALOG AND DIGITAL CONTROL LAWS FOR THE UMCSL TRUSS M.S. Thesis
ANTHONY M. MITCHELL 1992 157 p
(AD-A267980; AFIT/CI/CIA-93-008) Avail: CASI HC A08/MF A02

This thesis is based on research conducted at the University of Washington Department of Aeronautics and Astronautics Control Systems Laboratory (UWCSL). The UWCSL 20-bay planar truss is a replica of an experimental testbed at the United States Air Force Academy. Validation and modification of existing finite element models of the truss and the two primary means of structurally-borne actuation, the air jet thrusters and the reaction mass actuators, was accomplished and is discussed. Verification of classical analog controllers to actively suppress vibration of the planar bending modes of the truss using the air jet thruster and reaction mass actuators in independent and in hybrid configurations is reported in this thesis. The discretization and digitization of the classical control law was accomplished and the results of computer simulation, linear and non-linear, and experimental testing are reported. A comparison of the performance of the analog and the digital control laws is reported. The design of an optimal controller for the reaction mass actuators utilizing Linear Quadratic (LQ) techniques is reported, and includes non-linear simulation. Simulation of hybrid actuation utilizing the optimal reaction mass actuator control law and the classical air jet thruster controllers is also reported. Recommendations for future study based upon both the hardware implementation and the computer simulation are suggested in the conclusions of this thesis. DTIC

N94-18401# Naval Postgraduate School, Monterey, CA.
AN APPLICATION OF PARAMETER ESTIMATION TO THE STABILITY AND CONTROL OF THE BQM-147 UNMANNED AERIAL VEHICLE M.S. Thesis
PATRICK J. QUINN Jun. 1993 132 p
(AD-A268741) Avail: CASI HC A07/MF A02

Parameter estimation methods were used to obtain estimates of stability and control derivatives for the Marine Corps BQM-147

Unmanned Air Vehicle. The results from a simple, PC-based linear model and those from a more robust nonlinear model, pEst, were compared. A Cramer-Rao bound was used to assess the accuracy of the estimates for both methods. The bounds were high for both the longitudinal case and the lateral-directional case due to the limited maneuvers tested, high levels of noise in the same general frequency range as the control input, and the lack of body-angle data. The linear model failed to provide estimates for the lateral-directional case. Though the results may be used as starting points for a dynamic model of the aircraft, it is recommended that the flight test procedures be modified to address the issues raised concerning noise, recorded signals, and the need for repeated maneuvers. DTIC

N94-18541# Naval Postgraduate School, Monterey, CA.
CLOSE-COUPLED OSCILLATING CANARD EFFECTS ON POST-STALL LIFT ENHANCEMENT M.S. Thesis
DOUGLAS G. MCBANE Jun. 1993 97 p
(AD-A268938) Avail: CASI HC A05/MF A02

The effects of an oscillating close-coupled canard on the canard/wing vortex interaction for increased lift enhancement were studied. Two test conditions were studied: the first with a model angle of attack of 22 deg and the second of 34 deg. The canard was positioned at three mean deflection angles equal to 4, 7, and 10 deg for the model angle of attack of 22 deg and -4, -7, and -10 deg for the model angle of attack of 34 deg. At each of the canard mean deflection angles, the canard was oscillated with amplitudes of +/- 5 deg and +/- 10 deg with reduced frequencies ranging from 0.046 to 0.232. Because of the small effects noted which were of the order of accuracy of the balance, only general trends are discussed. The trends indicate that for this particular model configuration and geometry, lift was decreased slightly with increasing canard frequency and amplitude. No lift-enhancement benefits were revealed during the study. DTIC

N94-19316*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ISAC: A TOOL FOR AEROSERVOELASTIC MODELING AND ANALYSIS
WILLIAM M. ADAMS, JR. and SHERWOOD TIFFANY HOADLEY Dec. 1993 12 p See also A93-33974
(Contract RTOP 505-64-52-03)
(NASA-TM-109031; NAS 1.15:109031) Avail: CASI HC A03/MF A01

The capabilities of the Interaction of Structures, Aerodynamics, and Controls (ISAC) system of program modules is discussed. The major modeling, analysis, and data management components of ISAC are identified. Equations of motion are displayed for a Laplace-domain representation of the unsteady aerodynamic forces. Options for approximating a frequency-domain representation of unsteady aerodynamic forces with rational functions of the Laplace variable are shown. Linear time invariant state-space equations of motion that result are discussed. Model generation and analyses of stability and dynamic response characteristics are shown for an aeroelastic vehicle which illustrates some of the capabilities of ISAC as a modeling and analysis tool for aeroelastic applications. Author (revised)

N94-19615# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
THE DYNAMIC STABILITY OF THE HELICOPTER
H. WITTENBERG Apr. 1993 116 p
(LR-772; ISBN-9-06-275887-8; ETN-93-95031) Copyright Avail: CASI HC A06/MF A02

The longitudinal and lateral dynamic stability of conventional helicopters with one main rotor and tail rotor are analyzed. The analysis is similar as for fixed wing aircraft and based on linearized equations of motion. For the hovering flight the stability derivatives are derived for rotors with central unconstrained and constraint flapping hinges. The latter type simulates rotors with flapping hinge off set or hingeless rotors. The helicopter has a longitudinal and lateral unstable oscillatory mode in hovering flight. It is found that for highly constrained flapping hinges the lateral oscillatory mode can be slightly damped. The qualitative analysis of the dynamic stability in forward flight based on the root locus method of Evans is presented. It is shown that for helicopters with horizontal tail the longitudinal characteristics at moderate and high speeds are the same as for fixed wing aircraft. The short period motion and phugoid motion are damped and the helicopter is dynamically stable. The same observation applies to the lateral dynamic stability. The roll and Dutch roll modes are damped, but the spiral mode can be damped or undamped, depending on the contribution of the tailrotor in the stability derivatives. ESA

N94-19711 Technische Univ., Brunswick (Germany). Inst. fuer Regelungstechnik.
A LEARNING AUTOPILOT FOR AUTOMATICALLY CONTROLLED ROBUST REGULATION Ph.D. Thesis [EIN LERNENDER AUTOPILOT MIT SELBSTEINSTELLENDER ROBUSTER REGELUNG]
KAI SCHULZ 1992 140 p In GERMAN Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(ETN-93-95075) Avail: CASI HC A07

The motion control of vehicles in three dimensional space is investigated. Particular consideration is given to the improvement of trajectory accuracy, taking into account model uncertainties. The physical model parameters were estimated with an offline identification process. A two step procedure, based on the equation error and least squares methods, was chosen for the following reasons: it is unsensitive to noncorrelated perturbations; it is independent of convergence behavior; and it produces parameters for continuous models, in combination with state variable filters. The structure of the controller was realized with the H(infinity) norm in order to suppress the dependence on boundary conditions such as limit frequencies of actuators and sensors. A forward control concept is proposed which allows the strong interactions between the motion degrees of freedom to be compensated. Simulation results of ship steering are presented for validation of the autopilot system. 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.

A94-10325
FATIGUE TEST BY RANDOM LOADING OF A TRAINING AEROPLANE WING SPAR [UNAVOVA ZKOUSKA NOSNIKU KRIDLA CVICNEHO LETOUNU NAHODNYM ZATIZENIM]
JIRI FIDRANSKY, JIRI VRHEL, and JIRI FIALA Zpravodaj VZLU (ISSN 0044-5355) no. 2 1992 p. 61-68. In CZECH refs
Copyright

The article deals with problems of laboratory fatigue testing of aircraft structures of the flight-by-flight type with randomized sequence of loading peaks. A program called TALOS was developed for simulating the real loading of the aeroplane when implementing fatigue tests of jet training aeroplane airframes. To verify the factual contribution of the new fatigue testing methodology, a test of models of the training aeroplane main spars was realized. Fatigue test results confirmed the hypothesis that by using flight-by-flight methodology it is possible to prolong the service life of an aeroplane structure by up to 50 percent in comparison with the old proving methodology based on tests with constant loading amplitude cycles. Author (revised)

A94-10401
WIND TUNNELS AND WIND TUNNEL TEST TECHNIQUES; PROCEEDINGS OF THE CONFERENCE, SOUTHAMPTON, UNITED KINGDOM, SEPT. 14-17, 1992

London Royal Aeronautical Society 1992 582 p. For individual items see A94-10402 to A94-10448
(ISBN 1-85678-050-2) Copyright

The present conference discusses such topics in the field of wind tunnel testing as the use of heavy gas in future tunnels, the current status of the NASA-Langley National Transonic Facility, a low speed wind tunnel for acoustic measurements, phosphor thermography for hypersonic wind tunnels, the use of luminescence quenching for pressure field measurements, IR imaging of boundary layer transmission, and digital image processing for hypersonic wind tunnel heat transfer measurements. Also discussed are flexible wind tunnel walls, noise measurements in a cryogenic wind tunnel, the design of a low-disturbance supersonic wind tunnel, a novel shock tunnel for high enthalpies, whole field optical diagnostics for external transonic testing, piezo-foil sensors, liquid crystal thermography for low speed wind tunnels, jet boundaries for wind tunnel wall streamlining, and superlow turbulence subsonic wind tunnels. AIAA

A94-10402
FUTURE TEST FACILITY REQUIREMENTS AND THE ROLE OF HEAVY GAS
R. A. DAY (Boeing Commercial Airplane Group, Seattle, WA) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 1.1-1.17. refs
Copyright

An exploratory consideration is presented for the role that may be played by heavy gas in low-speed wind tunnel testing, in order to reach the requisite Reynolds numbers in such cases as those of high-lift airfoil systems tests. The combination of generous wind tunnel test section size, moderate pressure, and a heavy gas, is shown to furnish substantial gains in performance relative to current facilities. Attention is given to the technical, operational and environmental difficulties that are nevertheless associated with such heavier-than-air gases as sulfur hexafluoride. AIAA

A94-10403
REVIEW OF TSAGI WIND TUNNELS
V. YA. NEJLAND (TsAGI, Zhukovski, Russia) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 2.1-2.18.
Copyright

A survey is presented of the character and performance capabilities of wind tunnel test facilities operated by the Central Aerohydrodynamics Institute of Russia, TsAGI. In addition to such standard wind tunnel types as the subsonic, transonic, and supersonic, TsAGI has developed hypersonic wind tunnels for the study of vehicle aerothermodynamics and the behavior of thermal-protection systems. Additional specialized wind tunnel facilities address problems in physical gas dynamics, rarefied gas dynamics, and nozzle flows and complex interacting flows. AIAA

A94-10404* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CURRENT STATUS AND SOME FUTURE TEST DIRECTIONS FOR THE U.S. NATIONAL TRANSONIC FACILITY
BLAIR B. GLOSS (NASA, Langley Research Center, Hampton, VA) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 3.1-3.7. refs
Copyright

The construction of the National Transonic Facility was completed in September 1982 and the start-up and checkout of the tunnel systems were performed over the following two years. In August 1984, the facility was declared operational for final checkout of cryogenic instrumentation and control systems, and for the aerodynamics calibration and testing to commence. Since 1984 several operational problems have been identified and successfully solved which is demonstrated by the fact that the facility has operated the last year with no significant facility down times. Also during this time period, development of test techniques and instrumentation has continued. This paper will review some of the recent test techniques and instrumentation developments, and will briefly review the status of the facility.

A94-10405
A MODERNISED HST OF NLR
F. JAARSMA, J. SMITH, and R. K. VAN DER DRAAI (National Aerospace Lab., Amsterdam, Netherlands) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 4.1-4.13.
Copyright

The Netherlands' High Speed Tunnel (HST), which has been in operation since 1959, began a modernization process whose initial phase was completed in the fall of 1992. The modernization program encompasses an increase in test section length, an adaptive test section height, a new model-support system, and an upgraded control system. These changes are in various ways expected to yield larger model-attitude ranges, reduced test section noise levels, higher accuracy, and lower environmental pollution. AIAA

A94-10406
THE NEW ITALIAN TRANSONIC PILOT TUNNEL
LUDOVICO VECCHIONE (Centro Italiano Ricerche Aerospaziali S.p.A., Capua, Italy) and RICHARD BALDNER (FluiDyne Engineering Corp., Minneapolis, MN) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 5.1-5.13.
Copyright

The High Reynolds Transonic Tunnel (HRTT) is one of the major ground testing facilities in terms of size, requirements and performance, in development at the Italian Aerospace Research Center (CIRA). Early in the HRTT project, the need was recognized for a 1/10 scale pilot tunnel to check the transonic operation of the tunnel, verify the circuit pressure losses, develop transonic measurement methods and finally train the full-scale facility operators. This paper provides an engineering overview of the transonic pilot tunnel for the HRTT project, highlights the technical features of the facility and its components, and also provides information about project planning and status.

A94-10407
A NEW LOW SPEED 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 Univ., IN) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 6.1-6.13. Research supported by Univ. of Notre Dame refs
(Contract N00014-89-J-1783)
Copyright

An anechoic chamber was built with the option of installing an open-jet wind tunnel. The design, fabrication and calibration of the facility is presented. Low-frequency cut-off in the chamber with and without the wind tunnel installed was 125 Hz. The wind tunnel has a test-section area of 2 ft square, a variable jet length from 2 to 7 ft, and a velocity range from about 15 to 100 ft/sec. Maximum velocity fluctuations on the tunnel centerline increased with velocity and downstream distance from 0.02 percent at $x/D = 0$, to 0.35 percent at $x/D = 1.5$. Author (revised)

A94-10412
A SEMI-ANALYTICAL METHOD TO CORRECT FOR SUPPORT EFFECTS ON WIND TUNNEL MODELS
D. ECKERT (German-Dutch Wind Tunnel, Emmeloord, Netherlands) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992

p. 13.1-13.9.
Copyright
A simple numerical model which interprets the influence exerted on a wind tunnel model's wing, fuselage, and empennage flow by the model's support system is presently used for the dorsal, ventral, and rear stings that have been employed in the testing of an Airbus low-speed wind tunnel model. It emerges that the disturbance terms thus uncovered are primarily functions of the position of the support volumes relative both to the model and the wind tunnel walls. Empty test-section measurements have verified the accuracy of the calculation results. AIAA

A94-10413
MINIMIZATION OF STRUT INTERFERENCE IN A LOW SPEED WIND TUNNEL BY A NEW STRUT DESIGN CONCEPT
K. RETTIG and B. EWALD (Darmstadt Technical Univ., Germany) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 14.1-14.7. refs
Copyright
Analyses of wind tunnel model support struts have indicated that the use of suitably optimized fairings and strut design changes can substantially reduce flow interference effects. The present work shows that the assumed loading conditions lead to very slender model support struts; this can be further refined through incorporation of freely rotating fairings which have their bearings on the upper and lower ends of the struts. This new fairing design reduces frontal area by 50 percent, relative to the previous design. AIAA

A94-10414
INTERFERENCE CORRECTIONS IN WIND TUNNELS WITH SLOTTED WALLS
M. M. FREESTONE, S. R. MOHAN, and R. C. LOCK (City Univ., London, United Kingdom) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 16.1-16.14. Research supported by Department of Trade and Industry of United Kingdom refs
Copyright
The present consideration of interference determination for high Reynolds number wind tunnels with slotted liners notes that the requisite level of accuracy may be reached on the basis of a 'boundary value' method which gives attention to wall pressure and slot-velocity measurements. Attention is drawn to the further possibility of replacing flow measurements for each slot with theoretical predictions derived from slat and planum pressures. AIAA

A94-10415
PRESSURE DISTRIBUTION MEASUREMENTS ON A MODEL WITH EXTREME SPAN TO WIDTH RATIO IN THE DLR ADAPTIVE WALL RUBBER TUBE TEST SECTION
A. HEDDERGOTT, E. WEDEMEYER, and E. STANEWSKY (DLR, Goettingen, Germany) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 17.1-17.12. refs
Copyright
The DLR's High Speed Wind Tunnel has been fitted with a fully three-dimensionally adaptive rubber tube-formed test-section wall. A circular cross-section was chosen due to its ease of manufacture and uniform load distribution on the supporting jacks. An account is here given of tests conducted to explore the limits of that adaptive wall test section in generating interference-free results for large-span aircraft models. The virtual elimination of three-dimensional wall interference by wall adaptation is confirmed. AIAA

A94-10416
TRANSONIC WALL INTERFERENCE CORRECTIONS FOR SMALL WIND TUNNELS
R. C. CRITES and M. RUEGER (McDonnell Aircraft Co., Saint Louis, MO) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 18.1-18.13. refs
Copyright
Transonic wind tunnel wall interference correction methods that are adequate for large tunnels with small models, may not be acceptable for smaller tunnels with relatively large models. A multi-year independent research and development project was initiated to establish general wall interference correction methods that would give improved accuracy for small tunnels (or large tunnels with very large models). The result is a procedure that uses a combination of computational fluid dynamics (CFD) and empirical boundary conditions to obtain corrections to the forces measured in the wind tunnel at test values of Mach number and pitch angle. A semi-empirical mathematical model of the wall cross-flow/boundary layer displacement process was developed to provide equivalent inviscid boundary conditions for the in-tunnel CFD solutions. A set of four geometrically similar models of different size were built and tested in three wind tunnels of different size to provide an experimental data base for validation of the new correction procedure. Finally, it is shown that corrections obtained for one configuration in a specific tunnel, can be scaled to other configurations in the same tunnel at the same operating conditions without need for further CFD.

A94-10417
TECHNICAL EXCELLENCE AND PRODUCTIVITY - THE ETW CHALLENGE
J. PRIEUR, J. A. TIZARD, and X. BOUIS (ETW GmbH, Cologne, Germany) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 19.1-19.17. refs
Copyright
The ETW facility is a high Reynolds number transonic wind-tunnel using N2 as the low temperature/moderately high pressure working fluid; its design-goal is the simultaneous maximization of test measurement quality and operational productivity. Quality-oriented features encompass minimal thermal distortions, flow collimation, fine nozzle tuning, and flexible LN2 injection-nozzle configuration control. Productivity-maximizing features include the 'modular multiple cart concept', as well as the ability to work on 'cold' models. AIAA

A94-10418
THE USE OF THE ETW FOR TESTS AT HIGH REYNOLDS NUMBER
C. R. TAYLOR (Defence Research Agency, Bedford, United Kingdom) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 20.1-20.12. refs
Copyright
An evaluation is presented of the operational limits of the ETW cryovapor working-fluid wind tunnel, notably the highest Reynolds numbers thus far quantified; these are noted to encompass a wide range of conditions for both civil transport and combat aircraft. Attention is given to maximum performance-inhibiting factors which relate to high-pressure operation; the restrictions that such operations create through sting-generated interference are noted. AIAA

A94-10419
A SUMMARY OF NOISE MEASUREMENTS IN A SLOTTED CRYOGENIC WIND TUNNEL
D. G. MABEY (Imperial College of Science, Technology, and Medicine, London, United Kingdom) and J. P. HANCY (ETW GmbH, Cologne, Germany) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical

Society 1992 p. 21.1-21.14. refs
Copyright

This paper summarizes a comprehensive series of noise measurements in a cryogenic wind tunnel with slotted walls at subsonic and transonic speeds. Pressure fluctuations were measured within the working section, both on a center-line cone and at four different streamwise positions on the sidewall, as well as at two streamwise positions within the plenum chamber and the first, diffuser. Principal noise sources identified were t.he flrst. diffuser, the slots, the vertical supports downstream in the plenum chamber and the fan. Tunnel configurations investigated included a second throat, (to isolate the diffuser noise), reduced plenum chamber volume (to confirm the importance of the slots and the supports) and a few variations in open area ratio. Analysis of the measurements confirms the complexity of the noise field in a transonic wind tunnel and suggests some topics for further research. There are no new features of the tunnel noise specific to cryogenic operation.

A94-10420

NEW TESTING TECHNIQUES IN THE T2 CRYOGENIC WIND TUNNEL

A. BLANCHARD, J. B. DOR, and A. SERAUDIE (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 22.1-22.12. refs
Copyright

ONERA's T2 wind tunnel employs cryogenic working fluid flows to study Reynolds numbers effects on model surface laminar flow for transition-location detection. The T2 facility incorporates adaptive walls and low turbulence level features, and was recently fitted with a 3D LDV apparatus. Stagnation temperature is limited to 110 K. AIAA

A94-10421

THE CONCEPT OF THE KRYO-KANAL-KOELN (KKK) - OPERATIONAL EXPERIENCE, TEST RESULTS OF FLOW QUALITY AND FORCE MEASUREMENTS AT AGARD-CALIBRATION MODEL

G. VIEHWEGER (DLR, Cologne, Germany) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 23.1-23.15. refs
Copyright

The KKK's aerodynamic tests to date have demonstrated high test section flow quality over the entire operational range envisioned for such a cryogenic wind tunnel. Attention is presently given to the correlation between test results obtained to date and the AGARD-developed calibration model for the tunnel. It has been established that the highly automated control system regulates Mach and Reynolds number, as well as temperature, with the requisite accuracy. AIAA

A94-10422

INVESTIGATIONS ON THE FORMATION OF ICE CRYSTALS IN THE CRYOGENIC WIND TUNNEL COLOGNE

B. STAHL (DLR, Cologne, Germany) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 24.1-24.9. refs
Copyright

The cooling-down process of the KKK is not problematic, as long as the gas temperature does not fall below the dew point temperature (below -46 C). The ice crystals present at this point will not block the wind tunnel screens. At this limiting value for the dew point temperature, the gas volume of 4600 cu m contains 0.28 kg water. As a result of drying-out tests on one element of the internal insulation of the KKK, it was possible to test a modified cool-down procedure successfully. In this case, the tunnel is purged with dry air, as well as GN2, and cooled down at the same time by injecting LN2, so that the gas temperature remains above the dew point temperature until the critical dew point temperature is reached. Author (revised)

A94-10423

A REVIEW OF EUROPEAN HYPERSONIC FACILITIES

JOHN F. WENDT (Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese, Belgium) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 26.1-26.8. refs
Copyright

A review of facility requirements in light of proposed missions, including a scramjet ascent vehicle, leads to the identification of shortcomings with regard to the present situation. Recommendations are made to provide adequate support to programs on quiet tunnels, the hot testing technique, a dedicated non-equilibrium flow facility, and associated instrumentation techniques. In addition a facility research program is recommended; it should examine a wide range of ideas for hypervelocity and super-pressure facilities which have the potential to provide the flow conditions required for testing scramjet-powered vehicles.

A94-10424* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

DESIGN FEATURES OF A LOW-DISTURBANCE SUPERSONIC WIND TUNNEL FOR TRANSITION RESEARCH AT LOW SUPERSONIC MACH NUMBERS

STEPHEN W. D. WOLF, JAMES A. LAUB, LYNDELL S. KING, and DANIEL C. REDA (NASA, Ames Research Center, Moffett Field, CA) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 28.1-28.13. refs
Copyright

A unique, low-disturbance supersonic wind tunnel is being developed at NASA-Ames to support supersonic laminar flow control research at cruise Mach numbers of the High Speed Civil Transport (HSCT). The distinctive design features of this new quiet tunnel are a low-disturbance settling chamber, laminar boundary layers along the nozzle/test section walls, and steady supersonic diffuser flow. This paper discusses these important aspects of our quiet tunnel design and the studies necessary to support this design. Experimental results from an 1/8th-scale pilot supersonic wind tunnel are presented and discussed in association with theoretical predictions. Natural laminar flow on the test section walls is demonstrated and both settling chamber and supersonic diffuser performance is examined. The full-scale wind tunnel should be commissioned by the end of 1993.

A94-10425

HYPERSONIC TESTING IN THE AACHEN SHOCK TUNNEL

M. VETTER, H. OLIVIER, and H. GROENIG (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 29.1-29.10. Research supported by Dassault Aviation refs
Copyright

The Shock Tunnel TH2 is intensively used for hypersonic testing since the beginning of the development of the European space glider HERMES. Attention is given to the set-up of the tunnel and the results of calibration tests which have been performed at different flow conditions. From the measured pressures and heat fluxes c(p) and Stanton number distributions are deduced. This requires knowledge of both the free stream conditions and the total enthalpy. A combined experimental and theoretical method has been developed which is based on the measurement of pitot pressure and stagnation point heat flux. A comparison between this simplified method and a complete nozzle calculation using a nine component equilibrium air model shows good agreement up to 5000 K stagnation temperature. Actual comparisons between experimental and CFD results for the shock tube and nozzle flow

as well as for models tested demonstrate the achieved accuracy and the reproducibility of the experimental results.
Author (revised)

A94-10426
RECENT ENHANCEMENTS TO THE DRA SHOCK TUNNEL
T. V. JONES (Oxford Univ., United Kingdom), P. STREET, and M. WESTBY (Defence Research Agency, Farnborough, United Kingdom) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 30.1-30.14. refs
Copyright

A development history is presented for the conversion of the DRA shock tunnel on the basis of techniques derived from the Isentropic Light Piston Tunnel and the Ludwieg Tube (LT), which also employs isentropic compression heating. A fast-acting and controllable plug valve has been installed to retain much of the LT charge after a run. It is shown that high Reynolds numbers are achievable, and that the increased operational periods allow comprehensive data to be obtained using traversing robes and model movement. AIAA

A94-10427
HEG - A NEW SHOCK TUNNEL FOR HIGH ENTHALPIES
WALTER BECK, GEORG EITELBERG (DLR, Goettingen, Germany), and DIETRICH VENNEMANN (ESA/CNES Joint Group, Toulouse, France) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 31.1-31.9. refs
Copyright

HEG, a new high enthalpy shock tunnel has recently been inaugurated at DLR in Goettingen. Its principal function within the aerodynamic strategy of the HERMES space vehicle project is to examine the influence of nonequilibrium gas dynamics on the external aerodynamics and heat fluxes of the vehicle in the range where heat loads are highest. The facility layout of this free piston shock tunnel consists of three main sections, the driver section, the shock tube and the test section including a contoured nozzle. The main features of this arrangement are described along with a presentation of its main operating characteristics. A description of the tunnel instrumentation focuses on the LIF system which is being developed and validated for use in HEG. Some validation results are presented.

A94-10438
A NEW EXPERIMENTAL APPARATUS FOR THE STUDY OF THE UNSTEADY FLOWFIELD OVER AN AIRFOIL IN PITCHING AND HEAVING MOTIONS USING LASER DOPPLER ANEMOMETRY
P. WERNERT, G. KOERBER, and F. WIETRICH (Saint-Louis, French-German Research Inst., France) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 45.1-45.10. refs
(Contract DRET-86-156)
Copyright

This paper describes a new experimental set-up used for the study of the flowfield over an airfoil undergoing arbitrary pitching or heaving motions. This set-up is basically composed of two parts: a novel driving mechanism, based on an automatic apparatus, 2 speed drives 2 brushless motors and a support system, which allows the airfoil to be put into a wide range of periodic or transient motions and a classical two-dimensional Laser Doppler Anemometry system which provides streamwise and transversal components of the velocity. Data acquisition, data reduction and synchronization problems are also discussed. A few results concerning dynamic stall features observed in the near wake of a pitching airfoil at a Reynolds number of 287,000 are given.

A94-10439
A MULTI-DEGREE-OF-FREEDOM DYNAMIC WIND TUNNEL TEST TECHNIQUE FOR DEPARTURE PREDICTION
S. TULING and M. H. LOWENBERG (Univ. of the Witwatersrand, Johannesburg, South Africa) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 46.1-46.14. Research supported by Council for Scientific and Industrial Research of South Africa refs
Copyright

The use of a three degree-of freedom wind tunnel technique to predict departure is proposed. The method is intended to complement analytical predictions and has the advantage of being low cost. It is able to reveal non-linear motions that analytical techniques would not predict in the absence of a comprehensive data base. A 1/8th scale model of a high performance aircraft, which exhibits departure and other high angle-of-attack phenomena, is being used to develop this technique. The problem of using video motion analysis in large amplitude dynamic tests is also addressed.

A94-10440
AN OVERVIEW OF THE CAPABILITIES OF ARA FOR THE MEASUREMENT OF NOZZLE DISCHARGE AND THRUST
R. S. SALE, M. ELLIOTT, and I. F. BURNS (Aircraft Research Association, Ltd., Bedford, United Kingdom) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 48.1-48.11. refs
Copyright

Details are given of the present nozzle thrust and discharge measuring ability of ARA and the practical application of the measurements explained. Two major facilities for the measurement of thrust and discharge, the Mach Simulation Tank (MST) and the Large Scale Thrust Measuring Rig (LSTMR) are described in detail. The history of the development of these facilities is discussed and present data quality standards illustrated. Special emphasis is placed on the need for high precision mass flow measurements. The use of reference nozzles for qualification tests is described and possible future evolution of both facilities presented.

A94-10441
DEVELOPMENT OF A PRESSURE WAVE SIMULATOR FOR SURGE INTERACTION TESTING
BRIAN CLEATOR (British Aerospace Defence, Ltd., Preston, United Kingdom) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 49.1-49.13.
Copyright

Turbine engine compressor-stage 'surge' blocks high pressure flow to the combustor while allowing combustion gases to migrate upstream. Attention is here given to this phenomenon in the case of a twin-intake engine duct, with a view to interaction effects between the ducts. An account is presently given of the design and operation of two types of surge valves for wind tunnel simulation of this phenomenon: a cyclic surge wave generator and a 'single-shot' surge wave generator. Attention is given to the effects of the surging duct on its mate, especially in the case of the single-shot wave generator. AIAA

A94-10442
THE CRYOGENIC A310 DA WIND TUNNEL MODEL DEVELOPMENT AND WIND TUNNEL TEST RESULTS
T. BALDEN, W. BURGSMUELLER (Deutsche Airbus GmbH, Bremen, Germany), and G. VIEHWEGER (DLR, Cologne, Germany) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 50.1-50.13. refs
Copyright

A development history and current development evaluation are presented for the cryogenic wind tunnel research achievements to date of the Kryo Kanal Koeln program for the Airbus series of commercial aircraft. Attention is given to the configuration and performance capabilities of a typical instrumented model for this cryogenic tunnel. AIAA

A94-10443

THE DEVELOPMENT OF A RANGE OF INTERNAL WIND TUNNEL BALANCES FOR CONVENTIONAL AND CRYOGENIC TUNNELS

B. EWALD (Darmstadt Technical Univ., Germany) and E. GRAEWE (Deutsche Airbus GmbH, Bremen, Germany) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 51.1-51.13. refs

Copyright

The electron beam-welded balance method has been used to develop internal balances of various kinds and sizes for cryogenic wind tunnels. Test results indicate that the accuracy and reliability of these balances is excellent. Attention is given to both a novel calibration method associated with these balances and an automated apparatus for its implementation. AIAA

A94-10444

A UNIQUE FACILITY TO SUPPORT CRYOGENIC WIND TUNNEL OPERATIONS

R. PORTER (Aircraft Research Association, Ltd., Bedford, United Kingdom) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 52.1-52.10.

Copyright

The cryogenic environmental room at ARA is designed to support research activities related to the design of cryogenic wind tunnel models and to provide a means of checking out a fully instrumented wind tunnel model, at relatively low cost in preparation for a test campaign at cryogenic temperatures. The facility is essentially a large thermally insulated room which houses a low speed open return wind tunnel circuit. Cooling is achieved by the direct injection of liquid nitrogen into the circuit. A centrifugal fan generates moderate forced convection velocities of up to 40 m/s over a model which is located in the exit section of the circuit. The room is constructed in a modular form such that modifications can readily be performed and the tunnel circuit can be reconfigured for alternative working section arrangements. The installation of the environmental room and associated systems is complete and a commissioning phase is at an advanced stage. To date, the facility has been successfully operated at temperatures down to 123K.

A94-10445

A LOW SPEED WIND-TUNNEL WITH EXTREME FLOW QUALITY - DESIGN AND TESTS

ALEXANDER SAHLIN, ARNE V. JOHANSSON, and P. H. ALFREDSSON (Royal Inst. of Technology, Stockholm, Sweden) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 53.1-53.9. Research supported by SE Bank Foundation for Economic and Technical Research, NFR, and Goran Gustafsson Foundation refs

Copyright

An account is given of the processes of aerodynamic design and test methodology for low-noise wind tunnels which were engaged in during the configurational development of the British Royal Institute's low-turbulence wind tunnel. The strategic research themes to be addressed by this wind tunnel encompassed turbulent boundary layers, the modeling of the turbulent processes, and the laminar-turbulent transition. AIAA

A94-10446

IMPROVEMENT OF THE FLOW QUALITY IN THE ARA TRANSONIC TUNNEL BY MEANS OF A LONG CELL HONEYCOMB

D. R. STANNILAND, C. A. MCHUGH, and J. E. GREEN (Aircraft Research Association, Ltd., Bedford, United Kingdom) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 54.1-54.12. refs

Copyright

In August 1990, the flow smoothing screen in the ARA 9 x 8 ft. Transonic Wind Tunnel was replaced by a honeycomb with a high ratio of cell length to diameter. This paper describes investigations into a suitable honeycomb design and presents the resulting changes in flow quality in the wind tunnel. Detailed surveys of the total pressure, steady and unsteady flow angularity and turbulence show that a high degree of flow uniformity has been achieved in the test section. Turbulence levels of 0.05 percent longitudinally and 0.18 percent laterally have been derived from measurements in the working section. These are in good agreement with values derived from settling chamber measurements and compare well with the estimates of minimum longitudinal and lateral turbulence levels (0.06 percent and 0.15 percent) achievable with the chosen design of honeycomb. Author (revised)

A94-10447

RECENT IMPROVEMENTS IN THE SWISS FEDERAL AIRCRAFT FACTORY 5M X 7M WIND TUNNEL AT EMMEN

P. K. DRESCHER and R. POZZORINI (Swiss Federal Aircraft Factory, Emmen, Switzerland) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 55.1-55.11. refs

Copyright

A survey is given on a series of major improvements realized in recent years in the 5m x 7m low speed closed circuit wind tunnel. The redesign of the inlet nozzle and the rearrangement of the diffuser configuration led to a considerable extension of the usable test section. By optimizing the flow equalizing screens, the flow quality was highly enhanced. A novel 90 degree-sting suspension with very low interference was developed for high angle of attack testing. A method was implemented and perfected for the fast fieldwise recording and storage of total pressure data and associate coordinates of the measurement locations. Its use for flow visualization and drag reduction purposes is demonstrated. A modern on-line method for determining wall interference corrections was installed. A selection of typical results is presented to illustrate its flexibility

A94-10448

SUPER LOW TURBULENCE SUBSONIC WIND TUNNELS

W. PFENNINGER (Analytical Services and Materials, Inc., Hampton, VA) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 57.1-57.12. refs

Copyright

An account is given of current ultralow-turbulence wind tunnels whose turbulence levels approach the atmospheric microscale turbulence responsible for the phenomenon of transition. The apparatus in question addresses the aerodynamic and acoustic disturbances generated by wind tunnel diffusors and turning vanes by means of boundary layer suction slots. Such slots halve the power required to overcome diffusor losses. Suction compressors can be acoustically isolated; driving fan tip speed and noise are much lower than for a conventional wind tunnel. AIAA

A94-10779

HYPERSONIC WIND TUNNEL TESTING

R. K. MATTHEWS (Calspan Corp., Arnold AFB, TN) *In* Advances in hypersonics. Vol. 1 - Defining the hypersonic environment Boston, MA Birkhaeuser 1992 p. 72-108. refs

Copyright

An overview of hypersonic wind tunnel testing techniques is presented. Tests are performed for: force and moment, pressure flow-field diagnostics, heat transfer, discrete measurements, and material/structures. Attention is given to intrusive measurement techniques, namely, pitot probe, total temperature probe, and Mach flow angularity probe. Nonintrusive measurement systems are discussed, with emphasis on the boundary-layer transition detector, laser particle monitor, and laser Doppler velocimeter. The determination of thermal environments, and thermal mapping techniques are examined. Demonstration of hardware survivability, a major stage in the development of structural components, is also discussed. AIAA

A94-10781
HIGH-ENTHALPY TESTING IN HYPERSONIC SHOCK TUNNELS
B. ESSER, H. GROENIG, and H. OLIVIER (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) *In* Advances in hypersonics. Vol. 1 - Defining the hypersonic environment Boston, MA Birkhaeuser 1992 p. 182-258. refs
Copyright

After an introduction into different types of high-enthalpy hypersonic ground test facilities the performance of the shock tunnel is described in detail with special consideration given to the Aachen tunnel. The basic shock tube performance is presented with numerical calculations using an equilibrium air model. The influence of boundary layer effects and van der Waals driver gas effects on the shock tube flow is included. Numerical calculations of equilibrium and frozen air flow in the nozzle are shown. The relaxation zone behind a bow shock is calculated using the air model together with 34 elementary reactions. The attainable simulation parameters are discussed. The experimental methods cover the measurements of pressures, forces and moments and heat flux; time resolved flow visualization is possible. The experimental results given include nozzle calibrations and a study of the nozzle starting process. A table is included giving properties behind incident and reflected shocks at initial pressures of 0.01, 0.1, and 1 bar for equilibrium air. Author (revised)

A94-10782
LOW DENSITY FACILITIES
GEORG KOPPENWALLNER (Hyperschall Technologie Goettingen, Germany) *In* Advances in hypersonics. Vol. 1 - Defining the hypersonic environment Boston, MA Birkhaeuser 1992 p. 259-323. refs
Copyright

Testing at low densities covers a wide spectrum of possible phenomena to be investigated. Similarity rules can only partially be obeyed. Three different major simulation tasks - rarefied aerodynamics, surface flow reactions, and gas surface interactions - are defined. For every field a special category of facilities is necessary, namely, low-density wind tunnels, low-density arc jet facilities, and molecular beam facilities. Hypersonic rarefied flow regimes and simulation requirements, and operation conditions in low-density tunnels are discussed. Attention is given to different elements of low-density tunnels, low-density arc jet facilities, and molecular beam facilities. AIAA

A94-11991 National Aeronautics and Space Administration, Washington, DC.
A GRAPHICAL WORKSTATION BASED PART-TASK FLIGHT SIMULATOR FOR PRELIMINARY RAPID EVALUATION OF ADVANCED DISPLAYS
CRAIG WANKE, JAMES KUCHAR, EDWARD HAHN, AMY PRITCHETT, and R. J. HANSMAN (MIT, Cambridge, MA) Oct. 1992 9 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(Contract NSF MSS-85-52702; NGL-22-009-640; NAG2-12; NAG2-716; DTRS-57-88-C-0078; NAG1-690)
(SAE PAPER 921953) Copyright

Advances in avionics and display technology are significantly changing the cockpit environment in current transport aircraft. The MIT Aeronautical Systems Lab (ASL) has developed a part-task flight simulator specifically to study the effects of these new technologies on flight crew situational awareness and performance. The simulator is based on a commercially-available graphics workstation, and can be rapidly reconfigured to meet the varying demands of experimental studies. The simulator has been successfully used to evaluate graphical microburst alerting displays, electronic instrument approach plates, terrain awareness and alerting displays, and ATC routing amendment delivery through digital datalinks.

A94-11998
THE TEST, EVALUATION, DEVELOPMENT, AND USE OF A MANNED FLIGHT SIMULATOR TO SUPPORT NAVY DEVELOPMENTAL TESTING OF THE V-22 OSPREY
GERY VANDERVLIET (U.S. Navy, Naval Air Warfare Center, Warminster, PA) Oct. 1992 10 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921978)

Initial shipboard compatibility tests of the V-22 Osprey VSTOL tilt-rotor aircraft were conducted aboard the USS Wasp (LHD-I) on 4-8 December 1990. In preparation for this event, the Naval Air Warfare Center Aircraft Division Patuxent River (NAWCADPAX) Manned Flight Simulator (MFS) was used for pilot training and engineering analysis. The focused task was V-22 shipboard launch and recoveries which was comprised of the shipboard approach, transition, hover, landing, and takeoff. In preparation for follow-on V-22 at-sea tests, the performance of this 'first-cut' simulation, with regard to both hardware and software, were tested and evaluated. The scope of the initial at-sea test was, although hazardous, limited in nature, thus, the use of the simulator was limited. This paper examines the simulator fidelity requirements, test requirements, development, and integration efforts imposed on the MFS to enable it to be an effective engineering and training tool for both the initial and follow-on V-22 shipboard Developmental Tests. Author (revised)

A94-12017* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FRICTION EVALUATION OF CONCRETE PAVER BLOCKS FOR AIRPORT PAVEMENT APPLICATIONS
THOMAS J. YAGER (NASA, Langley Research Center, Hampton, VA) Oct. 1992 7 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922013) Copyright

The development and use of concrete paver blocks is reviewed and some general specifications for application of this type of pavement surface at airport facilities are given. Two different shapes of interlocking concrete paver blocks installed in the track surface at NASA Langley's Aircraft Landing Dynamics Facility (ALDF) are described. Preliminary cornering performance results from testing of 40 x 14 radial-belted and bias-ply aircraft tires are reviewed. These tire tests are part of a larger, ongoing joint NASA/FAA/Industry Surface Traction and Radial Tire (START) Program involving several different tire sizes. Both dry and wet surface conditions were evaluated on the two concrete paver block test surfaces and a conventional, nongrooved Portland cement concrete surface. Future test plans involving evaluation of other concrete paver block designs at the ALDF are indicated.

A94-12084
GROUND SUPPORT EQUIPMENT (GSE) FOR AIRCRAFT CONDITION MONITORING SYSTEM (ACMS)
A. LEVIONNOIS (SFIM, Massy, France) Sep. 1992 11 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

A general description is given of the Ground Support Equipment (GSE) used for the Aircraft Condition Monitoring System (ACMS) and of the ACMS itself. GSE software is outlined and fleet management, programming of the Data Management Unit, smart access recorder data decompression, ADEPT and APM interfaces, user management, hardware and software requirements, and network configuration are briefly described. AIAA

A94-12101
TODAY'S AND NEW TRENDS FOR 1990'S - THE A129 TRAINING SYLLABUS
D. CANETTA and A. CERIOTTI (Agusta Sistemi, Tradate, Italy) Sep. 1992 12 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

The design of a new aircraft, whatever the application, cannot today be separated from the development of a training syllabus. The joint development of aircraft and training systems allows the constructive utilization of the mutual experience gained in the single design. Agusta has been aware, since the beginning of the A129 project, of the importance in offering a training syllabus together with the new anti-rank helicopter A129. For this reason the needs of crew and maintenance staff for the helicopter were analyzed and, on this basis, various training systems were chosen as a function of the cost/effectiveness ratio. Due to this work Agusta is today able to offer a complete training syllabus, comprising Computer Based Trainer's, Part Task Trainer's, Maintenance Trainer's, and a Combat Mission Simulator for the specified helicopter.

A94-12234
THE SUPER PUMA HELICOPTER SIMULATOR OR 'HOW TO MEET THE MOST DEMANDING REQUIREMENTS OF THE 90'S'
D. FORGET and A. FLIPO (Thomson-CSF, Cergy, France) 1992 8 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper

The objectives of the study reported here were to (1) identify the elements essential for piloting the helicopter; (2) prioritize the importance of these elements; (3) relate these elements to current or future simulator technology; and (4) define a simulator able to provide this operational training at a reasonable cost. The concepts developed during the study were implemented in the AS332 SUPER PUMA simulator, specifically designed to provide tactical flight training, including nap-of-the-earth flight training in a realistic European type environment. These capabilities are achieved by combining a large visual field of view, high detail visual images, and realistic simulated helicopter behavior near the ground.
AIAA

A94-12692* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL AEROELASTICITY IN WIND TUNNELS - HISTORY, STATUS, AND FUTURE IN BRIEF
RODNEY H. RICKETTS (NASA, Langley Research Center, Hampton, VA) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 5 - Structural dynamics and aeroelasticity New York American Society of Mechanical Engineers 1993 p. 151-177. refs
Copyright

The state of the art of experimental aeroelasticity in the United States is assessed. A brief history of the development of ground test facilities, apparatus, and testing methods is presented. Several experimental programs are described that were previously conducted and helped to improve the state of the art. Some specific future directions for improving and enhancing experimental aeroelasticity are suggested.
AIAA

A94-13072
GASEOUS DETONATION DRIVER FOR A SHOCK TUNNEL
H.-R. YU (Chinese Academy of Sciences, Inst. of Mechanics, Beijing, China), B. ESSER, M. LENARTZ, and H. GROENIG (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) Shock Waves (ISSN 0938-1287) vol. 2, no. 4 1992 p. 245-254. refs
Copyright

The concept of a shock tunnel with gaseous detonation driver is discussed. A detonation driver presents an alternative to a free-piston driver because comparable values of high enthalpy can be attained, however, without the fast movement of a heavy piston. Wave diagrams, pressure and temperature distributions are presented. Finally, first experimental results are given.

N94-10431# Aeronautica Macchi S.p.A., Varese (Italy). Aerodynamics Dept.
DESIGN AND PRODUCTION OF INSULATED WIND TUNNEL MODELS OF THE HERMES SHUTTLE FOR HEAT TRANSFER MEASUREMENTS AT HYPERSONIC SPEEDS
L. VISINTINI and C. COUEDOR (Dassault Aviation, Istres, France.) *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 9 p Apr. 1993
Copyright Avail: CASI HC A02/MF A04

Among all kinds of wind tunnel experiments undertaken up to now by Dassault Aviation to develop the European HERMES shuttle, those relative to heat transfer measurements could be the last to be fully accomplished. To some extent, one could say that difficulties came from sensors themselves, from their integration conditions, and finally from additional similitude parameters not considered before. The paper introduces to Dassault Aviation so-called 'insulated models' and describes the ongoing activity developed with the collaboration of AerMacchi. The models have the purpose of making heat transfer measurements with correct simulation of surface temperatures due to its demonstrated effect on boundary layer transition. A number of pathfinder models were developed for this purpose: after a first attempt made by using a machinable ceramic, the second one was intended for surface temperatures up to 400 C and was made in a temperature resistant composite material, and the third one, able to sustain skin temperatures above 1000 C, is made by an insulating ceramic coating on a steel core. The fluid-dynamic and technological aspects related with the design and manufacture of these models are described.
Author (revised)

N94-10432# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (Germany).
THE UPGRADING OF THE ARC HEATED WIND TUNNEL OF THE DLR (LBK) WITH RESPECT TO ITS EFFECTS ON THE MATERIAL TESTING
A. GUELHAN and K. KINDLER *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 11 p Apr. 1993
Copyright Avail: CASI HC A03/MF A04

The arc heated wind tunnel (LBK) of the DLR is a useful device for high enthalpy tests of thermal protection systems of spacecrafts. The facility is described concerning its capability in simulation of the gas-surface interaction phenomena at the stagnation point of space vehicles. The working area of the tunnel resulting from tests on SiC-samples is discussed and compared with other arc heated wind tunnels. To support experimental works on the LBK numerical computations including flow solutions based on chemical equilibrium, frozen chemistry, and chemical nonequilibrium were performed. It is shown that the flow field downstream the nozzle throat is nearly frozen. Finally, the upgrading concept and the proposed performance of the facility are discussed.
Author

N94-10669* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
DYNAMIC TESTER FOR ROTOR SEALS AND BEARINGS Patent
GEORGE L. VONPRAGENAU, inventor (to NASA) 31 Aug. 1993 7 p Filed 1 Apr. 1991 Supersedes N91-25155 (29 - 17, p 2737) (NASA-CASE-MFS-28493-1; US-PATENT-5,239,864; US-PATENT-APPL-SN-678780; US-PATENT-CLASS-73-118.1; US-PATENT-CLASS-73-119R; US-PATENT-CLASS-73-865.9; INT-PATENT-CLASS-G01M-15/00; INT-PATENT-CLASS-G01N-19/00) Avail: US Patent and Trademark Office

A dynamic tester for testing vibration damping seals and bearings is constructed having a hollow shaft extending through the seal or bearing, with the shaft internally supported at each end by fluid bearings on hollow bosses connected to an interior of an enclosure, with no rolling members connected to the shaft is described. A high pressure working fluid is forced through the hollow bosses to operate the bearings. Additionally, the shaft is provided with a reaction turbine that angularly vents a portion of the high pressure working fluid in order to rotate the shaft at high speed, up to 40,000 rpm. The seal or bearing is mounted in a bushing, in turn supported by rods to a shaking device that vibrates the seal or bearing as the shaft is rotated. A plurality of proximity sensors are mounted from outside the enclosure to sense shaft and seal bushing vibrations, and a plurality of pressure ports are disposed in the enclosure to allow sensing of dynamic and static pressures of the testing apparatus.

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

N94-10733# National Aerospace Lab., Tokyo (Japan). Control Systems Div.

FLIGHT SIMULATOR EXPERIMENT OF THE COCKPIT ADVISORY SYSTEM [KOKKUPITTO ADOBAIZARI SHISUTEMU NO SHIMYURETA HYOUKA JIKKEN]

KEIJI TANAKA, HIROYASU KAWAHARA, KOUTAROU MATSUMOTO, and HIDEO MASUZAWA Apr. 1992 34 p In JAPANESE Original contains color illustrations

(ISSN 0389-4010)

(NAL-TR-1151; JTN-93-80432; DE93-767975) Avail: CASI HC A03/MF A01

This paper describes the flight simulation experiment of a cockpit human-interface system which monitors aircraft utility systems and provides timely displays of aircraft conditions, warnings, and suggestions of initial actions, as well as operational procedures. This 'Cockpit Advisory System' is a kind of intelligent display which functions as a real-time flight manual. The current system was developed using the utility systems of 'ASKA', a Short Take-Off and Landing (STOL) experimental aircraft of the National Aerospace Laboratory (NAL). The system has two displays controlled by a real-time expert system, i.e., one for conditions and procedures and the other for various messages. Two pilots participated in flight simulator tests in which various emergency situations were encountered. Results indicate that the system: (1) remarkably reduced pilot workload; (2) enhanced crew coordination and situation awareness due to looking at color graphic displays instead of reading written checklists; (3) created a different cockpit environment since reading checklists is not necessary; and (4) is proved to be especially useful for pilot training. Author (NASDA)

N94-10894# Aircraft Research Association Ltd., Bedford (England).

IMPROVEMENT OF THE FLOW QUALITY IN THE ARA TRANSONIC TUNNEL BY MEANS OF A LONG CELL HONEYCOMB

D. R. STANNILAND, C. A. MCHUGH, and J. E. GREEN Aug. 1992 13 p Presented at the Conference on Wind Tunnels and Wind Tunnel Test Techniques, Southampton, England, 14-17 Sep. 1992 Original contains color illustrations

(ARA-MEMO-375) Avail: CASI HC A03/MF A01

In August 1990, the flow smoothing screen in the ARA 9' x 8' Transonic Wind Tunnel was replaced by a honeycomb with a high ratio of cell length to diameter. Investigations into a suitable honeycomb design is described and the resulting changes in flow quality in the wind tunnel are presented. Detailed surveys of the total pressure, steady and unsteady flow angularity, and turbulence show that a high degree of flow uniformity was achieved in the test section. Turbulence levels of 0.05 percent longitudinally and 0.18 percent laterally were derived from measurements in the working section. These are in good agreement with values derived from settling chamber measurements and compare well with the estimates of minimum longitudinal and lateral turbulence levels (0.06 percent and 0.15 percent) achievable with the chosen design of honeycomb. Author (revised)

N94-11535*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

MEASURES FOR SIMULATOR EVALUATION OF A HELICOPTER OBSTACLE AVOIDANCE SYSTEM

JOE DEMAIO (Army Aviation Systems Command, Moffett Field, CA.), THOMAS J. SHARKEY (Monterey Technologies, Inc., Carmel, CA.), DAVID KENNEDY (Monterey Technologies, Inc., Carmel, CA.), MICHEAL HUGHES (CAE Electronics Ltd., Saint Laurent, Quebec.), and PERRY MEADE (CAE Electronics Ltd., Saint Laurent, Quebec.) *In* NASA. Johnson Space Center, Sixth Annual Workshop on Space Operations Applications and Research (SOAR 1992), Volume 2 p 507-511 Feb. 1993

Avail: CASI HC A01/MF A03

The U.S. Army Aeroflightdynamics Directorate (AFDD) has developed a high-fidelity, full-mission simulation facility for the demonstration and evaluation of advanced helicopter mission equipment. The Crew Station Research and Development Facility (CSRDF) provides the capability to conduct one- or two-crew full-mission simulations in a state-of-the-art helicopter simulator. The CSRDF provides a realistic, full field-of-regard visual environment with simulation of state-of-the-art weapons, sensors, and flight control systems. We are using the CSRDF to evaluate the ability of an obstacle avoidance system (OASYS) to support low altitude flight in cluttered terrain using night vision goggles (NVG). The OASYS uses a laser radar to locate obstacles to safe flight in the aircraft's flight path. A major concern is the detection of wires, which can be difficult to see with NVG, but other obstacles--such as trees, poles or the ground--are also a concern. The OASYS symbology is presented to the pilot on a head-up display mounted on the NVG (NVG-HUD). The NVG-HUD presents head-stabilized symbology to the pilot while allowing him to view the image intensified, out-the-window scene through the HUD. Since interference with viewing through the display is a major concern, OASYS symbology must be designed to present usable obstacle clearance information with a minimum of clutter.

Author (revised)

N94-11869*# National Aeronautics and Space Administration, Washington, DC.

OVERVIEW OF THE 1989 WIND TUNNEL CALIBRATION WORKSHOP

ARTHUR HENDERSON, JR. (Futron Corp., Washington, DC.) and L. WAYNE MCKINNEY Aug. 1993 45 p Workshop held in Hampton, VA, 19-20 Apr. 1989

(NASA-TP-3393; NAS 1.60:3393) Avail: CASI HC A03/MF A01

An overview of the 1989 Wind Tunnel Calibration Workshop held at NASA LaRC in Hampton, VA on 19-20 Apr. 1989 is presented. The purpose of the Workshop was to explore wind tunnel calibration requirements as they relate to test quality and data accuracy, with the ultimate goal of developing wind tunnel calibration requirements for the major NASA wind tunnels at ARC, LaRC, and LeRC. The two sessions addressed the following topics: (1) what constitutes a properly calibrated wind tunnel; and (2) the status of calibration of NASA's major wind tunnels. The most significant contributions to the stated goals are highlighted, and the consensus of the Workshop's conclusions and recommendations regarding formulation and implementation of that goal are presented. Author (revised)

N94-12824*# Purdue Univ., West Lafayette, IN. School of Aeronautics and Astronautics.

METHOD OF CHARACTERISTICS DESIGN OF A SUPERSONIC WIND TUNNEL NOZZLE WITH SQUARE CROSS-SECTION, SUPPLEMENT 3 Status Report, 1 Sep. 1992 - 1 Jan. 1993

STEVEN P. SCHNEIDER 1993 41 p

(Contract NAG1-1133)

(NASA-CR-194359; NAS 1.26:194359) Avail: CASI HC A03/MF A01

Nozzle design codes developed earlier were modified and used in order to design a supersonic wind tunnel nozzle with square cross-sections. As part of the design process, a post-processing code that generates square nozzles from the output of the Sivells code was written. The method is based on the results of an axisymmetric method of characteristics code and an axisymmetric boundary layer code. These design codes are documented.

Author (revised)

N94-13008*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

VERTICAL MOTION SIMULATOR FAMILIARIZATION GUIDE

GEORGE L. DANEK May 1993 62 p

(Contract RTOP 505-64-29)
(NASA-TM-103923; A-92031; NAS 1.15:103923) Avail: CASI HC A04/MF A01

The Vertical Motion Simulator Familiarization Guide provides a synoptic description of the Vertical Motion Simulator (VMS) and descriptions of the various simulation components and systems. The intended audience is the community of scientists and engineers who employ the VMS for research and development. The concept of a research simulator system is introduced and the building block nature of the VMS is emphasized. Individual sections describe all the hardware elements in terms of general properties and capabilities. Also included are an example of a typical VMS simulation which graphically illustrates the composition of the system and shows the signal flow among the elements and a glossary of specialized terms, abbreviations, and acronyms.

Author

N94-13127*# *Physical Sciences, Inc., Andover, MA.*

PROPULSION SIMULATOR FOR MAGNETICALLY-SUSPENDED WIND TUNNEL MODELS Final Report

P. B. JOSHI, M. R. MALONSON, G. P. SACCO, C. L. GOLDEY, KEITH GARBUTT, and M. GOODYER Jan. 1992 166 p
(Contract NAS1-18845; SBIR-02.02-9030; RTOP 505-59-54-01)
(NASA-CR-189560; NAS 1.26:189560; PSI-2090/TR-1140) Avail: CASI HC A08/MF A02

In order to demonstrate the measurement of aerodynamic forces/moments, including the effects of exhaust jets in Magnetic Suspension and Balance System (MSBS) wind tunnels, two propulsion simulator models were developed at Physical Sciences Inc. (PSI). Both the small-scale model (1 in. diameter X 8 in. long) and the large-scale model (2.5 in. diameter X 15 in. long) employed compressed, liquefied carbon dioxide as a propellant. The small-scale simulator, made from a highly magnetizable iron alloy, was demonstrated in the 7 in. MSBS wind tunnel at the University of Southampton. It developed a maximum thrust of approximate 1.3 lbf with a 0.098 in. diameter nozzle and 0.7 lbf with a 0.295 in. diameter nozzle. The Southampton MSBS was able to control the simulator at angles-of attack up to 20 deg. The large-scale simulator was demonstrated to operate in both a steady-state and a pulse mode via a miniaturized solinoid valve. It developed a stable and repeatable thrust of 2.75 lbf over a period of 4s and a nozzle pressure ratio (NPR) of 5.

Author (revised)

N94-13325*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

PRELIMINARY DESIGN FEATURES OF THE RASCAL: A NASA /ARMY ROTORCRAFT IN-FLIGHT SIMULATOR

EDWIN W. AIKEN, ROBERT A. JACOBSEN, MICHELLE M. ESHOW (Army Aviation Systems Command, Moffett Field, CA.), WILLIAM S. HINDSON, and DOUGLAS H. DOANE *In its* Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors p 471-486 Jul. 1993
Avail: CASI HC A03/MF A04

Salient design features of a new NASA/Army research rotorcraft - the Rotorcraft-Aircrew Systems Concepts Airborne Laboratory (RASCAL) - are described. Using a UH-60A Black Hawk helicopter as a baseline vehicle, the RASCAL will be a flying laboratory capable of supporting the research requirements of major NASA and Army guidance, control, and display research programs. The paper describes the research facility requirements of these programs together with other critical constraints on the design of the research system, including safety-of-flight. Research program schedules demand a phased development approach, wherein specific research capability milestones are met and flight research projects are flown throughout the complete development cycle of the RASCAL. This development approach is summarized, and selected features of the research system are described. The research system includes a full-authority, programmable, fault-tolerant/fail-safe, fly-by-wire flight control system and a real-time obstacle detection and avoidance system which will generate low-altitude guidance commands to the pilot on a wide field-of-view, color helmet-mounted display.

Author

N94-13337# National Aerospace Lab., Tokyo (Japan). Control Systems Div.

CONTROL SYSTEM DESIGN OF A CABLE-MOUNTED MODEL USED FOR DYNAMIC WIND TUNNEL TESTING [KEBURU SHIJI DOUTEKI FUUDOU SHIKEN NO TAMENO MOKEI SEIGYOKEI SEKKEI]

MASAAKI YANAGIHARA, MASAHIKO NAGAYASU, SHUUICHI SASA, and TAKASHI SHIMOMURA Jun. 1992 52 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1161; JTN-93-80484) Avail: CASI HC A04/MF A01

The control system of a cable-mounted aircraft model used for dynamic wind tunnel testing was designed using the root locus method. Computer simulations were initially performed to evaluate the designed control system, which was then applied to actual wind tunnel tests. Results confirmed the system's suitability, although the control gains required slight tuning. In addition, wind tunnel tests were conducted using the control system to identify the aerodynamic model of the cable-mounted model.

Author (NASDA)

N94-13498# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

FUTURE DEVELOPMENTS OF THE NLR RESEARCH FLIGHT SIMULATOR

C. J. JANSEN 31 Mar. 1992 14 p Presented at the Aeronautical Students Association Simulation Symposium, Haarlem, Netherlands, 20 Mar. 1990
(NLR-TP-92143-U; ETN-93-94345; AD-B169651L) Avail: CASI HC A03/MF A01

The upgrading program of the flight simulator is overviewed. The period from some years ago, when the simulator had a relatively small motion system and limited vision of the outside world, till the end of 1994 is addressed. The following major improvements which have already been realized are described: the avionics system (this consists of an ARINC bus interface system to couple Electronic Flight Instrument System (EFIS) displays, a programmable EFIS, and a general purpose graphics station); a new fully hydrostatic 6 degrees of freedom motion system with high bandwidth (only 45 deg phase lag at 4 Hz for acceleration commands from the simulator computer); and a high bandwidth digital bus interface system. Upgrades foreseen for the coming two years are also described. These involve increasing the computational power; installation of an F-16 cockpit with g seat; and a visual system with an increased field of view, at least 150 deg horizontal by 60 deg vertical.

ESA

N94-13544 Calgary Univ. (Alberta). Dept. of Civil Engineering.

AIRPORT TERMINALS: OPTIMUM CONFIGURATIONS AND GATE POSITION REQUIREMENT Ph.D. Thesis

J. M. S. J. BANDARA Dec. 1989 325 p
(ISBN-0-315-61722-5; CTN-93-60729) Copyright Avail: *Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville,* Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC/MF

The level of service method and the minimum cost method are used to determine the number of gate positions required at an airport terminal. The former method is used to calculate the number of gate positions required to provide a given level of reliability. In the latter method, an optimum number of gate positions that will minimize the sum of the cost of gates and the cost of delay to aircraft is obtained. An approximate procedure to determine the deterministic delay to aircraft, based on the information regarding the peaking of the aircraft arrival rate and the number of peaks per day is presented. Closed-form solutions are obtained for the cases of one peak and several identical nonoverlapping peaks, respectively. Given the size of the terminal in terms of the number of aircraft gates, an analytic expression is obtained for the mean passenger walking distance. A continuum expression is used to model passenger walking within the piers or satellites. The optimum geometry in terms of the number of piers or satellites and their sizes is obtained by minimizing the mean walking distance for all the passengers. Statistical parameters suitable for choosing the best configuration for the terminal are suggested. A numerical example to illustrate the selection of the best terminal geometry is presented. Author (CISTI)

N94-13588# Aeronautical Research Inst. of Sweden, Stockholm.
SIMULATOR STUDY OF UNCOUPLED CONTROL FUNCTIONS. USE OF MANUAL POINTING MODES WHEN AIMING AT GROUND TARGETS AND ONCOMING AIRBORNE TARGET
AAKE HYDEN and GUNNAR HOVMARK Oct. 1992 54 p
(Contract FMV-FLYG-82450-87-348-24-001; FMV-FLYG-82450-88-341-73-0)
(FFA-TN-1992-18; ETN-93-94380) Avail: CASI HC A04/MF A01

A number of flight simulator tests were carried out to find whether manually controlled pointing in pitch and yaw would be valuable as a complement to an automatically controlled pointing mode. The results showed that a manual pointing mode will not give a general increase of the aircraft aiming capabilities. Most of the 19 pilots who tried the manual pointing modes in the simulator were quite positive in their opinions, but the aiming results and other results are only slightly better and sometimes not as good as the ones achieved with conventional control. The main advantage of pointing mode over conventional control was that a greater minimum distance to target could be achieved. The risk of confusing the controls, the often longer periods of straight flight paths, the pilots experiencing a higher workload and taking the left hand (and the control grip) away from other important tasks are factors that speak against manual pointing. ESA

N94-14157# Arnold Engineering Development Center, Arnold AFS, TN.
CHARACTERIZATION OF FLOW FIELDS IN HYPERSONIC GROUND TEST FACILITIES
ALBERT H. BOUDREAU *In* VKI, Methodology of Hypersonic Testing 15 p 1993 Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
Copyright Avail: CASI HC A03/MF A03

The fundamental differences between nonequilibrium encountered in flight and nonequilibrium phenomena encountered in ground test facilities are described. Focus is on facility induced non-equilibrium, describing the gross effects on bodies and the methods now available to characterize such flows. It shows that hypersonic test facilities are inherently difficult to characterize. In the past, many hypersonic facilities were reputed to produce test data of inferior quality when, in fact, it was poor characterization of the flow field principally at fault. With the renaissance in hypersonics at hand, experimentalists face new challenges in characterizing flow fields. The hypersonic test community has developed techniques to accurately determine free stream conditions. These 'tools of characterization', are described and a standard by which all hypersonic wind tunnels should be compared is suggested. ESA

N94-14158# Calspan Corp., Arnold AFS, TN.
AERODYNAMIC AND AEROTHERMAL FACILITIES 1: HYPERSONIC WIND TUNNELS
A. ANDERSON and R. K. MATTHEWS *In* VKI, Methodology of Hypersonic Testing 13 p 1993 Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
Copyright Avail: CASI HC A03/MF A03

An overview of hypersonic test facilities, which continue to play a major role in the development of hypersonic vehicles, is given. In the past, ground test facilities were often used to perform configuration parametric studies and/or to develop large data bases. Future testing will emphasize understanding of fluid physics and validation of codes. Computational Fluid Dynamics (CFD) has made great progress in the past two decades, but the marriage of CFD and ground testing is clearly a reality today, and will become even more important in the future as computational and experimental researchers learn how to work together. One of the challenges for the experimentalist is to develop and utilize facilities that simulate hypersonic flight, and to provide the required data precision to validate CFD codes. Fundamental considerations of facilities and simulation issues are reviewed. It is clear that no one facility will meet the wide variety of test objectives; therefore, the test facilities span a range of size, run time, complexity, and operating cost. Representative facilities are described, as well as their test capabilities and their shortfalls. ESA

N94-14159# Calspan Corp., Arnold AFS, TN.
AERODYNAMIC AND AEROTHERMAL FACILITIES 2. PART 1: SHORT-DURATION, HIGH-ENTHALPY FACILITIES
JAMES R. MAUS *In* VKI, Methodology of Hypersonic Testing 15 p 1993 Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
Copyright Avail: CASI HC A03/MF A03

Short duration facilities primarily used for aerodynamic or aerothermal testing are reviewed. Facilities which have useful run times ranging from a few hundred microseconds to a few hundred milliseconds are considered. The following types of facilities are addressed: arc heated hot shot tunnels, shock heated devices, compression heated wind tunnels, and aeroballistic ranges. Examples of both U.S. and European facilities are given. Principles of operation, facility performance, and strengths and weaknesses of the various types of facilities are emphasized. ESA

N94-14876 Defence Research Agency, Bedford (England).
A GUIDE TO THE DRA 13 FT X 9 FT LOW SPEED WIND TUNNEL FACILITY
M. H. HUNTER Apr. 1993 33 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A267739; DRA-TR-93014; DRIC-BR-318697) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

This Technical Report is intended to provide a guide to the 13 ft. x 9 ft. Low Speed Wind Tunnel Facility. It details the model support and balance assemblies, provides an insight to the instrumentation and computing capabilities, and indicates the different flow visualization techniques available. A description of the tunnel and local facilities is included, along with contact numbers for customers' use. DTIC

N94-14908# Army Construction Engineering Research Lab., Champaign, IL.
VIBRO-ACOUSTIC ANALYSIS OF AN AIRCRAFT MAINTENANCE DOCK Final Report
JAMES WILCOSKI and LOUIS SUTHERLAND Aug. 1992 253 p
(Contract MIPR-ENM9486)
(AD-A266778; CERL-TR-FM-92/03) Avail: CASI HC A12/MF A03

This report documents an analysis of the effects of high-level acoustic environments on an Aircraft Maintenance Dock (AMD) designed for the U.S. Air Force by the U.S. Army Corps of Engineers. The analysis includes detailed estimation of the maximum sound levels inside the facility, identification of facility components that are potentially sensitive to high-level vibro-acoustic loads, and a summary of design considerations appropriate for this environment. Several critical components of the AMD were analyzed. Design modifications have been recommended as a result of this analysis for this facility, including increases in ductwork thickness, a new ductwork joint design, and vibration isolation for ductwork, exhaust fans, pipe systems, light fixtures, and wind truss supports. A summary of recommended design practices to minimize potential structural damage or equipment malfunction due to the high vibro-acoustic environments was developed. The type of steel construction to be employed for this facility is not normally exposed to high-intensity vibro-acoustic loading. However, if proper consideration is given to the vibro-acoustic loads specified here for building design and qualifications of internal equipment, the planned use of the facility should not be significantly impaired. DTIC

N94-15117*# MCAT Inst., San Jose, CA.
DEVELOPMENT OF A QUIET SUPERSONIC WIND TUNNEL WITH A CRYOGENIC ADAPTIVE NOZZLE Progress Report
STEPHEN W. D. WOLF Oct. 1993 138 p Original contains

color illustrations
(Contract NCC2-604)
(NASA-CR-194548; NAS 1.26:194548; MCAT-93-19) Avail: CASI HC A07/MF A02; 6 functional color pages

The main objective of this work is to develop an interim Quiet (low-disturbance) supersonic wind tunnel for the NASA-Ames Fluid Mechanics Laboratory (FML). The main emphasis is to bring on-line a full-scale Mach 1.6 tunnel as rapidly as possible to impact the NASA High Speed Research Program (HSRP). The development of a cryogenic adaptive nozzle and other sophisticated features of the tunnel will now happen later, after the full scale wind tunnel is in operation. The work under this contract for the period of this report can be summarized as follows: provide aerodynamic design requirements for the NASA-Ames Fluid Mechanics Laboratory (FML) Laminar Flow Supersonic Wind Tunnel (LFSWT); research design parameters for a unique Mach 1.6 drive system for the LFSWT using an 1/8th-scale Proof-of-Concept (PoC) supersonic wind tunnel; carry out boundary layer transition studies in PoC to aid the design of critical components of the LFSWT; appraise the State of the Art in quiet supersonic wind tunnel design; and help develop a supersonic research capability within the FML particularly in the areas of high speed transition measurements and schlieren techniques. The body of this annual report summarizes the work of the Principal Investigator. Derived from text

N94-15123# Netherlands Association of Aeronautical Engineers, Amsterdam.
THE FUTURE OF SCHIPHOL: GROWTH WITHIN BOUNDARIES [DE TOEKOMST VAN SCHIPHOL: GROEIEN BINNEN GRENZEN]
R. DENBESTEN *In* NAL, Symposium on the Future of Aeronautics in the Netherlands 16 p 1991 In DUTCH
Avail: CASI HC A03/MF A02

The planned, controlled growth of the Schipol airport considering clear environmental boundary conditions is discussed. Within the tendency of concentration in the European aviation, Schipol tries to become one of the mainports ('hubs') on which intercontinental air traffic concentrates. The planned expansions of the airport and the consequences for the employment and the environment are outlined. ESA

N94-15129# National Aerospace Lab., Amsterdam (Netherlands).
EXPECTATIONS FOR THE FUTURE OF THE NATIONAL AEROSPACE LABORATORY [TOEKOMSTVERWACHTINGEN NATIONAAL LUCHT- EN RUIMTEVAARTLABORATORIUM]
B. M. SPEE *In its* Symposium on the Future of Aeronautics in the Netherlands 17 p 1991 In DUTCH
Avail: CASI HC A03/MF A02

The perspectives of the National Aerospace Laboratories (NLR) in the field of aeronautics are depicted. The new required civil and military technologies to which NLR is planning to contribute are overviewed. The required research will take place in an international framework. The important role of the large NLR research facilities is described. ESA

N94-15325* National Aeronautics and Space Administration, Washington, DC.
ROTORCRAFT RESEARCH (Videotape)
Jun. 1986 Videotape: 2 min. 40 sec. playing time, in color, with sound
(NASA-TM-109452; NONP-VT-93-190249) Avail: CASI VHS A01/BETA A22

This document describes wind tunnel testing and computer modeling done on the rotorcraft prior to building the final aircraft. CASI

N94-15794*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WALL INTERFERENCE AND BOUNDARY SIMULATION IN A TRANSONIC WIND TUNNEL WITH A DISCRETELY SLOTTED TEST SECTION
JASSIM A. AL-SAADI Washington Sep. 1993 75 p
(Contract RTOP 505-59-54-01)
(NASA-TP-3334; L-16973; NAS 1.60:3334) Avail: CASI HC A04/MF A01

A computational simulation of a transonic wind tunnel test section with longitudinally slotted walls is developed and described herein. The nonlinear slot model includes dynamic pressure effects and a plenum pressure constraint, and each slot is treated individually. The solution is performed using a finite-difference method that solves an extended transonic small disturbance equation. The walls serve as the outer boundary conditions in the relaxation technique, and an interaction procedure is used at the slotted walls. Measured boundary pressures are not required to establish the wall conditions but are currently used to assess the accuracy of the simulation. This method can also calculate a free-air solution as well as solutions that employ the classical homogeneous wall conditions. The simulation is used to examine two commercial transport aircraft models at a supercritical Mach number for zero-lift and cruise conditions. Good agreement between measured and calculated wall pressures is obtained for the model geometries and flow conditions examined herein. Some localized disagreement is noted, which is attributed to improper simulation of viscous effects in the slots. Author

N94-15819*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NASA LEWIS 9- BY 15-FOOT LOW-SPEED WIND TUNNEL USER MANUAL
RONALD H. SOEDER Jul. 1993 50 p
(Contract RTOP 505-62-84)
(NASA-TM-106247; E-7968; NAS 1.15:106247) Avail: CASI HC A03/MF A01

This manual describes the 9- by 15-Foot Low-Speed Wind Tunnel at the Lewis Research Center and provides information for users who wish to conduct experiments in this atmospheric facility. Tunnel variables such as pressures, temperatures, available tests section area, and Mach number ranges (0.05 to 0.20) are discussed. In addition, general support systems such as air systems, hydraulic system, hydrogen system, laser system, flow visualization system, and model support systems are described. Instrumentation and data processing and acquisition systems are also discussed. Author

N94-15847 Wright Lab., Wright-Patterson AFB, OH.
DESIGN OF ROUND-TO-SQUARE TRANSITION SECTION; ANALYSIS AND COMPUTER CODE Interim Report, 1 Dec. 1992 - 31 Jan. 1993
TZONG H. CHEN and ABDOLLAH S. NEJAD Jan. 1993 19 p
Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract AF PROJ. 2308)
(AD-A267173; WL-TR-93-2054) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

A generalized analytical form of the surface of a transition section which interfaces round and square cross sections of a wind tunnel is presented. Also included is a listing of the computer code which generates the surface coordinates in the format required by the vax computer at the Air Force Machine Shop at Wright-Patterson Air Force Base. DTIC

N94-15856 Aeronautical Research Labs., Melbourne (Australia).
FLIGHT INSTRUMENT SOFTWARE FOR THE F/A-18 RESEARCH SIMULATOR
Y. Y. LINK Mar. 1993 26 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A267170; ARL-TN-17; DODA-AR-006-680) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The standby flight instruments are replicated on two high resolution raster displays for the F/A-18 research simulator. A software package was developed using NOVA*CG1, an implementation of the CGI graphics standard, to control a MVME393 multi-channel graphics controller. The software is written in C for the Motorola MVME147 single board computer under the UNIX System V/68 operating system. Increased performance is achieved by decomposing the instrument dial pointers into a number of trapezoids, and storing these as device level command lists. DTIC

N94-17405# Naval Civil Engineering Lab., Port Hueneme, CA.
STRUCTURED FINITE VOLUME MODELING OF US NAVY AIRCRAFT ENGINE TEST CELLS TASK 2: TURBOPROP ENGINE, VOLUME 1 Final Report, 1990 - Sep. 1992
P. L. DALEY and W. A. MAHAFFEY Jun. 1993 59 p
(Contract N47408-91-C-1228)
(AD-A267833; NCEL-CR-93-003-VOL-1) Avail: CASI HC A04/MF A01

This report presents results of the numerical simulation of a U.S. Naval turboprop test cell facility. The ultimate purpose of this simulation was to provide the Navy with a numerical model to be used for the evaluation of the aerothermal performance of test cells. This simulation was performed using the structured finite volume (SFV) computer code. A description of the physical model, mathematical details, boundary conditions, and results of the study are presented and covered in Volume 1. Volume 2, Code Documentation and Listings, provides a copy of the input files developed for the modeling of turboprop test cells. DTIC

N94-17432# Adaptive Research Corp., Huntsville, AL.
STRUCTURED FINITE VOLUME MODELING OF US NAVY AIRCRAFT ENGINE TEST CELLS. TASK 1: TURBOSHAFT ENGINE, VOLUME 1 Final Report, Dec. 1990 - Sep. 1992
P.L. DALEY and W.A. MAHAFFEY Jun. 1993 59 p
(Contract N47408-91-C-1228)
(AD-A268176; NCEL-CR-93-002-VOL-1) Avail: CASI HC A04/MF A01

This report presents results of the numerical simulation of a U.S. Naval turboshaft test cell facility. The ultimate purpose of this simulation was to provide the Navy with a numerical model to be used for the evaluation of the aerothermal performance of test cells. This simulation was performed using the structured finite volume (SFV) computer code. A description of the physical model, mathematical details, boundary conditions, and results of the study are presented and covered in Volume 1. Volume 2, Code Documentation and Listings, provides a copy of the input files developed for the modeling of turboshaft test cells. DTIC

N94-17508 Adaptive Research Corp., Huntsville, AL.
STRUCTURED FINITE VOLUME MODELING OF US NAVY AIRCRAFT ENGINE TEST CELLS. TASK 1: TURBOSHAFT ENGINE-CODE DOCUMENTATION AND LISTINGS, VOLUME 2 Final Report, Dec. 1990 - Sep. 1992
P.L. DALEY and W.A. MAHAFFEY Jun. 1993 147 p
(Contract N47408-91-C-1228)
(AD-A268177; NCEL-CR-93-002-VOL-2) Avail: CASI HC A07

This report presents results of the numerical simulation of a U.S. Naval turboshaft lest cell facility. The ultimate purpose of this simulation was to provide the Navy with a numerical model to be used for the evaluation of the aerothermal performance of test cells. This simulation was performed using the structured finite volume (SFV) computer code. A description of the physical model, mathematical details, boundary conditions, and results of the study are presented and covered in Volume 1. Volume 2, Code Documentation and Listings, provides a copy of the input files developed for the modeling of turboshaft test cells. DTIC

N94-17569# Adaptive Research Corp., Huntsville, AL.
STRUCTURED FINITE VOLUME MODELING OF US NAVY AIRCRAFT ENGINE TEST CELLS. TASK 2: TURBOPROP ENGINE. VOLUME 2: CODE DOCUMENTATION AND LISTINGS Final Report, Dec. 1990 - Sep. 1992
P. L. DALEY and W. A. MAHAFFEY Jun. 1993 135 p
(Contract N47408-91-C-1228)
(AD-A268386; NCEL-CR-93-003-VOL-2) Avail: CASI HC A07/MF A02

This report presents results of the numerical simulation of a U.S. Naval turboprop test cell facility. The ultimate purpose of this simulation was to provide the Navy with a numerical model to be used for the evaluation of the aerothermal performance of test cells. This simulation was performed using the structured finite volume (SFV) computer code. A description of the physical model, mathematical details, boundary conditions, and results of the study are presented and covered in Volume 1. Volume 2, Code Documentation and Listings, provides a copy of the input files developed for the modeling of turboprop test cells. DTIC

N94-18123# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany). Hauptabt. Verkehrsforschung.
TRANSPORT POLICY OPTIONS FOR REDUCING NOISE AT AIRPORTS; HAMBURG AIRPORT TAKEN AS AN EXAMPLE [VERKEHRSPOLITISCHE OPTIONEN ZUR LAERMREDUKTION AN FLUGHAEFEN DARGESTELLT AM BEISPIEL DES FLUGHAFENS HAMBURG]
STEFAN BEYHOFF, HANSJOCHEN EHMER, HORST FOCKE, and VOLKER WARLITZER Dec. 1992 279 p In GERMAN
(ISSN 0939-2963)
(DLR-FB-92-40; ETN-93-94872) Avail CASI HC A13/MF A03

The air transport demand of scheduled and charter traffic in the northern part of Germany is studied. Based on a detailed analysis of passenger transport demand by size and structure and the assignment to the airports Hamburg and Hannover a forecast of the demand by region and of passenger emplanement and aircraft movements by airport for the year 2000 was made. Measures of transport policy for reducing noise emissions at Hamburg airport are presented. Detailed descriptions of the measures like noise contingents, differentiation of fees, restrictions or bans of certain aircraft or segments of demand, cooperation between airports, and influencing the model split between air and rail transport are given. It is concluded that in the long run larger conforming measures like noise contingents are more efficient as compared with administrative measures. ESA

N94-18324# Aeronautical Research Labs., Melbourne (Australia).
A WIND TUNNEL MODEL CONTROL SURFACE ACTUATOR INTERFACE
S. A. KENT Jun. 1993 45 p
(AD-A268729; ARL-TN-13; DODA-AR-006-658) Avail: CASI HC A03/MF A01

A microprocessor controlled system is described for the remote positioning of flight control surfaces on a wind tunnel aircraft model. The system utilizes DC micromotors and Linear Variable Displacement Transducers (LVDTs) for driving force and accurate position feedback. The Actuator Module was developed primarily for use with a 1/9th scale F/A-18 model to collect data for the International Follow On Structural Test Program (IFOSTP). DTIC

N94-18330# Florida Univ., Eglin AFB.
INTERFEROMETER STATIONS AT THE AIR FORCE AEROBALLISTIC RESEARCH FACILITY Final Report, Aug. 1988 - Dec. 1990
R. C. ANDERSON and J. E. MILTON Jul. 1993 41 p
(Contract F08635-88-C-0160)
(AD-A268776; WL-TR-92-7035) Avail: CASI HC A03/MF A01

Two interferometer stations were installed in the Eglin AFB ballistic range--a holographic and a common path interferometer. The latter was used in both dark central ground and field absorption modes. A theoretical development given for the common path instrument predicts an improved type of phase contrast interferometer with a half wave shifting filter instead of the quarter wave used in the past. Experimentally measured interferograms were found to be in good agreement with synthetic interferograms calculated with data from a Navier-Stokes Computational Fluid Dynamics (CFD) code. DTIC

N94-18963* National Aeronautics and Space Administration, Washington, DC.
THE WORLD'S LARGEST WIND TUNNEL (Videotape)
Oct. 1987 Videotape: 2 min. 47 sec. playing time, in color, with sound

(NASA-TM-109371; NONP-VT-94-198218) Avail: CASI VHS A01/BETA A22

NASA's National Full Scale Aerodynamics Complex, which houses two of the world's largest wind tunnels and has been used for testing experimental aircraft since 1944, is presented. This video highlights the structure and instrumentation of the 40 x 80 foot and 80 x 120 foot wind tunnels and documents their use in testing full scale aircraft, NASA's Space Shuttle and the XV-15 Tiltrotor aircraft. CASI

N94-19372# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.

SURVEY ON THE APPLICATION OF A 3D GENERAL PURPOSE WIND-TUNNEL RESEARCH MODEL

M. J. PAGEN Mar. 1993 49 p

(LR-713; ETN-93-95024) Avail: CASI HC A03/MF A01

A general purpose wind tunnel research model, which is the major element of a proposed aerodynamic design research program, is described. As a first stage in the design of the model a study was conducted to determine the aspects of interest of aircraft configuration research. This has brought out that attention in configuration aerodynamics is directed to the aerodynamic integration of highly loaded propellers, and the performance evaluation of multi wings. The model is designed in assembly kit form so that various configurations can be composed, including two and three surface arrangements of which the lifting surfaces can have different settings. The propulsion system can be mounted in various fashions. Systematic component buildup tests were performed starting from a baseline fuselage to identify aerodynamic contributions of individual airframe components, and aerodynamic interference effects. The same configurations were used to establish the effects of propeller slipstream on the flow field around the model. ESA

N94-19880 Carnegie-Mellon Univ., Pittsburgh, PA. Software Engineering Inst.

STRUCTURAL MODELING: AN APPLICATION FRAMEWORK AND DEVELOPMENT PROCESS FOR FLIGHT SIMULATORS Final Report

GREGORY D. ABOWD, LEN BASS, LARRY HOWARD, and LINDA NORTHROP Aug. 1993 35 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality

(Contract F19628-90-C-0003)

(AD-A271348; CMU/SEI-93-TR-14; ESC-TR-93-192) Avail: CASI HC A03

In this paper, we present the structural modeling approach, an application framework and development process for the construction of flight simulators. Structural modeling was developed to address functional, nonfunctional, and process requirements for flight simulators. It has been successfully used in the development of large scale (one million lines of Ada code) flight simulators for the United States Air Force. A structural model promotes a simple and coherent software architecture with a small number of specialized structural elements obeying a few system-wide coordination strategies. It is this simplicity coherence of the software architecture that enables analysis to demonstrate the quality of the system. DTIC

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.

A94-10718*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AERODYNAMIC CONFIGURATION DESIGN USING RESPONSE SURFACE METHODOLOGY ANALYSIS

WALTER C. ENGELUND, DOUGLAS O. STANLEY, ROGER A. LEPSCH, MARK M. MCMILLIN (NASA, Langley Research Center, Hampton, VA), and RESIT UNAL (Old Dominion Univ., Norfolk, VA) Aug. 1993 12 p. AIAA, Aircraft Design, Systems and Operations Meeting, Monterey, CA, Aug. 11-13, 1993 refs

(AIAA PAPER 93-3967) Copyright

An investigation has been conducted to determine a set of optimal design parameters for a single-stage-to-orbit reentry vehicle. Several configuration geometry parameters which had a large impact on the entry vehicle flying characteristics were selected as design variables: the fuselage fineness ratio, the nose to body length ratio, the nose camber value, the wing planform area scale factor, and the wing location. The optimal geometry parameter values were chosen using a response surface methodology (RSM) technique which allowed for a minimum dry weight configuration design that met a set of aerodynamic performance constraints on the landing speed, and on the subsonic, supersonic, and hypersonic trim and stability levels. The RSM technique utilized, specifically the central composite design method, is presented, along with the general vehicle conceptual design process. Results are presented for an optimized configuration along with several design trade cases.

A94-11104

OPTIMAL REENTRY TRAJECTORIES BY ASYMPTOTIC MATCHING

NGUYEN X. VINH and DONGSUK HAN (Michigan Univ., Ann Arbor) Oct. 1993 15 p. IAF, International Astronautical Congress, 44th, Graz, Austria, Oct. 16-22, 1993 refs

(IAF PAPER 93-012) Copyright

In this paper, we use the matched asymptotic expansions method coupled with the full use of the known exact integrals of motion to derive the explicit optimal control laws for lift and bank modulations during entry. The outer solutions are the limiting solutions in the Keplerian region where the gravitational force is predominant. The inner solutions are the solutions near the planetary surface where the aerodynamic force is predominant. Since the adjoint equations can be integrated in closed forms near these extreme boundaries by retaining the dominant forces, the optimal aerodynamic controls can be expressed explicitly in terms of the state variables and two sets of constants. The results from this control strategy by asymptotic matching have been compared with the exact numerical solutions for a variety of skip and glide entry trajectories. Its performance is excellent in the sense that the control exhibits the same characteristic behavior as the exact solution and as such it leads to nearly the same cost function. Author (revised)

A94-11105

APPROXIMATE CHATTERING ARC FOR MINIMUM TIME FLIGHT

JENG-SHING CHERN (Chung Shan Inst. of Science and Technology, Lungtan, Taiwan), ZUU-CHANG HONG, and YU-TAI CHEN (National Central Univ., Chungli, Taiwan) Oct. 1993 11 p. IAF, International Astronautical Congress, 44th, Graz, Austria, Oct. 16-22, 1993 refs

(IAF PAPER 93-014) Copyright

The purpose of this paper is to investigate the G-constrained approximate chattering arc for minimum-time aerobraking maneuver of a shuttle-type space vehicle at constant altitude. Theoretically, in a chattering arc of the first kind, the control chatters between its maximum and minimum values at an infinite rate. The resulting flight path is along the arc of a great circle, and is 1D. There is a complete analytic solution for this theoretical chattering arc; in the approximate chattering arc, the bank control switches at a finite rate. The resulting flight path is 2D and there is a penalty in the form of a shorter longitudinal range. If we allow the vehicle to coast for a short distance and then change to an approximate chattering arc, the longitudinal range is satisfied and a longer flight time becomes the penalty. The penalty of longer flight time is minimized by increasing the number of control switchings while selecting the optimal instants for the switchings. When the number of control switchings is five, the resulting optimal trajectory is adequate. With additional control switchings, excessive numerical computations are required for minor performance-index improvements. The G constraint has significant effect on the trajectory. Author (revised)

A94-11258
ANALYSIS STUDIES ON RAM COMBUSTOR-NOZZLE SYSTEMS FOR HYPERSONIC PROPULSION
FABIO TURRINI (Fiat Avio S.p.A., Turin, Italy) and ANDREA RICCIARDI (ASI, Rome, Italy) Oct. 1993 19 p. IAF, International Astronautical Congress, 44th, Graz, Austria, Oct. 16-22, 1993 Research supported by ASI refs
(IAF PAPER 93-482) Copyright

The paper describes a study of ram-combustor-nozzle systems for the first stage engine of a Two Stage to Orbit vehicle. This engine is characterized by typical hypersonic flight conditions and by the use of hydrogen as fuel. The main features of two different burner-nozzle designs are explored: an axisymmetric plug nozzle configuration and a 2D Single Expansion Ramp Nozzle solution. Thermal loading acting on the components surfaces is removed using a combination of two methods: direct cooling with cold hydrogen fuel for fixed parts and indirect cooling of moving parts with air previously cooled by the cold fuel. The work includes a prediction of combustor efficiency and nozzle performance and a description of flowfield features obtained using semiempirical correlations and Navier-Stokes CFD codes. A design study focused on cooling system and mass assessment is also described. The comparison between the two configurations suggests that the final choice in terms of nozzle performance is determined by the flight envelope region to which the engine optimization is addressed. Nevertheless, the thrust to total mass ratio clearly indicates the axisymmetric configuration as the best solution. Nevertheless, the design of a feasible and efficient cooling system for both the alternatives has emerged as the crucial and decisive point of the whole system. Author (revised)

A94-11259
RAMJET/SCRAMJET PLUS ROCKET PROPULSION FOR A HEAVY-LIFT SPACE SHUTTLE
EDWARD LANTZ Oct. 1993 10 p. IAF, International Astronautical Congress, 44th, Graz, Austria, Oct. 16-22, 1993 refs
(IAF PAPER 93-480) Copyright

The possibility of using hydrogen-fueled ramjet/scramjet engines for improving the performance and reducing the operating cost of a second-generation Space Shuttle is examined. For a heavy-lift capability, a two-stage system would be necessary. This could consist of a central Trans Atmospheric Vehicle (TAV) with a hypersonic booster attached to each side. A wheeled ground-based launcher could make the takeoff of such a system possible. By using data from the NASP project and the present Space Shuttle, it is shown that a TAV, which is about 20 percent longer than a Boeing 747, could take a payload of about 200,000 pounds to an earth orbit. AIAA

A94-12007* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PEGASUS HYPERSONIC FLIGHT RESEARCH
ROBERT E. CURRY, ROBERT R. MEYER, JR., and GERALD D. BUDD (NASA, Flight Research Center, Edwards, CA) Oct. 1992 16 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Research supported by DARPA and Orbital Sciences Corp refs
(SAE PAPER 921995) Copyright

Hypersonic aeronautics research using the Pegasus air-launched space booster is described. Two areas are discussed in the paper: previously obtained results from Pegasus flights 1 and 2, and plans for future programs. Proposed future research includes boundary-layer transition studies on the airplane-like first stage and also use of the complete Pegasus launch system to boost a research vehicle to hypersonic speeds. Pegasus flight 1 and 2 measurements were used to evaluate the results of several analytical aerodynamic design tools applied during the development of the vehicle as well as to develop hypersonic flight-test techniques. These data indicated that the aerodynamic design approach for Pegasus was adequate and showed that acceptable margins were available. Additionally, the correlations provide insight into the capabilities of these analytical tools for more complex vehicles in which design margins may be more stringent. Near-term plans to conduct hypersonic boundary-layer transition studies are discussed. These plans involve the use of a smooth metallic glove at about the mid-span of the wing. Longer-term opportunities are proposed which identify advantages of the Pegasus launch system to boost large-scale research vehicles to the real-gas hypersonic flight regime. Author (revised)

A94-12029* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE EFFECT OF RUNWAY SURFACE AND BRAKING ON SHUTTLE ORBITER MAIN GEAR TIRE WEAR
ROBERT H. DAUGHERTY and SANDY M. STUBBS (NASA, Langley Research Center, Hampton, VA) Oct. 1992 10 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922038) Copyright

In 1988, a 1067 m long touchdown zone on each end of the Kennedy Space Center (KSC) Shuttle Landing Facility (SLF) was modified from its original heavy-broom finish with transverse grooves configuration to a longitudinal corduroy surface texture with no transverse grooves. The intent of this modification was to reduce the spin-up wear on the Orbiter main gear tires and provide for somewhat higher crosswind capabilities at that site. The modification worked well, so it was proposed that the remainder of the runway be modified as well to permit even higher crosswind landing capability. Tests were conducted at the NASA Langley Aircraft Landing Dynamics Facility (ALDF) to evaluate the merit of such a modification. This paper discusses the results of these tests, and explains why the proposed modification did not provide the expected improvement and thus was not implemented. Also, in an ongoing program to evaluate the origin of various tire wear phenomenon, a series of tests was conducted to evaluate the effect of braking on tire wear. Finally, a modified tire is discussed in terms of its wear performance under rollout and braking operations. Author (revised)

A94-12471
DATA EXCHANGE IN THE DLR - THE WIN SCIENTIFIC NETWORK ENSURES INFORMATION EXCHANGE BETWEEN DLR SITES [DER DATENAUSTAUSCH IN DER DLR - WISSENSCHAFTSNETZ WIN SICHERT DEN INFORMATIONSAUSTAUSCH ZWISCHEN DLR-STANDORTEN]
OLAF GOERING DLR-Nachrichten (ISSN 0937-0420) no. 72 Aug. 1993 p. 5, 6. In GERMAN
Copyright

The exchange of data between the various DLR centers is discussed. The role of a computerized network in this exchange is examined. AIAA

A94-12883
MODELING THE DYNAMICS OF A HIGH-VELOCITY ROTATING ELASTIC FLIGHT VEHICLE [MODELIROVANIE DINAMIKI VYSOKOSKOROSTNOGO VRASHCHAYUSHCHEGOSYA UPRUGOGO LETATEL'NOGO APPARATA]
V. A. ZORIN, V. I. MOROZOV, and A. T. PONOMAREV
Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Tverdogo Tela (ISSN 0572-3299) no. 4 July-Aug. 1993 p. 28-38. In RUSSIAN refs
Copyright

A method is proposed for constructing a model of the three-dimensional motion of a high-velocity rotating elastic flight vehicle. The model is implemented in the form of nonlinear integro-differential equations linearized with respect to aerodynamics and elasticity and complemented by terms allowing for the vehicle rotation and mass variability in time. The approach is based on the synthesis of data obtained by means of computer-aided aerodynamics and structural mechanics methods. AIAA

N94-10423# Avions Marcel Dassault, Saint-Cloud (France).
AERODYNAMIC AND AEROTHERMAL CHALLENGES FOR THE DESIGN OF THE HERMES SPACEPLANE
PIERRE PERRIER *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 10 p Apr. 1993
Copyright Avail: CASI HC A02/MF A04

The Hermes spaceplane will represent a major step in the European space activities. It will be placed into orbit by the heavy-lift launcher Ariane 5. After completion of the mission, it will glide back from low earth orbit to its landing site. In order to take the different problems linked to the ascent and the reentry phases, an aerodynamic strategy was set up. A global review of this strategy will be made. It will contain elements on the available and necessary tools (experimental and theoretical) for the Hermes definition and qualification phases. Some aspects such as the design of the Hermes spaceplane will also be highlighted. It will review the different constraints that will be faced during the ascent and reentry phases. Constraints may come from mission requirements such as crossrange capability or from technology limits such as thermal limits on the thermal protection system or from guidance and control requirements. A new methodology was selected in order to take constraints and uncertainties into account in the design oriented towards qualification of the Hermes spaceplane. The main line of this methodology is the projection on a typical reentry trajectory of the uncertainties in the aerodynamic characteristics checked on control points. Author

N94-10459# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Military Aircraft Div.
NUMERICAL METHODS FOR AEROTHERMODYNAMIC DESIGN OF HYPERSONIC SPACE TRANSPORT VEHICLES
K. M. WANIE, A. BRENNEIS, A. EBERLE, and S. HEISS *In* AGARD, Theoretical and Experimental Methods in Hypersonic Flows 12 p Apr. 1993
Copyright Avail: CASI HC A03/MF A04

The requirement of the design process of hypersonic vehicles to predict flow past entire configurations with wings, fins, flaps, and propulsion system represents one of the major challenges for aerothermodynamics. In this context computational fluid dynamics has come up as a powerful tool to support the experimental work. A couple of numerical methods developed at MBB designed to fulfill the needs of the design process are described. The governing equations and fundamental details of the solution methods are shortly reviewed. Results are given for both geometrically simple test cases and realistic hypersonic configurations. Since there is still a considerable lack of experience for hypersonic flow calculations an extensive testing and verification is essential. This verification is done by comparison of results with experimental data and other numerical methods. The results presented prove that the methods used are robust, flexible, and accurate enough to fulfill the strong needs of the design process. Author (revised)

N94-10765*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SPECIFICATION AND TESTING FOR POWER BY WIRE AIRCRAFT
IRVING G. HANSEN and BARBARA H. KENNEY Aug. 1993 8 p Presented at the 28th Intersociety Energy Conversion Engineering Conference, Atlanta, GA, 8-13 Aug. 1993; sponsored by American Chemical Society
(Contract RTOP 538-01-11)
(NASA-TM-106232; E-7951; NAS 1.15:106232) Avail: CASI HC A02/MF A01

A power by wire aircraft is one in which all active functions other than propulsion are implemented electrically. Other nomenclature are 'all electric airplane,' or 'more electric airplane.' What is involved is the task of developing and certifying electrical equipment to replace existing hydraulics and pneumatics. When such functions, however, are primary flight controls which are implemented electrically, new requirements are imposed that were not anticipated by existing power system designs. Standards of particular impact are the requirements of ultra-high reliability, high peak transient bi-directional power flow, and immunity to electromagnetic interference and lightning. Not only must the electromagnetic immunity of the total system be verifiable, but box level tests and meaningful system models must be established to allow system evaluation. This paper discusses some of the problems, the system modifications involved, and early results in establishing wiring harness and interface susceptibility requirements. Author (revised)

N94-12567# Federal Aviation Administration, Oklahoma City, OK. Civil Aeromedical Inst.
SATORI: SITUATION ASSESSMENT THROUGH THE RE-CREATION OF INCIDENTS Final Report
MARK D. RODGERS and DUANE A. DUKE Jul. 1993 13 p
(DOT/FAA/AM-93/12) Avail: CASI HC A03/MF A01

A system was developed that graphically re-creates the radar data recorded at En Route air traffic control (ATC) facilities. Each facility records data sent to the displays associated with the airspace under its control on a System Analysis Report (SAR) tape. SATORI (Situation Assessment Through Re-creation of Incidents) overlays the SAR data on the appropriate sector maps using map data from the Adaptation Control Environmental System (ACES) database. The analog switch display settings of the plan view display (PVD) are not recorded; however, subroutines were written for SATORI that allow the display to be set up with the settings reported to have been used by a given controller. In addition, SATORI has the capability to display the high and low weather intensity that was displayed on a given PVD. All software routines written for SATORI use Open Systems Foundation (OSF) technology. Similar data to those available from En Route facilities are recorded at Terminal Radar Approach Control (TRACON) facilities and should allow for the development of a re-creation tool much like the one discussed. Once SATORI is developed and evaluated, it will be possible to accomplish the goals of evaluating system designs, over-the-shoulder appraisals, training outcomes, procedures, airspace design, and measuring controller performance. Not only will the capabilities and features of SATORI provide those interested in air traffic with a valuable tool for assessing the dynamics of the air traffic situation, but additionally, and more importantly, the Agency will be in a better position to bring about effective change in future ATC systems. Author (revised)

N94-12806*# Rockwell International Corp., Canoga Park, CA. Rocketdyne Div.
STS-55 PAD ABORT: ENGINE 2011 OXIDIZER PREBURNER AUGMENTED SPARK IGNITER CHECK VALVE LEAK Final Report
22 Mar. 1993 132 p
(Contract NAS8-40000)
(NASA-CR-193830; NAS 1.26:193830; RSS-8898) Avail: CASI HC A07/MF A02

The STS-55 initial launch attempt of Columbia (OV102) was terminated on KSC launch pad A March 22, 1993 at 9:51 AM E.S.T. due to violation of an ME-3 (Engine 2011) Launch Commit Criteria (LCC) limit exceedance. The event description and timeline are summarized. Propellant loading was initiated on 22 March, 1993 at 1:15 AM EST. All SSME chill parameters and launch commit criteria (LCC) were nominal. At engine start plus 1.44 seconds, a Failure Identification (FID) was posted against Engine 2011 for exceeding the 50 psia Oxidizer Preburner (OPB) purge pressure redline. The engine was shut down at 1.50 seconds followed by Engines 2034 and 2030. All shut down sequences were nominal and the mission was safely aborted. The OPB purge pressure redline violation and the abort profile/overlay for all three engines are depicted. SSME Avionics hardware and software performed nominally during the incident. A review of vehicle data table (VDT) data and controller software logic revealed no failure indications other than the single FID 013-414, OPB purge pressure redline exceeded. Software logic was executed according to requirements and there was no anomalous controller software operation. Immediately following the abort, a Rocketdyne/NASA failure investigation team was assembled. The team successfully isolated the failure cause to the oxidizer preburner augmented spark igniter purge check valve not being fully closed due to contamination. The source of the contaminant was traced to a cut segment from a rubber O-ring which was used in a fine clean tool during valve production prior to 1992. The valve was apparently contaminated during its fabrication in 1985. The valve had performed acceptably on four previous flights of the engine, and SSME flight history shows 780 combined check valve flights without failure. The failure of an Engine 3 (SSME No. 2011) check valve to close was sensed by onboard engine instruments even though all other engine operations were normal. This resulted in an engine shutdown and safe sequential shutdown of all three engines prior to ignition of the solid boosters. Derived from text

N94-12810*# Chrysler Technologies Airborne Systems, Inc., New Orleans, LA. Data Management Systems.
RESULTS OF EXPERIMENTAL INVESTIGATIONS TO DETERMINE EXTERNAL TANK PROTUBERANCE LOADS USING A 0.03-SCALE MODEL OF THE SPACE SHUTTLE LAUNCH CONFIGURATION (MODEL 47-OTS) IN THE NASA/ARC UNITARY PLAN WIND TUNNEL, VOLUME 1
S. R. HOULIHAN (Rockwell International Corp., Los Angeles, CA.) Feb. 1992 414 p
(Contract NAS9-17840)
(NASA-CR-167690; NAS 1.26:167690; DMS-DR-2476-VOL-1)
Avail: CASI HC A18/MF A04

Data were obtained on a 3-percent model of the Space Shuttle launch vehicle in the NASA/Ames Research Center 11x11-foot and 9x7-foot Unitary Plan Wind Tunnels. This test series has been identified as IA190A/B and was conducted from 7 Feb. 1980 to 19 Feb. 1980 (IA190A) and from 17 March 1980 to 19 March 1980 and from 8 May 1980 to 30 May 1980 (IA190B). The primary test objective was to obtain structural loads on the following external tank protuberances: (1) LO2 feedline, (2) GO2 pressure line, (3) LO2 antigeyser line, (4) GH2 pressure line, (5) LH2 tank cable tray, (6) LO2 tank cable tray, (7) Bipod, (8) ET/SRB cable tray, and (9) Crossbeam/Orbiter cable tray. To fulfill these objectives the following steps were taken: (1) Eight 3-component balances were used to measure forces on various sections of 1 thru 6 above. (2) 315 pressure orifices were distributed over all 9 above items. The LO2 feedline was instrumented with 96 pressure taps and was rotated to four positions to yield 384 pressure measurements. The LO2 antigeyser line was instrumented with 64 pressure taps and was rotated to two positions to yield 128 pressure measurements. (3) Three Chrysler miniature flow direction probes were mounted on a traversing mechanism on the tank upper surface centerline to obtain flow field data between the forward and aft attach structures. (4) Schlieren photographs and ultraviolet flow photographs were taken at all test conditions. Data from each of the four test phases are presented. Author

N94-12965*# Chrysler Technologies Airborne Systems, Inc., New Orleans, LA. Data Management Services.
RESULTS OF WIND TUNNEL TESTS OF AN ASRM CONFIGURED 0.03 SCALE SPACE SHUTTLE INTEGRATED VEHICLE MODEL (47-OTS) IN THE AEDC 16-FOOT TRANSONIC WIND TUNNEL, VOLUME 2
J. MARROQUIN (Rockwell International Corp., Downey, CA.) and P. LEMOINE (Rockwell International Corp., Downey, CA.) Oct. 1992 393 p Microfiche as supplement
(Contract NAS9-17840)
(NASA-CR-185697; NAS 1.26:185697; DMS-DR-2549-VOL-2)
Avail: CASI HC A17/MF A04

An experimental Aerodynamic and Aero-Acoustic loads data base was obtained at transonic Mach numbers for the Space Shuttle Launch Vehicle configured with the ASRM Solid Rocket Boosters as an increment to the current flight configuration (RSRB). These data were obtained during transonic wind tunnel tests (IA 613A) conducted in the Arnold Engineering Development Center 16-Foot transonic propulsion wind tunnel from March 27, 1991 through April 12, 1991. This test is the first of a series of two tests covering the Mach range from 0.6 to 3.5. Steady state surface static and fluctuating pressure distributions over the Orbiter, External Tank and Solid Rocket Boosters of the Shuttle Integrated Vehicle were measured. Total Orbiter forces, Wing forces and Elevon hinge moments were directly measured as well from force balances. Two configurations of Solid Rocket Boosters were tested, the Redesigned Solid Rocket Booster (RSRB) and the Advanced Solid Rocket Motor (ASRM). The effects of the position (i.e., top, bottom, top and bottom) of the Integrated Electronics Assembly (IEA) box, mounted on the SRB attach ring, were obtained on the ASRM configured model. These data were obtained with and without Solid Plume Simulators which, when used, matched as close as possible the flight derived pressures on the Orbiter and External Tank base. Data were obtained at Mach numbers ranging from 0.6 to 1.55 at a Unit Reynolds Number of 2.5 million per foot through model angles of attack from -8 to +4 degrees at sideslip angles of 0, +4 and -4 degrees. Author

N94-13191*# Chrysler Technologies Airborne Systems, Inc., New Orleans, LA. Data Management Services.
RESULTS OF WIND TUNNEL TESTS OF AN ASRM CONFIGURED 0.03 SCALE SPACE SHUTTLE INTEGRATED VEHICLE MODEL (47-OTS) IN THE AEDC 16-FOOT TRANSONIC WIND TUNNEL (IA613A), VOLUME 1
J. MARROQUIN (Rockwell International Corp., Downey, CA.) and P. LEMOINE (Rockwell International Corp., Downey, CA.) Oct. 1992 998 p
(Contract NAS9-17840)
(NASA-CR-185696; NAS 1.26:185696; DMS-DR-2549-VOL-1)
Avail: CASI HC A99/MF A10

An experimental Aerodynamic and Aero-Acoustic loads data base was obtained at transonic Mach numbers for the Space Shuttle Launch Vehicle configured with the ASRM Solid Rocket Boosters as an increment to the current flight configuration (RSRB). These data were obtained during transonic wind tunnel tests (IA 613A) conducted in the Arnold Engineering Development Center 16-Foot transonic propulsion wind tunnel from March 27, 1991 through April 12, 1991. This test is the first of a series of two tests covering the Mach range from 0.6 to 3.5. Steady state surface static and fluctuating pressure distributions over the Orbiter, External Tank and Solid Rocket Boosters of the Shuttle Integrated Vehicle were measured. Total Orbiter forces, Wing forces and Elevon hinge moments were directly measured as well from force balances. Two configurations of Solid Rocket Boosters were tested, the Redesigned Solid Rocket Booster (RSRB) and the Advanced Solid Rocket Motor (ASRM). The effects of the position (i.e. top, bottom, top and bottom) of the Integrated Electronics Assembly (IEA) box, mounted on the SRB attach ring, were obtained on the ASRM configured model. These data were obtained with and without Solid Plume Simulators which, when used, matched as close as possible the flight derived pressures on the Orbiter and External Tank base. Data were obtained at Mach numbers ranging from 0.6 to 1.55 at a Unit Reynolds Number of 2.5 million per foot through model angles of attack from -8 to +4 degrees at sideslip angles of 0, +4 and -4 degrees. Author

N94-13645# Mitsubishi Heavy Industries Ltd., Tokyo (Japan).
HOPE REAL TIME FLIGHT OPERATIONS ANALYSES FOR RETURN TO EARTH PHASE, PART A [HOPE KIKAN KANSEI FEZU NO RIARU TAIMU UNYOU NO KAISEKI]
National Space Development Agency 31 Mar. 1993 17 p In JAPANESE
(NASDA-CNT-930010-PT-A; JTN-93-80464) Avail: CASI HC A03/MF A01

The results of the HOPE (H-2 Orbiting Plane) real time flight operation analysis for return to earth phase are presented. The analyses of the flight parameter real time estimation accuracy was conducted (including definition of the estimate system operation, close examination of required function and programs, and study on the verification and experiment plans) and the following two items of the system verification and experiment are proposed: (1) utilization of the ETS-X (Engineering Test Satellite-X); and (2) utilization of mock-up landing experiment plane. The study on the limit of deviation from the flight path was conducted, and various factors to improve the flight path deviation are outlined. Author (NASDA)

N94-14277# Tokyo Univ., Sagamihara (Japan). Inst. of Space and Astronautical Science.
RESEARCH AND DEVELOPMENT OF SPACE TRANSPORTATION SYSTEMS IN ISAS
JUNJIROU ONODA *In* Science and Technology Agency, Asia-Pacific ISY Conference, Volume 2 p 356-359 31 Mar. 1993
Avail: CASI HC A01/MF A04

An overview of the research and development activities in the ISAS (the Institute of Space and Astronautical Science) focusing on the Mu-5 launch vehicle, the winged space vehicle, and the ATR (Air Turbo Ramjet) engine is presented. The design guidelines, characteristics, dimensions, and subsystems, such as rocket motor, nose fairing, and attitude control subsystem of the Mu-5 launch vehicle, one of the versions of Mu series rocket, which is capable of launching 1.8 tons of payload into LEO (Low Earth Orbit) are outlined. The research and development activities on winged space vehicle called the HIMES (Highly Maneuverable Experimental Space) Vehicle and the ATR propulsion system are outlined. Author (NASDA)

N94-15753*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT TESTING OF AIRBREATHING HYPERSONIC VEHICLES
JOHN W. HICKS Oct. 1993 37 p Presented at Space Course 1993, Munich, Germany, 11-12 Oct. 1993 Sponsored by NASA, Washington
(Contract RTOP 505-70-00)
(NASA-TM-4524; PAPER-37; H-1934; NAS 1.15:4524) Avail: CASI HC A03/MF A01

Using the scramjet engine as the prime example of a hypersonic airbreathing concept, this paper reviews the history of and addresses the need for hypersonic flight tests. It also describes how such tests can contribute to the development of airbreathing technology. Aspects of captive-carry and free-flight concepts are compared. An incremental flight envelope expansion technique for manned flight vehicles is also described. Such critical issues as required instrumentation technology and proper scaling of experimental devices are addressed. Lastly, examples of international flight test approaches, existing programs, or concepts currently under study, development, or both, are given. Author (revised)

N94-16905*# Florida Univ., Gainesville. Center for Intelligent Machines and Robotics.
DEVELOPMENT OF A PROTOTYPE KINESTATIC PLATFORM FOR APPLICATION TO SPACE AND GROUND SERVICING TASKS. PHASE 1: CONCEPT MODELING Final Report
J. DUFFY and C. CRANE Sep. 1993 53 p Original contains color illustrations
(Contract NAG10-0109)
(NASA-CR-194036; NAS 1.26:194036) Avail: CASI HC A04/MF A01; 2 functional color pages

The Center for Intelligent Machines and Robotics (CIMAR) of the University of Florida, in conjunction with Rockwell International is developing an electro-mechanical device called a Kinestatic Platform (KP) for aerospace applications. The goal of the current project is to develop a prototype KP which is capable of manipulating a 50 lb. payload. This prototype will demonstrate the feasibility of implementing a scaled up version to perform high precision manipulation of distributed systems and to control contact forces and allowable motions (rotations and translations), which is defined here as Kinestatic Control, in a six dimensional, partially constrained environment, simultaneously and independently. The objectives of the Phase 1 effort were as follows: (1) Identify specific NASA applications where the KP technology can be applied. (2) Select one application for development. (3) Develop a conceptual design of the KP specifically for the selected application. This includes the steps of developing a set of detailed performance criteria, establishing and making selection of the mechanism design parameters, and evaluating the expected system response. (4) Develop a computer graphics animation of the KP as it performs the selected application. This report will proceed by providing a technical description of the KP followed by how each of these objectives was addressed. Derived from text

N94-18760 Air Force Inst. of Tech., Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.
DYNAMIC RESPONSE ANALYSIS OF COMPOSITE STRUCTURAL MEMBERS DURING MISSILE LAUNCH
LIANZHU HE and PEILING ZHAO 14 Sep. 1993 12 p Transl. into ENGLISH from Hangkong Xuebao (Aeronautics), China, v. 13, no. 8 Aug. 1992 p 448-451 Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A270023; FASTC-ID(RS)T-0201-93) Avail: CASI HC A03

By analyzing the dynamic characteristics and the dynamic response of composite structural members of aircraft wings, the article presents the methods and steps for computational analysis, as well as further processing of the analytical results, in addition to suggestions for design improvements. It was found that improved lamina design can eliminate design weakness since local vibration phenomena were discovered in the prototype design when the dynamic characteristics of structural members were analyzed. By comparing three computational missile launch variants for outboard wing, mid-wing, and inner-wing, the values of the dynamic response in the most serious situation are given. Finally, the dynamic strength is determined. DTIC

N94-20075# Volvo Flygmotor A.B., Trollhaettan (Sweden). Space Propulsion.
TURBINE DESIGN
PER ANDERSSON *In* VKI, Spacecraft Propulsion 11 p 1993 Copyright Avail: CASI HC A03/MF A04

Turbines for most space propulsion applications, such as the hydrogen and oxygen pump turbines for the Vulcain engine, are characterized by a high pressure ratio, a highly energetic working fluid, and a small size. Data on Vulcain turbines are given. The following topics are reviewed: turbine concept design and design tools; blade design; losses occurring in a blade which are due to friction, secondary flow, tip clearance and shock formation; and turbine testing. The purpose of any turbine is to provide power for other parts of an engineering system (compressors, electrical generators, pumps) or to drive mechanical components such as wheels or propellers to give propulsion to a vehicle. It should therefore always be the performance and cost effectiveness of this larger system and not of the isolated turbine that are the main objectives for the turbine design engineer. ESA

11

CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A94-10084

WEAVING NEW STRENGTH INTO COMPOSITES

ALAN S. BROWN Aerospace America (ISSN 0740-722X) vol. 31, no. 9 Sept. 1993 p. 26-29, 35.

Copyright

New approaches to fabricating composites for the aerospace industry based on old textile methods are discussed. The new textiles run another set of fiber through the thickness of the weave to create a 3D structure. Through-thickness (z-axis) reinforcement makes it possible to boost shear and transverse tension strength. Three-dimensional reinforcements block crack growth and delamination. A new 3D composite braiding process eliminates the slow throughput and high cost of early braiding technologies. Resin transfer molding results in a towpreg, a fiber tow preimpregnated with resin. The powders act like a liquid underneath their fused surface. The approach maintains the fiber's original pliancy and facilitates weaving and braiding of towpreg. It is concluded that the powder-textile combination fundamentally changes composite economics opening new opportunities. AIAA

A94-10659

ADVANCES IN COST EFFECTIVE PROCESSING OF TITANIUM

O. E. NELSON (Oregon Metallurgical Corp., Albany) *In* Synthesis, processing, and modelling of advanced materials Aedermannsdorf, Switzerland and Brookfield, VT Trans Tech Publications 1993 p. 103-113. refs

Copyright

Near-net shape technologies aimed at improving titanium's cost effectiveness, which include investment casting, superplastic forming (SPF), powder metallurgy, and precision forging, are considered. It is concluded that casting technology has progressed further and faster than other net shape technologies. AIAA

A94-10660

POWDER METALLURGY OF ADVANCED TITANIUM ALLOYS

W. T. NACHTRAB, P. R. ROBERTS (Nuclear Metals, Inc., Concord, MA), and H. A. NEWBORN (Industrial Materials Technology, Inc., Andover, MA) *In* Synthesis, processing, and modelling of advanced materials Aedermannsdorf, Switzerland and Brookfield, VT Trans Tech Publications 1993 p. 115-139. refs

Copyright

Requirements for high-performance high-temperature materials for hypervelocity aircraft have placed emphasis on the development of new titanium and titanium aluminide alloys for both monolithic and MMC applications. Many of these alloys are difficult to produce in useful forms by conventional fabrication techniques that involve ingot metallurgy; however, P/M is an alternative approach that offers many metallurgical and processing advantages. Recent advances in the field of Ti P/M have demonstrated that high-quality titanium alloy powders can be produced in commercial quantities leading to the possibility of utilizing P/M for many of the advanced high temperature components. The processing of several representative titanium alloys and alpha 2 and gamma titanium aluminides is described and the characteristics of the powder discussed. Hot isostatic pressing can be used to produce either NNS parts or preforms for subsequent processing such as forging or rolling. The use of powder to make preforms offers advantages in terms of homogeneity and microstructural control.

Author (revised)

A94-10670

MODELLING OF THE HOT-WORKING OF HIGH PERFORMANCE ALLOYS

R. W. EVANS (Swansea Univ. College, United Kingdom) *In* Synthesis, processing, and modelling of advanced materials Aedermannsdorf, Switzerland and Brookfield, VT Trans Tech Publications 1993 p. 227-239.

Copyright

A computer model capable of predicting flow and microstructure evolution of superalloys is described. The model takes into account the mechanics of the forging machine and the kinetics of microstructure change. The model is applied to the hammer forging of a RB211-HPC2 disc in IMI834 and the model predictions are compared with the obervational results. Results show that the forging process model is capable of predicting not only the deformation patterns and energy requirements during the operation but also the final microstructures of a component. AIAA

A94-10671

THE SIMULATION OF SINGLE CRYSTAL TURBINE BLADE SOLIDIFICATION

J. L. DESBIOLLES, T. IMWINKELRIED, M. RAPPAZ (Lausanne, Ecole Polytechnique Federale, Switzerland), S. ROSSMANN (Sulzer Innotec Co., Winterthur, Switzerland), and PH. THEVOZ (Calcom, S.A., Lausanne, Switzerland) *In* Synthesis, processing, and modelling of advanced materials Aedermannsdorf, Switzerland and Brookfield, VT Trans Tech Publications 1993 p. 241-252. Research supported by Office Federal de l'Education et de la Science and Sulzer Innotec Co refs

Copyright

Single crystal turbine blades can be produced by directly casting superalloy melts over a copper chill plate in a preheated mould. This so-called SMCT process has been studied by a combined experimental-simulation approach in order to optimize the process parameters as a function of the casting geometry. Instrumented castings of various geometries, from simple straight cylinders up to complex 3-dimensional turbine blades, have been made with temperatures measured in the casting and in the copper chill. The later ones were used to calculate the heat flow at the casting- and ceramic-copper chill interfaces with a finite difference 2-dimensional inverse method. Radiation calculation, including the shadowing effect, was implemented into Finite Element codes of solidification and the temperatures calculated for these castings were compared with the measurements.

A94-10678

ENVIRONMENTAL EFFECTS IN TITANIUM ALUMINIDES ALLOYS

D. ELIEZER (Negev Univ., Beersheba, Israel) and F. H. FROES (Idaho Univ., Moscow) *In* Synthesis, processing, and modelling of advanced materials Aedermannsdorf, Switzerland and Brookfield, VT Trans Tech Publications 1993 p. 321-328. refs

Copyright

The effect of hydrogen on titanium aluminides of two types including the ordered, hexagonal close-packed Ti3Al(alpha2) and the ordered, face-centered tetragonal TiAl(gamma) is discussed to determine their applicability to NASP and generic hypersonic vehicles. It is concluded that hydrogen has an adverse effect on the mechanical properties of both alpha2-based and gamma-based alloys, with the much lower solubility in the latter alloys resulting in reduced degradation. Ti3Al takes up hydrogen much more easily than TiAl, but not as rapidly as therminal titanium alloys. The two alloys are severely degraded by hydrogen exposure at moderate temperatures, because of hydride formation which is similar to that observed in conventional titanium alloys. The Ti3Al compositions appear to be less susceptible to hydrogen embrittlement than Ti3Al. AIAA

A94-12030

AN ADVANCED ALLOY FOR LANDING GEAR AND AIRCRAFT STRUCTURAL APPLICATIONS - AERMET 100 ALLOY

PAUL M. NOVOTNY and THOMAS J. MCCAFFREY (Carpenter

Technology Corp., Reading, PA) Oct. 1992 9 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922040) Copyright

Unlike such other high-strength stells as 4340 and 300 M, which are quenched and tempered, AerMet 100 is a low-C Fe-Ni lath martensitic alloy that achieves its strength through the precipitation of Mo2C and Cr2C carbides during aging. Attention is here given to AerMet 100's microstructure, properties relative to other aerospace steels, and aging curve data. The alloy is applicable to aircraft landing gears and other high load-concentration applications; an ultimate tensile strength of 1965 MPa is achievable. AIAA

A94-12031
AERMET 100 ALLOY FOR LANDING GEAR APPLICATIONS - A SUMMARY OF FORGING STUDIES
MICHAEL L. SCHMIDT (Carpenter Technology Corp., Reading, PA) Oct. 1992 21 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922041) Copyright

Forging trials of AerMet 100 Alloy have been conducted using upset forgings reduced 0 percent, 2:1 and 3:1 and press forgings that received a 3:1 reduction in cross-sectional area. The effects of forging temperature and normalizing on ASTM grain size and mechanical properties were evaluated. The data indicate AerMet 100 Alloy has a wide hot working temperature range and that normalizing can have a beneficial effect. Production-scale forgings of AerMet 100 Alloy have been produced and the results are discussed. These forgings include the lower side strut for a B757, the upper strut for the main gear on a B747, the launch bar for the nose gear of the A 12 and the piston, shock strut for the main gear of the A 12. The results include analyses of heat composition and billet and forging capability tests, and they are compared against the requirements of AMS 6532. Author (revised)

A94-12653 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LIQUID LUBRICANTS FOR ADVANCED AIRCRAFT ENGINES
WILLIAM R. LOOMIS and ROBERT L. FUSARO (NASA, Lewis Research Center, Cleveland, OH) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 4 - Tribological materials and NDE New York American Society of Mechanical Engineers 1993 p. 31-57. Previously announced in STAR as N92-32863 refs
(Contract RTOP 505-63-5A)
Copyright

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.

A94-12655
SOLID LUBRICANTS FOR AERONAUTICS
J. K. LANCASTER (Tribology Consultants, Ltd., Marton-cum-Grafton, United Kingdom) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 4 - Tribological materials and NDE New York American Society of Mechanical Engineers 1993 p. 93-112. refs
Copyright

The various groups of materials currently, or potentially, of interest as solid lubricants in aeronautics are described, with emphasis on lamellar solids, plastics and soft metals, and carbons and graphite. Transfer from an auxiliary source, and dispersions in oils and greases are examined as well. It is argued that in many applications, self-lubricating composites are often preferred to bonded coatings because their approach to failure tends to be gradual rather than catastrophic. The high load-carrying capacity composites used for flight-control bearings almost invariably incorporate polytetrafluoroethylene and are thus limited to temperatures below about 250 C. Some higher temperature composites (to 316 C) have been developed for similar purposes, based on carbon-fiber-reinforced polyimide with added WSe2/Ga/In as a solid lubricant and (NH4)2HPO4 as an adjuvant/antioxidant. AIAA

A94-12993
DAMAGE ASSESSMENT IN MMC COMPOSITES USING THERMOELASTIC TECHNIQUES
T. E. PURCELL (Pratt & Whitney Group, West Palm Beach, FL) *In* International Congress on Experimental Mechanics, 7th, Las Vegas, NV, June 8-11, 1992, Proceedings. Vol. 2 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 1550-1557. refs
(Contract F33615-88-C-2811)
Copyright

In situ thermoelastic damage tracking techniques were evaluated on two titanium matrix composite (TMC) materials current being considered for aerospace applications. One analysis demonstrated the full field damage evaluation capabilities of the thermoelastic stress analysis (TSA) technique in an SCS-6/Ti-24-11 TMC in the smooth gage section of a unidirectional ply specimen during an LCF test to failure. The technique was also applied to an angle ply SCS-6/Beta Ti TMC on notch specimens designed to evaluate the materials sensitivity to machined holes at room temperature and 427 C. The TSA technique demonstrated an ability to monitor the damage progression in both a unidirectional ply smooth MMC specimen and an angle ply notched MMC with dispersed damage and localized damage occurring in the material. AIAA

N94-10003# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Stuttgart (Germany). Structures and Design Inst.
HIGH TEMPERATURE MATERIALS FOR HYPERSONIC TRANSPORT
R. KOCHENDOERFER *In* ESA, Advanced Materials for Lightweight Structures p 7-13 Oct. 1992
Copyright Avail: CASI HC A02/MF A04

The requirements of high temperature materials for a hypersonic transport are discussed. The challenging structural requirements of hypersonic vehicles and the available materials for these high temperature structures are discussed. The critical issues for ceramic matrix composite materials are discussed. At present there is no alternative to these materials for lightweight structures operating over 1000 C. A fast silicon infiltration process for the fabrication of ceramic matrix composite structures and the implication this has for the designer are described. ESA

N94-10011# Westland Aerostructures Ltd., East Cowes (England).
THE APPLICATION OF ADVANCED MATERIALS TO AIRCRAFT NACELLE STRUCTURES
M. J. CURRAN and N. C. EATON *In* ESA, Advanced Materials for Lightweight Structures p 57-62 Oct. 1992
Copyright Avail: CASI HC A02/MF A04

The application of fiber reinforced plastic composites in the nacelle structures designed and manufactured over the last twelve years is traced. The design, development, and manufacturing techniques which have evolved to meet the requirements of aerospace quality structural composites, are highlighted. ESA

N94-10023# Deutsche Airbus G.m.b.H., Bremen (Germany).
INVESTIGATIONS ON ALUMINIUM-LITHIUM ALLOYS FOR DAMAGE TOLERANT APPLICATION
W. ZINK, Y. BARBAUX (Aerospatiale, Suresnes, France.), A.

CAMACHO (Construcciones Aeronauticas S.A., Madrid, Spain.), H. PRICE (British Aerospace Public Ltd. Co., Bristol, England.), G. VAESSEN (Fokker B.V., Amsterdam, Netherlands.), L. TIRILLY (Pechiney Co., Paris, France.), S. SCHWANTES (Dornier System G.m.b.H., Friedrichshafen, Germany.), N. BERNICOT (Dassault Aviation, Istres, France.), S. PANTELAKIS (Patras Univ., Greece.), R. GRIMES (British Aluminum Co. Ltd., London, England.) et al. *In* ESA, Advanced Materials for Lightweight Structures p 129-134 Oct. 1992
Copyright Avail: CASI HC A02/MF A04

The Al-Li damage tolerant alloys now becoming available do not cover the whole range of properties required by the aircraft industry; for successful application on aerospace structures in the future, a full understanding of the material behavior will be necessary. Therefore a development program was initiated in 1990 by the European airframe industry and aerospace institutes with the following objectives: improving the properties of existing alloys as compared to conventional alloys; and evaluating the existing damage tolerant Al-Li alloys from a fundamental point of view, giving confidence in terms of all safety and reliability aspects for real aircraft applications. A survey of this project and some initial results are presented. ESA

N94-10767# American Technologies International, Clearwater, FL.
NEW THERMOPLASTIC LAMINATING ADHESIVES FOR THE AIRCRAFT INDUSTRY WITH LOW HEAT RELEASE AND LOW SMOKE EMISSION
SARFRAZ A. SIDDIQUI *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 13-20 Mar. 1993
Avail: CASI HC A02/MF A03

In Aeroplas '90 and Fire Safety '91, the flammability behavior of several aircraft substrates with different types of decorative laminates were discussed. We concluded that due to the substrate's own fire characteristics, aircraft decorative laminate manufacturers have substantial problems meeting current Heat Release and Smoke Emission requirements. To solve this problem, we decided to develop new thermoplastic adhesives which will help decorative laminates manufacturers meet current Federal Aviation Administration (FAA) flammability requirements on virtually all substrates. These adhesive films are tested on commercially available thermoplastic decorative laminate with a PVF surface, after bonding to crushed core substrate. All flammability tests are carried out in FAA-approved OSU Heat Release and NBS Smoke Emission Chambers. Toxicity tests are also carried out using the same NBS Smoke Chamber. The flammability test data of these new adhesives are discussed. Author (revised)

N94-10768# Gill (M. C.) Corp., El Monte, CA. Research and Development.
A NEW LOW SMOKE, LOW HEAT RELEASE STRUCTURAL FOAM
MARTIN I. COHEN and MELVIN R. KANTZ *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 21-28 Mar. 1993
Avail: CASI HC A02/MF A03

Gillfoam was developed specifically to be a structural phenolic foam capable of providing increased cabin safety during a fire in an aircraft. This product meets current Federal Airworthiness Regulations pertaining to peak and total heat release, vertical and 45 deg flammability, smoke density, and toxic gas release. The NIST smoke density (D(sub s)) for the highest density foam (20 lbs/ft(sup 3)) is less than 50 when the product is tested in the flaming mode. Foams having densities ranging between 4.0 and 20.0 lbs/ft(sup 3) are currently being evaluated for a variety of potential applications. Some of these applications include: environmental control system (ECS) ducting; cores for partitions, bulkheads, and galley panels; and for close-outs in laminated honeycomb sidewall panels. Gillfoam, as sheet stock, is also conformable in crushed core applications so it can be laminated to produce contoured profiles. When fabricated into a duct, the low smoke foam product is lighter in weight than either a multi-layer prepreg duct or an aluminum duct of comparable size. Moreover, Gillfoam ducts may require no additional thermal insulation, depending on specific applications. Development issues, performance properties, and several applications of this state-of-the-art structural foam are described. Author (revised)

N94-10769# IMITECH, Inc., Elk Grove Village, IL.
POLYIMIDE FOAM INSULATION SYSTEMS: A MAJOR WEIGHT REDUCTION AND IMPROVEMENT IN FIRE RESISTANCE OF SIDEWALL SYSTEMS
MICHAEL D. ODONNELL *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 29-35 Mar. 1993
Avail: CASI HC A02/MF A03

As a result of the 1967 Apollo fire, NASA started the Fireman Program. NASA's requirements for materials were for the lowest possible smoke, flame spread, toxicity, off-gassing, and out-gassing. The final NASA requirement was that weight should not exceed that of the existing materials. This resulted in the full development of polyimide foam. Solimide polyimide foam exceeds all of the stated requirements including weight, which is up to five times lighter in some applications than the materials it replaces. Commercial aircraft is a different situation. Today there are very limited fire requirements on insulation materials, or any material outside those requiring the O.S.U. Heat Release and Furnace Burners. However, there are several potential changes in requirements that would effect insulation in the future: (1) expansion of the fire test requirements such as O.S.U. Heat Release, Smoke Generation, etc. to include all non-metallic materials, structures, and systems from the skin in-board throughout the entire interior; and (2) burn-through requirements as discussed by the CAA and their proposed test and fire hardening of aircraft being developed by Darchem Engineering, Ltd. Additional testing or improved fire hardening has usually been considered as costly and unnecessary relative to benefits derived. Author (revised)

N94-10775# Fokker B.V., Amsterdam (Netherlands). Design and Integration Dept.
APPLICATIONS OF CONTINUOUS FIBER REINFORCED THERMOPLASTICS IN AIRCRAFT INTERIORS
ROBERT G. DIEHL *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 93-104 Mar. 1993
Avail: CASI HC A03/MF A03

As part of a technology development program, actual aircraft interior parts were manufactured from polyetherimide (PEI) resin reinforced with woven glass fiber in the form of composite solid laminates and sandwich materials. These parts are evaluated against an aircraft manufacturer's design criteria, highlighting critical areas. The status of a number of the parts is given - technology proving, flying prototype part, serial production, etc. The materials have good fire safety properties, some unexpected mechanical properties, and an above average contribution to parts cost. The state of the art is such that the present interior applications for this material are restricted to areas with highly specific requirements. Further development to improve some mechanical properties and process control could quickly open up the field because of substantial savings in manufacturing costs. Author (revised)

N94-10776# SP Systems, Los Angeles, CA.
ADVANCED PHENOLIC SYSTEMS FOR AIRCRAFT INTERIORS
HERMAN GUPTA and MICKEY MCCABE *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 105-119 Mar. 1993
Avail: CASI HC A03/MF A03

Recent advances in the phenolic prepreg systems suitable for aircraft interior's applications are described. The current state of the art phenolic systems achieve a balance of properties and comfortably meet heat release and smoke emission requirements of various regulatory agencies such as FAR 25.853 and ATS 1000.001. A recent commercially available phenol formaldehyde resin based prepreg product SPH 2400 is reviewed. A single ply

SPH 2400 sandwich laminates fabricated from Nomex honeycomb core and 7781 style fiberglass show Ohio State University (OSU) test peak heat release characteristics as low as 18 KW/M(sup 2) and an average OSU heat release of 15 KW-Min/M(sup 2) over a period of two minutes. The optical density of smoke emission measured by NBS method in naming mode was found to be only 6 when measured over four minutes. The product SPH 2400 can be processed by using a variety of techniques such as vacuum bag molding, multiple opening press (MOP) molding, and crushed core (CC) press molding. The prepreg system possesses outstanding self adhesive characteristics to a variety of core substrate and does not require an additional adhesive layer for core bonding. A proprietary latent catalysis technology enables rapid cures at temperature as low as 132 C (270 F) while maintaining excellent out time at room temperature.
Author (revised)

N94-10777# Furane Plastics, Inc., Los Angeles, CA. Aerospace Product Group.
URALANE (TM) 5774-A/B: CIBA-GEIGY'S ADVANCED URETHANE ADHESIVE FOR THE AIRCRAFT INDUSTRY
EDWIN C. CLARK and JOSE SALAZAR *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 121-135 Mar. 1993
Avail: CASI HC A03/MF A03

In the aircraft industry, several trends in the fabrication of aircraft interiors have been observed in recent years. One development has been the application of new, flame resistant thermoplastics (i.e. Declar-T, Ultem, Kydex, Europlex, Radel, etc.) to the construction of aircraft interiors. Use of these advanced materials by aircraft manufacturers has created an accompanying need for new adhesives that can effectively bond the tough-to-join thermoplastics and also provide the required flame, smoke, and toxicity (FST) performance. In addition to these materials trends, is a heightened industry awareness of worker safety and the importance of minimizing worker exposure to chemicals. In response to industry demands generated by the above-mentioned factors, CIBA-GEIGY Corporation's Furane Aerospace Product Group initiated a new product development effort several years ago. The program was aimed at formulating an effective thermoplastic bonding adhesive that could be supplied in an environmentally improved package. The result was the creation of Uralane 5774-A/B urethane adhesive. Uralane 5774-A/B is a two-component urethane adhesive designed to bond the advanced thermoplastics used in fabricating aircraft interior components. The adhesive complies with the FST requirements of FAR 25.853 a. And, it is formulated with a 2 to 1 mix ratio by volume, permitting packaging in Accumix dual barrel cartridge kits. The kits are designed to accurately store, mix, and dispense Uralane 5774-A/B without the need for direct worker exposure to the adhesive. An additional safety benefit of Uralane 5774-A/B is that it can be applied to unabraded substrates and requires only minimal surface preparation, thereby reducing worker exposure to dust and harsh solvents. Several major airframe manufacturers, aircraft interior fabricators, and airlines have now specified this new adhesive for use in their shops. It is the intent to highlight the features and benefits of Uralane 5774-A/B as they apply to the aircraft industry.
Author (revised)

N94-10778# Tomark Industries, Inc., Wilmington, DE.
THE FIRE PROPERTIES OF INSULATION BAGS, AS INSTALLED AND AFTER AIRCRAFT OPERATIONS
ROBERT F. DAVIS *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 137-143 Mar. 1993
Avail: CASI HC A02/MF A03

Polymeric films and insulation bag materials made from these films were exposed to hydrolysis conditions and subjected to the 12 second Vertical Bunsen Burner Test. Despite a major weakening in mechanical strength of the polyester film samples, all the samples passed the test by shrinking away from the flame, immediately. Only by testing the samples in multiple layers were slight differences observed. Instead of developing a suitable accelerated aging program, it is recommended that the industry test used insulation bags when they are replaced during maintenance schedules, because the instability of polyester based materials may still be of concern.
Author

N94-10779# National Inst. of Standards and Technology, Gaithersburg, MD. Building and Fire Research Lab.
COMPUTER-AIDED MOLECULAR DESIGN OF FIRE RESISTANT AIRCRAFT MATERIALS
MARC R. NYDEN and JAMES E. BROWN *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 147-158 Mar. 1993
Avail: CASI HC A03/MF A03

Molecular dynamic simulations and Cone Calorimeter measurements were used to assess the effects of electron beam irradiation and heat treatments on the flammability of the honeycomb composites used in the sidewalls, ceilings, and stowage bins of commercial aircraft. The irradiation of this material did not result in any measureable changes. A dramatic reduction in the peak rate of heat release, however, was observed in samples that had been heated overnight at 250 C.
Author (revised)

N94-10783# Maryland Univ., College Park. Dept. of Fire Protection Engineering.
APPLICATIONS OF A MODEL TO PREDICT FLAME SPREAD OVER INTERIOR FINISH MATERIALS IN A COMPARTMENT
JAMES G. QUINTIERE, GERALD HAYNES, and BRIAN T. RHODES *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 207-224 Mar. 1993
Avail: CASI HC A03/MF A03

Results from a mathematical model are investigated for fire growth on wall and ceiling combustible interior finish material in a compartment. A corner fire ignition source is maintained for 10 minutes at 100 kW and subsequently increased to 300 kW. For this scenario experimental results are available from the EURIFIC program, and are compared to the model. The time for the total rate of energy release rate to reach 1 MW is examined. In addition to the 11 EURIFIC materials, eight other materials are examined in this scenario by using the model. These materials represent the type of materials formerly and currently used as cabin interior finish materials in commercial aircraft. The model yields good results in most cases: in other cases, the model can be made to yield better agreement with the experimental results by making small changes in the property data. These changes are within the range of uncertainty of the property data.
Author

N94-10784# National Research Council of Canada, Ottawa (Ontario). National Fire Lab.
THE OSU HEAT RELEASE RATE TEST USING THE OXYGEN CONSUMPTION PRINCIPLE
YOSHIO TSUCHIYA *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 225-232 Mar. 1993
Avail: CASI HC A02/MF A03

The FAA Heat Release Rate (HRR) Test using the Ohio State University (OSU) apparatus can be improved by adopting the oxygen consumption principle. Using the present thermal method, the large heat input from the electrically-heated source of the radiative heat flux causes high baseline values in the output signals. The baseline value is easily and significantly changed by the thermal history of the apparatus and thermal disturbances. The heat absorbed by the apparatus and heat lost to the surroundings also cause errors. By using the oxygen consumption principle, these thermal errors can be eliminated. In Canada, a standard test method for measuring the HRR of low heat-releasing materials was developed. The method uses the OSU apparatus with the oxygen consumption principle. This method is useful for testing the heat release rate of airplane cabin materials. Only the addition of an oxygen analyzer is required for the present OSU apparatus and, thus, costs are minimized.
Author

N94-10785# Benjamin/Clarke Associates, Inc., Kensington, MD.
PRACTICAL HAZARD ASSESSMENT: AN APPROACH TO THE FIRE SAFETY
FREDERIC B. CLARKE and JAMES R. HOOVER (Du Pont de Nemours, E. I. and Co., Wilmington, DE.) *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 233-244 Mar. 1993
Avail: CASI HC A03/MF A03

Fire hazard assessment, although a powerful technique, is usually complex and elaborate. A simplified approach for practical use is presented, which relies on simple, closed-form relationships to allow potential regulators and product designers to estimate the effects which material product fire and smoke properties would have on the developing fire hazard in aircraft interiors. The four steps in the process, scenario analysis, setting objectives, formulating a fire protection strategy, and test method selection and criteria setting are described and an illustrative example aircraft wire and cable is briefly discussed. (Most criteria involve more than one fire/smoke property, so that considerable flexibility in meeting the criteria is allowed.) Author (revised)

N94-10786# Georgia-Pacific Corp., Decatur, GA. Research and Development Lab.
FIRE RESISTANCE AND MECHANICAL PROPERTIES FOR PHENOLIC PREPREGS
SHAHID P. QURESHI *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 245-253 Mar. 1993
Avail: CASI HC A02/MF A03

Fire resistance performance, thermal analysis, and mechanical properties of glass fiber laminates prepared with four thermal cure phenol/formaldehyde resins are discussed. Prepregs for the laminates were produced by conventional solution process. This study was performed to optimize fire resistance (FR), and thermal and mechanical properties by changing formaldehyde/phenol (F/P) mole ratio. An optimum F/P ratio was identified for maximum fire resistance and thermal properties without any sacrifice in mechanical properties. The resins evaluated easily met Federal Aviation Administration (FAA) requirements for OSU heat release and NBS smoke tests. Also, all laminates exceeded the mechanical limits of MIL-R-9299C specifications. The resins are suitable for prepregs and honeycomb for aircraft interior applications.
Author (revised)

N94-10787# National Inst. of Standards and Technology, Gaithersburg, MD. Building and Fire Research Lab.
DEVELOPMENTS NEEDED TO EXPAND THE ROLE OF FIRE MODELING IN MATERIAL FIRE HAZARD ASSESSMENT
ANDREW J. FOWELL *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 255-262 Mar. 1993
Avail: CASI HC A02/MF A03

To assess the fire hazards associated with aircraft interior materials, prediction of how the materials perform under different fire scenarios is needed. This requires information on a variety of fire characteristics including thermal inertia, ease of ignition, rate of heat release, flame spread, products of combustion, and the response to suppressants. Exposure conditions such as location, orientation, ventilation, and proximity to other materials can influence some of those characteristics. Pass/fail test methods of the past cannot provide the information to assure fire safety under a variety of circumstances. Fire modeling in combination with new bench scale material flammability test methods can meet the need. National and international developments in model validation, documentation, and acceptance are presented. The transition to aircraft cabin fire hazard assessment using fire models requires a data base on material fire properties. The case is made for greater use of improved bench scale test methods which can provide data suitable for use in the fire models. Author (revised)

N94-10790# Federal Aviation Administration, Atlanta, GA. Materials Fire Safety.
AIRCRAFT MATERIAL FIRE TESTING AND THE CREATION OF AN INTERNATIONAL WORKING GROUP
RICHARD G. HILL *In its* Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 297-300 Mar. 1993
Avail: CASI HC A01/MF A03

The Fire Safety Branch at the Technical Center in Atlantic City, New Jersey is The Federal Aviation Administration's (FAA) Research and Development (R&D) organization responsible for providing data to the regulatory organizations within the FAA for their use in developing, modifying, and/or interpreting rules and regulations pertaining to aircraft fire safety. In carrying out that responsibility, the Fire Safety Branch has developed a number of new or modified fire test methods for aircraft interior materials that were adopted as requirements by not only the FAA, but also the Joint Airworthiness Authority (JAA) and other regulatory airworthiness authorities around the world. As a result, the Fire Safety Branch has a responsibility to the world aviation community when questions or problems arise pertaining to those test methods. The Fire Safety Branch is a leader in aircraft fire safety R&D and is committed to improving aviation safety worldwide through international cooperation. Author

N94-10792# *Boeing Commercial Airplane Co., Seattle,* WA.
FUTURE MATERIAL DEVELOPMENT TRENDS FOR COMMERCIAL AIRPLANE INTERIORS
PETER S. GUARD and JAMES M. PETERSON *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 313-319 Mar. 1993
Avail: CASI HC A02/MF A03

Advances in airplane interiors in the past have, for the most part, been made by airplane manufacturers primarily through initiatives to improve safety, but also to update appearance and functionality. Recently, regulation has played a very large role in the design of airplane interiors. The Federal Aviation Administration (FAA) heat release rule was a major challenge to designers and materials suppliers, and required the development and incorporation of new materials on a very tight schedule. Industry was able to meet the rule, but the result was non-optimum solutions. It is suggested that all affected parties - regulatory and industry - work together in advance of regulation to continuously improve cabin furnishings. Strategic research and development programs involving all parties should be established, using an integrated material, design, and manufacturing philosophy. We have looked at how we can operate in a 'continuous improvement mode', and will share with how we are trying to incorporate this.
Author (revised)

N94-10794# Deutsche Airbus G.m.b.H., Bremen (Germany).
FUTURE NEEDS IN THE DEVELOPMENT OF MATERIALS FOR AIRCRAFT INTERIORS AND EQUIPMENT
HANS-DIETER BERG *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 333-337 Mar. 1993
Avail: CASI HC A01/MF A03

The presentation starts with information on the state of the art of the materials for interior furnishings and equipment of the current Airbus Program. The second part deals with the intentions of Deutsche Aerospace Airbus with regard to further development of materials for interior furnishings and equipment. A very important criterion for interior materials development is the improvement of fire safety. In addition, aspects like human toxicity, environmental protection, repairability, costs and weight are important criteria for future new materials. Author (revised)

N94-10796# Federal Aviation Administration, Atlanta, GA.
ADVANCED AIRCRAFT MATERIALS RESEARCH AND DEVELOPMENT PLAN
RICHARD LYON and THOR EKLUND *In its* Proceedings of the

International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 345-364 Mar. 1993
Avail: CASI HC A03/MF A03

The DOT/FAA Long-Range Fire Safety Research Plan is outlined and a preliminary strategy for developing advanced, fire-resistant, aircraft materials as an integral component of the program is discussed. Long-range research thrusts are also proposed in fire modeling, aircraft vulnerability analysis, improved systems, advanced suppression, and fuel safety. The research plan anticipates fire safety needs for next-generation aircraft and attempts to identify emerging materials and systems technologies where a focused, sustained research effort could lead to order-of-magnitude improvements in air transportation fire safety over the next two decades. The FAA's role in the proposed framework is to initiate and maintain a balanced program of basic university research, private-sector advanced development, and in house applied research to facilitate technology insertion. The FAA Fire Safety Research Plan describes programmatic opportunities for the public from the increased research funding sought by the FAA for this activity. Leveraging of research dollars will be accomplished through collaboration and cost-sharing with government agencies having similar fire safety requirements. Technology transfer will occur through FAA-sponsored meetings, scientific publications, industrial liaisons, and student internships at the FAA Technical Center. It is expected that fire safety needs of the construction, manufacturing, and chemical process industries will provide opportunities for the utilization of advanced fire safety technology beyond commercial aviation. Author (revised)

N94-11106# Oak Ridge National Lab., TN.
LOW-EXPANSION CERAMICS INITIATIVE
D. P. STINTON and D. W. RICHERSON 1992 5 p Presented at the Annual Automotive Development Technology Contractors' Coordination Meeting, Dearborn, MI, 2-5 Nov. 1992
(Contract DE-AC05-84OR-21400)
(DE93-011860; CONF-9211101-9) Avail: CASI HC A01/MF A01

The U.S. Department of Energy and the Ceramic Technology Project support research into low-thermal-expansion ceramics for application in advanced diesel and turbine engines. New activities are being initiated to accelerate the development of these materials. The strength of this program includes the integration of efforts of engine companies, ceramic manufacturers, and universities. This paper briefly describes the application of the low-expansion sodium-zirconium-phosphate (NZP) class of materials in engines and summarizes a 2-year program plan for this area. DOE

N94-11107 Materials Research Labs., Ascot Vale (Australia).
THERMAL STABILITY OF SEALANTS FOR MILITARY AIRCRAFT: MODIFICATION OF POLYSULFIDE PREPOLYMERS WITH ETHER AND THIOETHER MONOMERS
P. J. HANHELA and W. MAZUREK Feb. 1993 25 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A264079; MRL-TR-92-2; DODA-AR-006-864) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The effect of modifying Thiokol polysulfide prepolymers with dimercapto diethyl ether and dimercapto diethyl sulfide on the resistance to heat aging has been examined together with a commercially modified (PR-1770 B-2) and an unmodified equivalent sealant (PR-1750 13-2). Mechanical test performed on specimens, after heat aging at 182 C, indicated that the modifications did not improve the best resistance of polysulfide sealants. DTIC

N94-11146# Illinois Univ., Urbana-Champaign.
ACCELERATED SCREENING METHODS FOR PREDICTING LUBRICANT PERFORMANCE IN REFRIGERANT COMPRESSORS
C. CUSANO Mar. 1993 11 p Prepared in cooperation with Air-Conditioning and Refrigeration Technology Inst., Inc., Arlington
(Contract DE-FG02-91CE-23810)
(DE93-014773; DOE/CE-23810/11C) Avail: CASI HC A03/MF A01

As the result of a thorough literature search and consultation with manufacturers of compressors, a specimen testing program is proposed to simulate specific contacts in components of compressors. Specimen testing will be conducted using a high pressure tribometer. Specific components to be simulated, with their approximate operating and environmental conditions, are identified. A list of references, related to compressors lubrication, friction and wear, is given in the Appendix. DOE

N94-11311 Aeronautical Research Labs., Melbourne (Australia).
FIELD EVALUATION OF SIX PROTECTIVE COATINGS APPLIED TO T-56 TURBINE BLADES AFTER 2500 HOURS OF ENGINE USE
S. G. RUSSO Apr. 1993 25 p Original contains color illustrations
(ARL-TR-27; AR-008-336; AD-A267177) Copyright Avail: Issuing Activity

An assessment of the performance of six different aluminide coatings applied to Allison T-56 high-pressure turbine blades after 2500 hours of engine operation is outlined. The results confirm the superior resistance of the precious metal (platinum and platinum/rhodium) modified aluminide coatings to high temperature oxidation and hot-corrosion, as previously indicated by the earlier progressive evaluations at 500, 1500 and 2000 hour intervals. Special attention was given to the use of qualitative analysis using energy dispersive x ray spectroscopy. This technique identified substantial residue quantities of precious metal (Pt and Pt/Rh) in their respective aluminide coated surfaces. The results show that the precious-metal modified aluminides are capable of affording protection to the T-56 substrate superalloy designated IN-738LC up to, and hopefully beyond, the desired 3000 hour interval. Author (revised)

N94-11317# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
SMART STRUCTURES FOR AIRCRAFT AND SPACECRAFT [LES STRUCTURES INTELLIGENTES POUR LES AERONEFS ET LES VAISSEAUX SPATIAUX]
Apr. 1993 387 p The 75th meeting was held in Lindau, Germany, 5-7 Oct. 1992
(AGARD-CP-531; ISBN-92-835-0701-X) Copyright Avail: CASI HC A17/MF A04

An overview of the state-of-the-art of 'Smart Structures' technology as well as detailed descriptions of specific applications is presented. This technology offers extremely attractive advantages in the design, development, and operation of aerospace structures.

N94-11326# Aastra Aerospace, Inc., Downsview (Ontario).
SMART STRUCTURES AT AASTRA CORPORATION
D. R. UFFEN, H. SCHOLAERT, and G. SCHMID *In* AGARD, Smart Structures for Aircraft and Spacecraft 8 p Apr. 1993 Sponsored in part by Canadian Space Agency and Defence Research Establishment
Copyright Avail: CASI HC A02/MF A04

Aastra Advanced Ceramics is a major manufacturer of piezoelectric ceramic materials. Aastra Aerospace is involved in the development of smart structures technology based on these materials. Piezoelectric ceramics as actuators offer high mechanical stiffness, large output stress, and good linearity. As strain sensors, piezoceramics offer very high sensitivity. Initial research into the use of externally-bonded or embedded piezoceramic strain sensors and actuators has lead to the development of in-line sensor-actuator systems for use in truss-type smart structures. The target applications for these units are large flexible space structures, but the technology is applicable to earth-based truss structures as well. Similarly, Aastra is investigating the use of piezoelectric materials for the active damping of aircraft structures, with the goal of reducing structure-borne cabin noise with minimum additional weight. The development of Aastra's piezoceramic research activities and an overview of present work in the field of smart structures is presented. Author (revised)

N94-11337# Canadian Marconi Co. Ltd., Montreal (Quebec).
FIBER-OPTIC SENSOR SYSTEMS FOR MEASURING STRAIN AND THE DETECTION OF ACOUSTIC EMISSIONS IN SMART STRUCTURES
F. A. BLAHA and S. L. MCBRIDE (Acoustic Emission Monitoring Services, Inc., Montreal, Quebec.) *In* AGARD, Smart Structures for Aircraft and Spacecraft 11 p Apr. 1993 Sponsored in part by Dept. of Defence and Canadair Ltd.
Copyright Avail: CASI HC A03/MF A04

The requirements of a fiber-optic strain sensor system for aircraft smart structures are outlined, and an experimental system developed by Canadian Marconi Company for this application is reported. Fiber-optic strain sensors were mounted on an aircraft undergoing full-scale durability and damage tolerance tests, the results of which are presented. Tests were also carried out to verify the response of fiber-optic sensors to acoustic impulse signals. Input signals, similar to the ones encountered in damaged materials under stress, were used to evaluate the response of the sensor to bulk, surface, and plate waves. This was done in order to assess the performance of fiber-optic sensors employed in the acoustic detection of damage in materials. Author (revised)

N94-11343# Wright Lab., Wright-Patterson AFB, OH. Structures Div.
AIRCRAFT SMART STRUCTURES RESEARCH IN THE USAF WRIGHT LABORATORY
GREGORY S. AGNES and KEVIN SILVA *In* AGARD, Smart Structures for Aircraft and Spacecraft 9 p Apr. 1993
Copyright Avail: CASI HC A02/MF A04

For several years, the Air Force Wright Laboratory has been investigating smart structures technologies. Smart structures incorporate active materials into structural components. Active materials either sense their environment or change in response to an external stimulus or both, and also should be able to carry loads. A smart structure is thus capable of sensing and/or reacting to its environment. Smart structures research at Wright Laboratory has mainly concentrated on aircraft sensory structures and multi-functional structures, such as integrated antennae (i.e., smart skins). Several major programs were initiated to apply and demonstrate these technologies. Recently, the ability of active materials (piezoceramics, for example) to control aircraft structures for improved performance and longevity, has received attention as well. The smart structures technologies are categorized as sensory, active, or multi-functional. The current state of the art for each area and programs aimed at exploiting smart technologies for aircraft applications are described. Gaps in the current technology are identified. Author (revised)

N94-11366# Sandia National Labs., Albuquerque, NM.
ADVANCED DIAGNOSTICS FOR IN SITU MEASUREMENT OF PARTICLE FORMATION AND DEPOSITION IN THERMALLY STRESSED JET FUELS
T. J. OHERN, W. M. TROTT, S. J. MARTIN, and E. A. KLAVETTER 1993 12 p Presented at the 31st AIAA Aerospace Sciences Meeting, Reno, NV, 11-14 Jan. 1993 Previously announced in IAA as A93-23045
(Contract DE-AC04-76DP-00789)
(DE93-009798; SAND-92-1168C; CONF-930108-6; AIAA PAPER 93-0363) Avail: CASI HC A03/MF A01

Two techniques have been developed and applied for in situ monitoring of the processes involved in thermal degradation and solids deposition when several different aviation fuels are thermally stressed. Photon correlation spectroscopy is a dynamic light scattering technique that has proven to be a valuable tool for both real-time and post-test analysis of thermally stressed jet fuels. In situ measurements of post-stressed fuels have shown that significant particle formation can occur at temperatures as low as 120 C, and that relatively large particles (greater than 200 nm mean hydrodynamic diameter) are formed at temperatures less than 200 C. Particle size tends to increase with increasing stress temperature over the range 125-180 C, with substantial changes in the mean particle size occurring over ranges of only 10-20 C. Real-time measurements indicate that the mean particle diameter increases with increased exposure time at fixed temperature. An induction time is also evident in the real-time data, as an increasingly shorter exposure time is needed for particles to form in detectable size and concentration as the stress temperature is increased. The particle diameters measured post-test, when the fuel has cooled to room temperature, are larger than those measured at elevated temperatures, demonstrating the need for real-time measurements. A complementary experimental system using a quartz crystal microbalance has proven valuable for in situ determination of mass deposition rates during thermal stress tests. These data can be used to determine such kinetic factors as the global activation energies for the tested fuels and for quantitative evaluation of fuel thermal stability. DOE

N94-12275# Advanced Fuel Research, Inc., East Hartford, CT.
A NOVEL TEST METHOD FOR FUEL THERMAL STABILITY Final Report, 13 Apr. 1992 - 13 Jan. 1993
MICHAEL A. SERIO, DAVID S. PINES, ERIK KROO, KIM S. KNIGHT, and PETER R. SOLOMON Feb. 1993 84 p
(Contract F33615-92-C-2213)
(AD-A265853; AFR-526021; WL-TR-93-2032) Avail: CASI HC A05/MF A01

The object of this work was to demonstrate that an FT-IR fiber optic probe and a quartz crystal microbalance (QCM) probe could be used to measure deposit formation from thermal stressing of jet fuels in a high-temperature, high pressure flow system. These probes were designed, constructed, and tested in an existing Fuel Stability Test System (FSTS) which had an FT-IR Attenuated Total Reflectance (ATR) circle cell monitoring the stressed fuel after cooling to ambient temperature. Shell Jet A and Sun Jet A-1 fuel were tested. It was demonstrated that both the FT-IR fiber optic probe and the QCM probe could successfully differentiate between a 'stable' and an 'unstable' fuel. The results from the QCM probe tests indicate that the drop in frequency for this particular probe results from viscosity dampening and not the mass of the film. The changes in the bulk fuel composition from thermal stressing were measured with the ATR circle cell and were found to be significantly different from the changes in the deposit layer composition measured by the fiber-optic probe. DTIC

N94-12282# Pennsylvania State Univ., University Park. Dept. of Materials Science and Engineering.
ADVANCED THERMALLY STABLE COAL-DERIVED JET FUELS: COMPOSITIONAL FACTORS AFFECTING THERMAL DEGRADATION OF JET FUELS Annual Report, 1 Aug. 1991 - 31 Jul. 1992
C. SONG, S. ESER, H. H. SCHOBERT, P. G. HATCHER, and M. M. COLEMAN Dec. 1992 177 p
(Contract MIPR-FY1455-91N-0638; AF PROJ. 3048)
(AD-A265842; WL-TR-93-2007) Avail: CASI HC A09/MF A02

This project focuses on the compositional factors affecting the high temperature thermal stability of coal-derived and petroleum-based jet fuels in the pyrolytic regime. Thermal stability refers to the resistance of fuel to chemical decomposition at high temperatures to cause the solid deposition and liquid depletion. There are four broad objectives in this project, and the research work is divided into four tasks. The first task clarifies the chemistry of fuel degradation and mechanisms of solid formation, identifies thermally stable classes of hydrocarbon compounds, and provides information for enhancing intrinsic stability of jet fuels. The second task involves characterization of the solids including deposits, sediments, and gums produced from fuels and model compounds at high temperatures. The third task is to explore the means to enhance the thermal stability of fuels by examining the effects of various additives. The fourth task is a newly initiated exploratory study on conversion of coals to thermally stable jet fuels. DTIC

N94-12403# California Univ., San Diego, La Jolla.
THEORIES OF TURBULENT COMBUSTION IN HIGH SPEED FLOWS Annual Report, Apr. 1992 - Apr. 1993
P. A. LIBBY and F. A. WILLIAMS 9 Apr. 1993 7 p

(Contract F49620-92-J-0184)
(AD-A265735; AFOSR-93-0382TR) Avail: CASI HC A02/MF A01

This research involves theoretical studies of the chemical and fluid mechanical phenomena which make turbulent combustion in high-speed flows different from such combustion in low-speed flows. Finite-rate chemistry plays a significant role in high-speed flows because of the small ratios of flow times to chemical times. The study addresses ignition and extinction phenomena in the nonpremixed turbulent combustion of hydrogen-air systems by both numerical and asymptotic methods. Attention also is paid to the effects of compressibility in high-speed turbulent combustion, with consideration given to interdispersal configurations of shocklets and flamelets. Efforts are made to provide a firmer foundation for the modeling of high-speed turbulent reacting flows, to aid in the development of a formulation which gives results that can be compared with experiments, and on turbulent combustion. DTIC

N94-12993# Aluminum Co. of America, Alcoa Center, PA.

ROLE OF MICROSTRUCTURE ON FATIGUE DURABILITY OF ALUMINUM AIRCRAFT ALLOYS

J. R. BROCKENBROUGH, R. J. BUCCI, A. J. HINKLE, J. LIU, and P. E. MAGNUSEN 15 Apr. 1993 131 p
(Contract F33615-92-C-5915)
(AD-A265627) Avail: CASI HC A07/MF A02

The goal of this program is to affect change in metallic aircraft life assessment methodology through quantitative understanding of how material microstructure impacts fatigue durability performance. Various studies have shown that most metal cracking problems encountered in service involve fatigue. Further studies have shown that metallurgical discontinuities and/or manufacturing imperfections often tend to exacerbate such problems by causing cracks to occur sooner than expected. This program concentrates on the initiation and early growth stage of fatigue cracks where the majority of structural life is spent. The program has two general objectives: (1) quantifying the effect of aluminum alloy microstructure on early stage fatigue damage evolution and growth, and (2) establishing an analytical framework to quantify structural component life benefits attainable through modification of intrinsic material microstructure. The modeling approach taken couples quantitative characterizations of representative material microstructures with concepts of probabilistic fracture mechanics. DTIC

N94-13089*# Yale Univ., New Haven, CT. High Temperature Chemical Reaction Engineering Lab.

RESEARCH ON CHEMICAL VAPOR DEPOSITION PROCESSES FOR ADVANCED CERAMIC COATINGS Final Technical Report, 1 Mar. 1988 - 1 Nov. 1992

DANIEL E. ROSNER Jan. 1993 24 p
(Contract NAG3-884)
(NASA-CR-193613; NAS 1.26:193613) Avail: CASI HC A03/MF A01

Our interdisciplinary background and fundamentally-oriented studies of the laws governing multi-component chemical vapor deposition (VD), particle deposition (PD), and their interactions, put the Yale University HTCRE Laboratory in a unique position to significantly advance the 'state-of-the-art' of chemical vapor deposition (CVD) R&D. With NASA-Lewis RC financial support, we initiated a program in March of 1988 that has led to the advances described in this report (Section 2) in predicting chemical vapor transport in high temperature systems relevant to the fabrication of refractory ceramic coatings for turbine engine components. This Final Report covers our principal results and activities for the total NASA grant of $190,000. over the 4.67 year period: 1 March 1988-1 November 1992. Since our methods and the technical details are contained in the publications listed (9 Abstracts are given as Appendices) our emphasis here is on broad conclusions/implications and administrative data, including personnel, talks, interactions with industry, and some known applications of our work. Author (revised)

N94-13138*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

NDE OF TITANIUM ALLOY MMC RINGS FOR GAS TURBINE ENGINES

GEORGE Y. BAAKLINI, LARRY D. PERCIVAL (Pratt and Whitney Aircraft, West Palm Beach, FL.), ROBERT N. YANCEY (Advanced Research and Applications Corp., Dayton, OH.), and HAROLD E. KAUTZ Sep. 1993 14 p Proposed for presentation at the Tenth Biennial Conference on Reliability Stress Analysis and Failure Prevention, Albuquerque, NM, 19-22 Sep. 1993; sponsored by ASME
(Contract RTOP 510-01-50)
(NASA-TM-106188; E-7892; NAS 1.15:106188) Avail: CASI HC A03/MF A01

Progress in the processing and fabrication of metal matrix composites (MMC's) requires appropriate mechanical and nondestructive testing methods. These methods are needed to characterize properties, assess integrity, and predict the life of engine components such as compressor rotors, blades, and vanes. Capabilities and limitations of several state-of-the-art nondestructive evaluation (NDE) technologies are investigated for characterizing titanium MMC rings for gas turbine engines. The use of NDE technologies such as x-ray computed tomography, radiography, and ultrasonics in identifying fabrication-related problems that caused defects in components is examined. Acousto-ultrasonics was explored to assess degradation of material mechanical properties by using stress wave factor and ultrasonic velocity measurements before and after the burst testing of the rings. Author (revised)

N94-13267*# Bell Helicopter Co., Fort Worth, TX.

FLIGHT SERVICE EVALUATION OF COMPOSITE COMPONENTS ON THE BELL HELICOPTER MODEL 206L Final Report

HENRY WILSON 1 Sep. 1993 129 p
(Contract NAS1-15279; RTOP 536-06-37-03)
(NASA-CR-191499; NAS 1.26:191499; REPT-699-099-359)
Avail: CASI HC A07/MF A02

This is the final report on the advanced composite components which were placed in service on the 206L LongRanger helicopters in the continental United States, Canada, and Alaska. This report covers all test data which was gathered, as well as maintenance histories of the parts. The previous reports describe the fabrication, service experiences, and test data through 1986. This report contains information from these references, as well as data gathered after 1986. The status of the 40 sets of components is discussed. Each set consisted of a vertical fin, forward fairing, litter door, and baggage door. Almost 500,000 flight hours were accumulated on the 160 parts, with the high-time part accumulating 14,687 flight hours. Over 60 percent of the parts were destructively tested to measure strength and stiffness retention over the course of the program. The vertical fins had the greatest strength retention followed by the litter doors. The baggage doors had the poorest retention of strength. There was very little difference in property retention between the four primary operating regions: Northwest U.S., Southwest U.S., Gulf of Mexico Coastal Region, and the Northeast U.S. and Eastern Canada Region. The field problems have ranged from two lightning-struck fins to significant delaminations in the baggage doors. There was only one environmentally related field incident, in which the glass windows on the litter doors were found to loosen due to high temperatures experienced in the southwest region. Author (revised)

N94-13458# National Aerospace Lab., Kakuda (Japan). Research Center.

CHEMICAL REACTIONS IN SCRAMJET ENGINES: REDUCED KINETIC MODELS FOR IGNITION, COMBUSTION AND NOZZLE FLOW [SUKURAMU JETTO NIOKERU KAGAKU HANNOU KANRYAKUKA HANNOUKEI NIYORU KOUSATSU]

TOORU MITANI Nov. 1992 32 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1184; JTN-93-80506) Avail: CASI HC A03/MF A01

Reduced kinetics for chemical reactions in scramjet engines were investigated. Ignition, combustion in combustors, and reactive flow in nozzles are described using a phase plane for radical concentrations. The effectiveness of radicals introduced to ignite premixtures was studied using analytical solutions representing time histories of three radical concentrations. The contribution of exothermicity to ignition delay and burning rate as well as inhibition caused by H2O were elucidated using simplified asymptotic analysis for H2/O2 systems. New reduced kinetic models for H2 combustion are proposed and compared with other models. Characteristics of ignition and flame-holding in scramjet combustors are discussed using the model derived here. Author (NASDA)

N94-13697# Aluminum Co. of America, Alcoa Center, PA.
ROLE OF MICROSTRUCTURE ON FATIGUE DURABILITY OF ALUMINUM AIRCRAFT ALLOYS Interim Status Report
9 Mar. 1993 26 p
(Contract N00014-91-C-0128)
(AD-A266350) Avail: CASI HC A03/MF A01

Alcoa historical 7050 fatigue test data has been assembled and reviewed. The range of microstructures examined in the program has been expanded from two in the contract proposal to five. In addition to the old and new quality thick plate, the program includes low porosity thick plate, low particle thick plate, and thin plate. These materials provide a range of microstructures/fatigue failure modes to help understand and model early stage fatigue damage. Though the scope of the program has expanded, the total program cost to the Navy has not changed. The fatigue test data on additional microstructural variants of 7050 have been assembled. Fractography of failed coupon specimens has been completed. The microstructural features controlling fatigue initiation have been identified. Samples of old and new quality plate have been supplied to the UCLA team in support of their ONR program. DTIC

N94-14126# Army Research Lab., Watertown, MA.
SYNTHETIC LUBRICANTS AND HIGH-PERFORMANCE FUNCTIONAL FLUIDS: PHOSPHAZENES Final Report
ROBERT E. SINGLER and MARY JO BIEBERICH (Naval Surface Warfare Center, Annapolis, MD.) Jan. 1993 18 p Repr. from Synthetic Lubricants and High Performance Functional Fluids: Phosphazenes, Chapter 10, 1992 p 215-228
(ARL-TR-45) Avail: CASI HC A03/MF A01

The synthesis, properties, and development of phosphazene fluids are reviewed, with an emphasis on military applications. Most of their search and development of phosphazene fluids has centered on the alkoxy- and aryloxycyclophosphazenes for fire-resistant, compression-ignition-resistant hydraulic fluids to meet requirements for MIL-H-19457. Related developments include applications such as high temperature lubricants for aircraft gas turbine engines, lubricity additives, applications in the electronic industry, fire-resistant additives, vacuum pump oil, and electrorheological fluids. Chemical compositions, physical properties, lubricity data, and toxicity information are given, along with projected costs for high volume use applications. Currently, some phosphazene fluids are commercially available in small quantities. Author

N94-14194# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de l'Energetique.
MODELING AND SIMULATION OF TRANSPORT AND COMBUSTION PHENOMENA IN A SUPERSONIC MIXING LAYER Ph.D. Thesis - Ecole Centrale de Paris [MODELISATION ET SIMULATION DES PHENOMENES DE TRANSPORT ET COMBUSTION DANS UNE COUCHE DE MELANGE SUPERSONIQUE]
PATRICK VUILLERMOZ Nov. 1992 267 p In FRENCH Sponsored by SEP, Vernon, France, and Ministere de la Recherche et de l'Espace, Paris, France Original contains color illustrations
(ISSN 0078-3781)
(ONERA-NT-1992-11; ETN-93-93970) Avail: CASI HC A12/MF A03

Numerical simulation and modeling of supersonic mixing layers are discussed. The theoretical background of compressible turbulence from a hydrodynamic point of view (Reynolds stress) as well as diffusive (turbulent mixing) and reactive turbulent combustion points of view are studied. The main experimental results and numerical studies in supersonic mixing are reviewed and the question of direct numerical simulation of turbulent mixing in nonsteady two dimensional and three dimensional mixing layers is addressed. These simulations are in agreement with experimental observations concerning the mixing regimes, the small scale structure in thin layers, and the effects of the convective Mach number. Before examining the effects of chemical reactions, the basic problem of one dimensional strained or unstrained diffusion flames are discussed as a benchmark for kinetics models and for the numerical codes. The theoretical analysis is carried out through a Crocco transformation that points out the inner structure of diffusion flames. These results were used for further numerical simulation of supersonic reactive mixing layers. The effect of the Damkoehler number in combustion regimes is studied. The simulations generated with reduced and with full chemistry are compared. A mixing enhancement technique is examined with simulations on a passively parallel computer. The results of the direct numerical simulations are used for modeling turbulent mixing and accounting for compressibility effects. ESA

N94-14436# Los Alamos National Lab., NM.
NONLINEAR WAVE PREDICTIONS IN CERAMICS
D. A. MANDELL 1993 6 p Presented at the International Union of Theoretical and Applied Mechanics Symposium, Victoria, Canada, 15-20 Aug. 1993
(Contract W-7405-ENG-36)
(DE93-016516; LA-UR-93-2437; CONF-9308130-1) Avail: CASI HC A02/MF A01

Accurate numerical prediction of nonlinear waves in metals and ceramics is important in the design of many products including aerospace structures, automobile engines, and other devices. The material strength and fracture of ceramics must be predicted in order to achieve optimum designs. As part of a project to develop a reliable, robust, design computer program, a number of material strength and fracture models have been implemented into the MESA-2D hydrocode and the predictions from the code have been compared to data. MESA-2D is an explicit, finite-difference Eulerian code with hydrodynamics, high explosives, material strength, fracture, and a number of equation of state models. The interface velocity as a function of time between an alumina target and a lithium fluorids window, impacted by an alumina disk at velocities between 544 m/s and 2329 m/s, was predicted by using the Steinberg ceramic material strength model and a maximum tensile fracture model. These one-dimensional flyer plate experiments were conducted at Sandia National Laboratories using Coors AD 995 alumina. DOE

N94-14573# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA: MATERIALS SCIENCE
14 Sep. 1993 37 p Transl. into ENGLISH from various Russian articles
(JPRS-UMS-93-006) Avail: CASI HC A03/MF A01

Translated articles cover the following topics: experimental investigation of the sensitivity of the mirror-shade method during testing of titanium disks in gas turbine engines with focusing transducers; thermal expansion of composites reinforced with carbon fibers and fabrics; laser microgalvanics - new method for protecting metallic coatings from localized corrosion; and modern refractory casting alloys for gas turbine engine blades. CASI

N94-14962 Wright Lab., Wright-Patterson AFB, OH.
SUPERSONIC COMBUSTION RESEARCH LABORATORY. VOLUME 1: DESIGN AND FABRICATION Interim Report, Jan. 1992 - 1993
MARK R. GRUBER and ABDOLLAH S. NEJAD Jan. 1993 54 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract AF PROJ. 2308)

(AD-A267667; WL-TR-93-2052-VOL-1) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The Experimental Research Branch of the Advanced Propulsion Division at Wright-Patterson Air Force Base began taking steps toward the development and installation of a supersonic combustion research facility during FY-90. A large-scale in-house research facility devoted to the study of supersonic fuel air mixing and combustion has been designed, fabricated, and installed. The purpose of the report that follows is to present documentation of the features of the air supply system, the design details and the characteristics of the actual supersonic combustion tunnel, and a description of the control system and instrumentation. DTIC

N94-15277*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PROCESSING, PROPERTIES AND APPLICATIONS OF COMPOSITES USING POWDER-COATED EPOXY TOWPREG TECHNOLOGY

T. D. BAYHA (Lockheed Aeronautical Systems Co., Marietta, GA.), P. P. OSBORNE (Lockheed Aeronautical Systems Co., Marietta, GA.), T. P. THRASHER (Lockheed Aeronautical Systems Co., Marietta, GA.), J. T. HARTNESS (BASF Structural Materials, Inc., Anaheim, CA.), N. J. JOHNSTON, J. M. MARCHELLO (Old Dominion Univ., Norfolk, VA.), and M. K. HUGH (Old Dominion Univ., Norfolk, VA.) *In* Old Dominion Univ., Polymer Infiltration Studies 21 p Jun. 1993 Presented at NASA's Fourth Advanced Composites Technology Conference, Salt Lake City, UT, Jun. 1993

Avail: CASI HC A03/MF A01

Composite manufacturing using the current prepregging technology of impregnating liquid resin into three-dimensionally reinforced textile preforms can be a costly and difficult operation. Alternatively, using polymer in the solid form, grinding it into a powder, and then depositing it onto a carbon fiber tow prior to making a textile preform is a viable method for the production of complex textile shapes. The powder-coated towpreg yarn is stable, needs no refrigeration, contains no solvents and is easy to process into various woven and braided preforms for later consolidation into composite structures. NASA's Advanced Composites Technology (ACT) program has provided an avenue for developing the technology by which advanced resins and their powder-coated preforms may be used in aircraft structures. Two-dimensional braiding and weaving studies using powder-coated towpreg have been conducted to determine the effect of resin content, towpreg size and twist on textile composite properties. Studies have been made to customize the towpreg to reduce friction and bulk factor. Processing parameters have been determined for three epoxy resin systems on eight-harness satin fabric, and on more advanced 3-D preform architectures for the downselected resin system. Processing effects and the resultant mechanical properties of these textile composites will be presented and compared. Author

N94-15345* National Aeronautics and Space Administration, Washington, DC.

BETTER AIRPLANE WINGS (Videotape)

Nov. 1989 Videotape: 3 min. 23 sec. playing time, in color, with sound

(NASA-TM-109446; NONP-VT-93-190243) Avail: CASI VHS A01/BETA A22

The videotape discusses the new composites that will be used to create lighter yet stronger aircraft wings. CASI

N94-16846*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AN OVERVIEW OF THE NASA TEXTILE COMPOSITES PROGRAM

H. BENSON DEXTER *In its* FIBER-TEX 1992: The Sixth Conference on Advanced Engineering Fibers and Textile Structures for Composites p 1-31 Aug. 1993

Avail: CASI HC A03/MF A03

The NASA Langley Research Center is conducting and sponsoring research to explore the benefits of textile reinforced composites for civil transport aircraft primary structures. The objective of this program is to develop and demonstrate the potential of affordable textile reinforced composite materials to meet design properties and damage tolerance requirements of advanced aircraft structures. In addition to in-house research, the program includes major participation by the aircraft industry and aerospace textile companies. The major program elements include development of textile preforms, processing science, mechanics of materials, experimental characterization of materials, and development and evaluation of textile reinforced composite structural elements and subcomponents. The NASA Langley in-house research is focused on science-based understanding of resin transfer molding (RTM), development of powder-coated towpreg processes, analysis methodology, and development of a performance database on textile reinforced composites. The focus of the textile industry participation is on development of multidirectional, damage-tolerant preforms, and the aircraft industry participation is in the areas of innovative design concepts, cost-effective fabrication, and testing of textile reinforced composite structural elements and subcomponents. Textile processes such as 3-D weaving, 2-D and 3-D braiding, and knitting/stitching are being compared with conventional laminated tape processes for improved damage tolerance. Through-the-thickness reinforcements offer significant damage tolerance improvements. However, these gains must be weighed against potential loss in in-plane properties such as strength and stiffness. Analytical trade studies are underway to establish design guidelines for the application of textile material forms to meet specific loading requirements. Fabrication and testing of large structural components are required to establish the full potential of textile reinforced composite materials. The goals of the NASA Langley-sponsored research program are to demonstrate technology readiness with subscale composite components by 1995 and to verify the performance of full-scale composite primary aircraft structural components by 1997. The status of textile reinforced composite structural elements under development by Boeing, Douglas, Lockheed, and Grumman are presented. Included are braided frames and woven/stitched wing and fuselage panels. Author

N94-16862*# Lockheed Engineering and Sciences Co., Hampton, VA.

DEVELOPMENT OF TEST METHODS FOR TEXTILE COMPOSITES

JOHN E. MASTERS, PETER G. IFJU (Virginia Polytechnic Inst., Blacksburg.), and MARK J. FEDRO (Boeing Defense and Space Group, Philadelphia, PA.) *In* NASA. Langley Research Center, FIBER-TEX 1992: The Sixth Conference on Advanced Engineering Fibers and Textile Structures for Composites p 249-269 Aug. 1993

Avail: CASI HC A03/MF A03

NASA's Advanced Composite Technology (ACT) Program was initiated in 1990 with the purpose of developing less costly composite aircraft structures. A number of innovative materials and processes were evaluated as a part of this effort. Chief among them are composite materials reinforced with textile preforms. These new forms of composite materials bring with them potential testing problems. Methods currently in practice were developed over the years for composite materials made from prepreg tape or simple 2-D woven fabrics. A wide variety of 2-D and 3-D braided, woven, stitched, and knit preforms were suggested for application in the ACT program. The applicability of existing test methods to the wide range of emerging materials bears investigation. The overriding concern is that the values measured are accurate representations of the true material response. The ultimate objective of this work is to establish a set of test methods to evaluate the textile composites developed for the ACT Program. Author (revised)

N94-16864*# Douglas Aircraft Co., Inc., Long Beach, CA.

TECHNO-ECONOMIC REQUIREMENTS FOR COMPOSITE AIRCRAFT COMPONENTS

RAY PALMER *In* NASA. Langley Research Center, FIBER-TEX 1992: The Sixth Conference on Advanced Engineering Fibers and

Textile Structures for Composites p 305-341 Aug. 1993
(Contract NAS1-18862)
Avail: CASI HC A03/MF A03

The primary reason for use of composites is to save structural weight. A well designed composite aircraft structure will usually save 25-30 percent of a well designed metal structure. The weight savings then translates into improved performance of the aircraft in measures of greater payload, increased flying range or improved efficiency - less use of fuel. Composite materials offer technical advantages. Key technical advantages that composites offer are high stiffness, tailored strength capability, fatigue resistance, and corrosion resistance. Low thermal expansion properties produce dimensionally stable structures over a wide range of temperature. Specialty resin 'char' forming characteristics in a fire environment offer potential fire barrier application and safer aircraft. The materials and processes of composite fabrication offer the potential for lower cost structures in the near future. The application of composite materials to aircraft are discussed. Author (revised)

N94-16996# Pennsylvania State Univ., University Park.
ADVANCED THERMALLY STABLE JET FUELS
H. H. SCHOBERT, S. ESER, C. SONG, P. G. HATCHER, P. M. WALSH, M. M. COLEMAN, J. BORTIATYNSKI, C. BURGESS, R. DUTTA, K. GERGOVA et al. Feb. 1993 131 p
(Contract DE-FG22-92PC-92104)
(DE93-017711; DOE/PC-92104/T1) Avail: CASI HC A07/MF A02

The Penn State program in advanced thermally stable coal-based jet fuels has five borad objectives: (1) development of mechanisms of degradation and solids formation; (2) quantitative measurement of growth of sub-micrometer and miocrometer-sized particles suspended in fuels during thermal stressing; (3) characterization of carbonaceous deposits by various instrumental and microscopic methods; (4) elucidation of the role of additives in retarding the formation of carbonaceous solids; and (5) assessment of the potential of production of high yields of cycloalkanes by direct liquefaction of coal. Pyrolysis of four isomers of butylbenzene was investigated in static microautoclave reactors at 450 C under 0.69 MPa of UHP N2. The rates of disappearance of substrates were found to depend upon the bonding energy of C(alpha)-C(beta) bond in the side chain in the initial period of pyrolysis reactions. Possible catalytic effects of metal surfaces on thermal degradation and deposit formation at temperatures greater than 400 C have been studied. Carbon deposition depends on the composition of the metal surfaces, and also depends on the chemical compositions of the reactants. Thermal stressing of JP-8 was conducted in the presence of alumina, carbonaceous deposits recovered from earlier stressing experiments, activated carbon, carbon black, and graphite. The addition of different solid carbons during thermal stressing leads to different reaction mechanisms. C-13 NMR spectroscopy, along with C-13-labeling techniques, have been used to examine the thermal stability of a jet fuel sample mixed with 5% benzyl alcohol. Several heterometallic complexes consisting of two transition metals and sulfur in a single molecule were synthesized and tested as precursors of bimetallic dispersed catalysts for liquefaction of a Montana subbituminous and Pittsburgh No. 8 bituminous coals. DOE

N94-17223# California Univ., Berkeley. Dept. of Materials Science and Mineral Engineering.
MICROMECHANISMS OF MONOTONIC AND CYCLIC SUBCRITICAL CRACK GROWTH IN ADVANCED HIGH MELTING POINT LOW-DUCTILITY INTERMETALLICS Final Report, 1 Apr. 1990 - 31 Mar. 1993
K. T. VENKATESWARARAO, L. MURUGESH, and R. O. RITCHIE May 1993 120 p
(Contract AF-AFOSR-0167-90)
(AD-A267764; UCB/R/93/A1091) Avail: CASI HC A06/MF A02

The next generation of high-performance engines will require stiffer materials operating at higher stress levels and capable of with-standing significantly higher temperatures up to 1650 C and above. Prime candidates for such applications include ordered intermetallics, ceramics, and composites based on metal, intermetallic, and ceramic or carbon matrices. However, these materials are currently of limited use due to their low ductility and toughness properties; moreover, an understanding of their fatigue resistance is still essentially lacking. Accordingly, the present research was aimed at examining one class of these materials, namely ductile-phase toughened intermetallic alloys, with respect to the critical factors influencing crack-propagation resistance under monotonic and cyclic loading. The model systems studied included TiNb- and Nb-reinforced gamma-TiAl, Nb-reinforced Nb3Al, and Nb-reinforced MoSi2. DTIC

N94-17381 California Inst. of Tech., Pasadena. Graduate Aeronautical Labs.
LIFTED TURBULENT JET FLAMES Ph.D. Thesis
JAY A. HAMMER 14 Apr. 1993 156 p
(Contract N00014-89-J-1991)
(AD-A267911) Avail: CASI HC A08

Experiments were conducted on lifted, turbulent jet diffusion flames. A linear photodiode array was used to measure the temporal history of the liftoff height, h. Measurements of the mean liftoff height, bar-h, under a wide range of flow conditions, including several fuels, nozzle diameters, and exit velocities U(sub s), showed an approximately linear relationship between bar-h and U(sub s), with a slight dependence on Reynolds number. A strain-rate model was developed for liftoff, based on far-field scaling of turbulent jets; it provides an explanation for the linear dependence of bar-h on U(sub s). When the nozzle fluid was diluted with varying amounts of air it was found that the slope of the bar-h vs. U(sub s), line increases faster than predicted by the far-field scaling. The discrepancy is attributed to near-field effects. The amplitudes of the fluctuations in bar-h were found to be of the order of the local large scale of the jet but the time scales were found to be much larger than the local large-scale time of the turbulence tau(sub delta). By using fuels of different chemical times to vary tau(sub delta), the measured correlation time tau(sub 1/2) normalized by tau(sub delta) was found to collapse with Richardson number xi(sub h). DTIC

N94-17418 Naval Air Warfare Center, Warminster, PA. Air Vehicle and Crew Systems Technology Dept.
AIRCRAFT CARRIER EXPOSURE TESTS OF CAST MAGNESIUM ALLOYS Final Report
JOSEPH KOZOL and EDWIN TANKINS 1 Mar. 1993 18 p
Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A268260; NAWCADWAR-93015-60) Avail: CASI HC A03

This report describes the results of an ongoing effort to determine the behavior of aircraft materials and finishes in the naval environment of aircraft carrier flight decks. Coated cast magnesium alloys were exposed to the carrier environment for a relatively short time and experienced significant corrosion effects compared to aluminum control specimens. DTIC

N94-17752# Oak Ridge National Lab., TN.
METALS 2000
S. W. ALLISON, L. C. ROGERS, G. SLAUGHTER, F. D. BOENSCH, R. O. CLAUS, and M. DEVRIES May 1993 213 p
(Contract DE-AC05-84OR-21400)
(DE93-016761; ORNL/ATD-73) Avail: CASI HC A10/MF A03

This strategic planning exercise identified and characterized new and emerging advanced metallic technologies in the context of the drastic changes in global politics and decreasing fiscal resources. In consideration of a hierarchy of technology thrusts stated by various Department of Defense (DOD) spokesmen, and the need to find new and creative ways to acquire and organize programs within an evolving Wright Laboratory, five major candidate programs identified are C-17 Flap, Transport Fuselage, Mach 5 Aircraft, Fighter Structures, and Missile Structures. These results were formed by extensive discussion with selected major contractors and other experts, and a survey of advanced metallic structure materials. Candidate structural applications with detailed metal structure descriptions bracket a wide variety of uses which warrant consideration for the suggested programs. An analysis on implementing smart skins and structures concepts is given from a metal structures perspective. DOE

N94-18113# Lawrence Livermore National Lab., CA.
SAND CONTACT IN DYNA3D
R. G. WHIRLEY and B. E. ENGELMANN 25 Aug. 1992 15 p
Presented at the DYNA3D User's Group Conference, Manchester, England, 22-23 Sep. 1992
(Contract W-7405-ENG-48)
(DE93-016451; UCRL-JC-111560; CONF-9209372-1) Avail: CASI HC A03/MF A01

This paper describes some recent developments in adaptive contact algorithms for the transient analysis of penetration and material failure in DYNA3D. A failure criterion is defined for volumes of potentially failing material on each side of a contact surface. As material within an element fails, the element is deleted from the calculation, and the contact surface is adaptively redefined to include the newly exposed outer material boundary. This algorithm admits arbitrary combinations of shell and solid elements to allow modeling of composite or honeycomb structures. The algorithms and their efficiency are illustrated with several DYNA3D simulations, and results are compared with experimental data. DOE

N94-18257# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
STUDIES ON HIGH PRESSURE AND UNSTEADY FLAME PHENOMENA: REVISION Annual Report, 15 Apr. 1992 - 14 Apr. 1993
C. K. LAW 4 Jun. 1993 139 p
(Contract F49620-92-J-0227)
(AD-A269138; AFOSR-93-0672TR) Avail: CASI HC A07/MF A02

The objective of the present program is to study the structure and response of steady and unsteady laminar premixed and nonpremixed flames in reduced and elevated pressure environments through (1) non-intrusive experimentation, (2) computational simulation using detailed flame and kinetic codes, and (3) asymptotic analysis with reduced kinetic mechanisms. During the reporting period, progress has been made in the following projects: (1) a theoretical and experimental study of unsteady diffusion flames; (2) a computational and experimental study of methane/air flames at elevated pressures; (3) an asymptotic analysis of the structure of methane/air premixed flames with reduced chemistry; (4) an asymptotic analysis of the extinction of laminar premixed flames with volumetric heat loss and chain mechanisms; and (5) asymptotic analyses of ignition in the supersonic laminar flat-plate boundary layer and mixing layer. A total of five reprints are appended. DTIC

N94-18327# Aeronautical Research Labs., Melbourne (Australia).
MATHEMATICAL MODELLING OF BONDED FIBRE-COMPOSITE REPAIRS TO AIRCRAFT
P. D. CHALKLEY May 1993 35 p
(AD-A268732; ARL-RR-7; DODA-AR-008-365) Avail: CASI HC A03/MF A01

Bonded fibre-composite doublers are increasingly being used to reinforce and/or repair damaged or underdesigned metallic aircraft structure. This trend will continue as the average age of Australian civilian and military aircraft increases. Two mathematical models of the stress state in bonded doublers are presented in this report: the end-tapered double-lap joint and the stepped double-lap joint. The mathematical development of the two models is detailed and the fidelity of the predicted stress states compared with that obtained from finite element analyses and experiment. DTIC

N94-18489 University of Eastern Kentucky, Richmond. Dept. of Chemistry.
ANALYSIS OF DEPOSIT PRECURSORS IN JET FUELS USING FOURIER TRANSFORM INFRARED SPECTROSCOPY Interim Report, Apr. - Aug. 1991
WILLIAM SCHULZ and DAVID B. SHEHEE Jan. 1993 53 p
Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract F33615-87-C-2714)
(AD-A269035; WL-TR-93-2015) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Thermal oxidation products from jet fuels will be formed in the presence of fuel and oxygen at elevated temperatures. Development of fuels that will not form solid residues depends on the development of a method to analyze the rate of oxidation of fuels. Gravimetric determination of fuel residues was imprecise and time consuming. Gas Chromatography-Mass Spectrometry (GC-MS) of oxidation products yields a great deal of fundamental information but is too specific to be used as a rapid method for determining the rate of oxidation. Fourier Transform Infrared (FTIR) Spectrometry is non-specific and gives integrated signals for classes of oxidation products that will give rapid analytical results for rates of oxidation as well as the ability to study the effectiveness of chemical additives. DTIC

N94-18630 Virginia Polytechnic Inst. and State Univ., Blacksburg.
THE 6TH JAPAN-U.S. CONFERENCE ON COMPOSITE MATERIALS Final Report, 1 Sep. 1991 - 31 Aug. 1992
K. L. REIFSNIDER Mar. 1993 877 p Conference held in Orlando, FL, 22-24 Jun. 1992 Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract AF-AFOSR-0330-91)
(AD-A268535; AFOSR-93-0620TR) Avail: CASI HC A99

This conference has achieved its goal of updating the research and development community about recent advances in the area of modern composite materials, and about interactions and opportunities associated with US-Japan Cooperation. The conference was organized and administered by the US-Japan Council for Composite Materials, with financial backing from the Virginia Institute for Materials Systems, which is part of Virginia Tech. Cooperating organizations include the American Society for Composites, American Society of Mechanical Engineers, Ohio Aeronautics Institute, and the Society of Engineering Mechanics. The scope of the Conference included all types of high performance composite systems, interfaces and interphases, high temperature materials, smart materials and structures, fracture, fatigue, and damage analysis. Specific topic areas include: Materials System Design, Manufacturing and Processing. Fabrication of Components, Interfaces and Interphases, Woven and n-Dimensional Materials, High Temperature Materials, Stress Analysis and Micromechanics. The conference lasted for three days with 120 papers presented (40 from Japan and 80 from the US). The papers presented at the conference were relevant for the current Air Force technology thrusts such as the Integrated High Performance Turbine Engine Program and the National Aerospace Plane. DTIC

N94-18761# Oak Ridge Y-12 Plant, TN.
NONDESTRUCTIVE INSPECTION OF GRAPHITE-EPOXY LAMINATES FOR HEAT DAMAGE USING DRIFT AND LPF SPECTROSCOPIES
G. L. AOWELL, N. R. SMYRL, C. J. JANKE (Oak Ridge National Lab., TN.), E. A. WACHTER (Oak Ridge National Lab., TN.), W. G. FISHER, J. LUCANIA (Harrick Scientific, Inc., Ossining, NY.), M. MILOSEVIC (Spectra-Tech, Inc., Stamford, CT.), and G. AUTH (MIDAC Corp., Cosa Mesa, CA.) 3 Jun. 1993 18 p Presented at the Conference on Characterization and NDE of Heat Damage in Graphite Epoxy Composites, Austin, TX, 27-28 Apr. 1993
(Contract DE-AC05-84OS-21400)
(DE93-017228; Y/DZ-1008/R1; CONF-9304170-1) Avail: CASI HC A03/MF A01

The effect of heat damage on polymer matrix composites (PMC) used in aircraft structures presents a unique problem for nondestructive testing (ND) in that damage may result as a combination of thermally cycling the PMC above the glass transition temperature of the polymer and oxidative degradation of the polymer or the polymer-fiber interface. The usual techniques for the detection of voids and flaws by radiographic, ultrasonic, and thermal imaging techniques play an important role in this ND problem. However, heat damage may result in loss of strength in these materials without producing physical flaws (cracks and delaminations) big enough to be detected. Diffuse reflectance Fourier transform infrared (DRIFT) and laser pumped fluorescence (LPF) measurements previously obtained on IM6/3501-6 laminate panels were re-evaluated to improve these techniques for the nondestructive inspection of aircraft. A more robust algorithm for relating flexural strength to changes in DRIFT spectra related to oxidation is presented and used to interpret previously reported evacuable cell DRIFT measurements. Recent advances in DRIFT technology are described which include an evacuable cell with a hemispherical window for oxidation kinetics studies, and the development of a portable DRIFT spectrometer that was used to make measurements on an aircraft. The use of a 633-nm helium-neon laser for LPF is reported as a means for rapidly relating both fluorescence intensity and spectral distribution to flexural strength. DOE

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.

A94-10101
THE PRESENT SITUATION AND FUTURE DEVELOPMENT OF CHINESE AVIATION RELIABILITY AND MAINTAINABILITY ENGINEERING
WEIMIN YANG, QINGCI TU, and JINGTANG JIAO (Beijing Univ. of Aeronautics and Astronautics, China) Beijing University of Aeronautics and Astronautics, Journal (ISSN 1001-5965) no. 1 Jan. 1992 p. 1-8. In CHINESE refs

This paper summarizes the historical process of Chinese aviation reliability and maintainability (R&M) engineering which underwent the embryonic stage and strode into the initial development stage during '7-5' period. It analyzes the characteristics of replacing the old design idea with a new one, the achievements made and the existing problems. On the basis of summarizing '7-5' experiences, according to the development needs of Chinese aviation industries and using the experiences of foreign countries for reference, this paper puts forward the requirements for establishing the Chinese reliability engineering discipline, describes the R&M engineering development framework in the '8-5' period, and draws up the key R&M engineering items application matrix of newly developing or modifying aircrafts (products). Author (revised)

A94-10102
THE APPLICATION OF SIMULATION IN AERO-RELIABILITY ENGINEERING
YIXING SHENG (Beijing Univ. of Aeronautics and Astronautics, China) Beijing University of Aeronautics and Astronautics, Journal (ISSN 1001-5965) no. 1 Jan. 1992 p. 9-15. In CHINESE refs

This article gives an introductory overview of the application and development of Monte Carlo simulation in Chinese aviation reliability engineering during the past 10 years. The article shows the role and position of reliability simulation in this field. Finally, the author presents some viewpoints on the further reliability simulation research. Author (revised)

A94-10104
A DISCUSSION OF THE PHASED CHARACTER OF RELIABILITY AND MAINTAINABILITY INDEXES
QINGCI TU (Beijing Univ. of Aeronautics and Astronautics, China) Beijing University of Aeronautics and Astronautics, Journal (ISSN 1001-5965) no. 1 Jan. 1992 p. 24-31. In CHINESE refs

This paper firstly introduces the actual growth situation and related statistical data of reliability and maintainability (R&M) indices of foreign and domestic combat or commercial aircraft during development, production, and deployment phases. Then it introduces the requirement of specifying different R&M indexes (goal or threshold value) at different life cycle phases mentioned in foreign standards, regulations, and documents. On this basis, this paper points out that the performance of a product can be fixed at the end of full-scale development phase, but its R&M can only reach a certain level. In order to achieve the final target of the maturity phase, it must continue to have a planned R&M growth. This is an objective law. Recognition of this law will reflect the idea of phased control and phased growth of products R&M during the decision making of planning, management and technology. It will also promote the implementation of optimum life cycle cost-effectiveness targets. Author (revised)

A94-10108
THE RELIABILITY PARAMETER ESTIMATION OF FIELD INFORMATION
GUOFANG HE (Beijing Univ. of Aeronautics and Astronautics, China) Beijing University of Aeronautics and Astronautics, Journal (ISSN 1001-5965) no. 1 Jan. 1992 p. 51-57. In CHINESE

The feature of field information has been investigated for many years in order to fully utilize the reliability information of aviation products obtained in the field, and a set of perfect processing methods for parameter point estimation of MTBFs has been established. In this paper, the point estimation is modified with statistical analysis method for practical applications. Formulas for interval estimation and one-sided lower limit estimation concerning random censored samples are derived. The calculated results of parameters of airborne items of the YUN-7 are given as examples. Author (revised)

A94-10299* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AUTOMATIC DIFFERENTIATION OF ADVANCED CFD CODES FOR MULTIDISCIPLINARY DESIGN
C. BISCHOF, G. CORLISS (Argonne National Lab., IL), L. GREEN (NASA, Langley Research Center, Hampton, VA), A. GRIEWANK (Argonne National Lab., IL), K. HAIGLER, and P. NEWMAN (NASA, Langley Research Center, Hampton, VA) Computing Systems in Engineering (ISSN 0956-0521) vol. 3, no. 6 Dec. 1992 p. 625-637. Symposium on High-Performance Computing for Flight Vehicles, Arlington, VA, Dec. 7-9, 1992. Previously announced in STAR as N93-22867 refs
(Contract W-31-109-ENG-38; NSF CCR-91-20008)
Copyright

Automated multidisciplinary design of aircraft and other flight vehicles requires the optimization of complex performance objectives with respect to a number of design parameters and constraints. The effect of these independent design variables on the system performance criteria can be quantified in terms of sensitivity derivatives which must be calculated and propagated by the individual discipline simulation codes. Typical advanced CFD analysis codes do not provide such derivatives as part of a flow solution; these derivatives are very expensive to obtain by divided (finite) differences from perturbed solutions. It is shown that sensitivity derivatives can be obtained accurately and efficiently using the ADIFOR source translator for automatic differentiation. In particular, it is demonstrated that the 3-D, thin-layer Navier-Stokes, multigrid flow solver called TLNS3D is amenable to automatic differentiation in the forward mode even with its implicit iterative solution algorithm and complex turbulence modeling. It is significant that by using computational differentiation, consistent discrete nongeometric sensitivity derivatives have been obtained from an aerodynamic 3-D CFD code in a relatively short time, e.g., O(man-week) not O(man-year).

A94-10408

APPLICATION OF LUMINESCENCE QUENCHING FOR PRESSURE FIELD MEASUREMENTS ON THE MODEL SURFACE IN A WIND TUNNEL

A. P. BUKOV, A. A. ORLOV, V. E. MOSHAROV, V. N. RADCHENKO, V. A. PESETSKIJ, A. V. SOROKIN, S. D. PHONOV (TsAGI, Zhukovski, Russia), L. ALATY, and V. COLUCCI (INTECO, Frosinone, Italy) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 8.1-8.11. refs

Copyright

The problems associated with wind tunnel model surface pressure measurement are presently addressed by the coating of such surfaces with a polymeric luminophore-molecule-based material. The resulting Luminescence Intensity Pressure Sensor has undergone testing in various types and scales of wind tunnel and model. Attention is presently given to the physical principles involved, the illumination and detection systems used, and problems associated with model surface dust. AIAA

A94-10409

OPTICAL SURFACE PRESSURE MEASUREMENT - INITIAL EXPERIENCE IN THE MCAIR PSWT

R. C. CRITES, M. E. BENNE, M. J. MORRIS, and J. F. DONOVAN (McDonnell Douglas Corp., Saint Louis, MO) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 9.1-9.13. refs

Copyright

An oxygen-quenched, luminescent, pressure-sensitive paint (PSP) has been developed and employed as a basis for optical surface pressure measurements during high speed wind tunnel tests. The PSP is excited by visible blue light. Attention is given to PSP-obtained wind tunnel test results for F-15, F/A-18, and MD-12 models. Calibration-based corrections for the data derived from PSP measurements are a critical consideration; accounts are given of the roles played by model motion and distortion and excitation-light variations. AIAA

A94-10411

DEVELOPMENT AND APPLICATION OF INFRARED- AND OTHER FLOW VISUALIZATION TECHNIQUES IN A HYPERSONIC WIND TUNNEL OF DLR COLOGNE

A. HENCKELS, A. F. KREINS, and F. MAURER (DLR, Cologne, Germany) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 11.1-11.12. Research supported by Dassault Aviation and MBB GmbH refs

(Contract DFG-SFB-253)

Copyright

For the investigation of hypersonic heat transfer phenomena experimental studies were performed in the blowdown facility 112K of DLR Cologne. This facilily with 60 cm nozzle exit diameter provides test run times up to 40 seconds at test conditions of Mach number 5.3 or 11.2 and Reynolds numbers between 0.3 and 19 million per meter. An infrared camera system (Inframetrics 600) installed inside the plenum chamber of this tunnel recorded the establishing temperature distribution on the model surface during the whole run time. To get a comprehensive information about the character of the flow field the infrared results were supported by additional diagnostic techniques like coincidence Schlieren optics, Pitot pressure measurements and oil flow visualization. The paper will demonstrate the capability of the applied measurement techniques by presenting infrared measurement results as for instance from a study of an oblique shock front impinging on the laminar boundary layer of a flat plate model. Also results from studies concerning a longitudinal corner flow field and the delta wing configuration are included. All these activities will be accompanied by efforts to improve the present infrared and oil flow visualition techniques, driven by the needs of increased precision for numerical validation in hypersonic aerothermodynamics.

A94-10429

THE EVOLUTION OF WHOLE FIELD OPTICAL DIAGNOSTICS FOR EXTERNAL TRANSONIC TESTING

K. A. FRY (Aircraft Research Association, Ltd., Bedford, United Kingdom) and P. J. BRYANSTON-CROSS (Warwick Univ., Coventry, United Kingdom) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 34.1-34.14. Research supported by Department of Trade and Industry of United Kingdom, SERC, Defence Research Agency, et al refs

Copyright

An evaluation is made of the limitations of conventional, single-point laser-based flow visualization techniques such as LDA, and a demonstration is presented of ways in which they can be overcome by the development of 'whole-field' measurement techniques. Attention is given to whole-field velocity data obtained in a transonic wind tunnel by means of the laser light-sheet, particle-image velocimetry, and 3D holographic flow-visualization techniques. These methods are nonintrusive and require no special preparation of the model. AIAA

A94-10430

NEW DEVELOPMENTS IN SENSORS, INSTRUMENTATION, AND FLOW DIAGNOSTICS FOR SIMULTANEOUS BOUNDARY LAYER MEASUREMENTS

S. M. MANGALAM and S. KUPPA (Analytical Services and Materials, Inc., Hampton, VA) *In* Wind tunnels and wind tunnel test techniques; Proceedings of the Conference, Southampton, United Kingdom, Sept. 14-17, 1992 London Royal Aeronautical Society 1992 p. 35.1-35.11. refs

Copyright

Multielement surface hot-film sensors for ascertaining the laminar-to-turbulent transition region, and characterizing the frequencies of the most highly amplified disturbances in turbulent boundary layers, have been extended through the discovery of phase-reversal signatures that can accurately determine the spatial locations of stagnation, separation, and reattachment points. To this has been added the breakthrough in thermal anemometry represented by a high-sensitivity/broad bandwidth anemometer that is uniquely suited for wind tunnel and flight-test applications. AIAA

A94-10521

LASER-SCANNING PARTICLE IMAGE VELOCIMETRY APPLIED TO A DELTA WING IN TRANSIENT MANEUVER

C. MAGNESS, O. ROBINSON, and D. ROCKWELL (Lehigh Univ., Bethlehem, PA) Experiments in Fluids (ISSN 0723-4864) vol. 15, no. 3 Aug. 1993 p. 159-167. Research supported by USAF refs

Copyright

A laser scanning technique, which utilizes a galvanometer scanner to produce particle-image photographs, is employed to investigate the flow over a delta wing undergoing pitching maneuvers at a high angle of attack. Use of a unique forcing system and a large-scale prism arrangement allow characterization of the instantaneous velocity field over the entire crossflow plane at a desired angle of attack. Contours of constant streamwise vorticity are calculated from the crossflow velocity field at various pitching rates. The vorticity distribution occurring during the pitch-up motion differs substantially from that on the stationary wing at the same angle of attack. During the pitch-up motion, the leading-edge vortex is remarkably coherent, in contrast to the disordered structure on the stationary wing. During the corresponding pitch-down motion, the vorticity distribution is quite similar to that on the stationary wing at the same angle of attack. This behavior is evident for a range of pitching rates.

A94-10743
CALCULATION OF ROTOR BLADE AIR LOADS FROM MEASURED STRUCTURAL RESPONSE DATA
H. OERY and H. W. LINDERT (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X) vol. 17, no. 4 Aug. 1993 p. 225-234. refs
(Contract DFG-SFB-25)
Copyright
A method for determining real spanwise rotor blade loads in the time domain is proposed. The method is based on evaluating measured blade structural response data (e.g. local bending moments, deformations or accelerations) from windtunnel or flight tests. The aerodynamic forces on the blade are reconstructed from the measured response data using basic structural dynamical relations. Knowledge of structural blade parameters (e.g. elasticity matrix, eigenfrequencies and mass distribution) is herefor required. The basic equations for the reconstruction method (RM) and results from model blade wind tunnel and helicopter flight test data evaluations are presented.

A94-10747
THE INFLUENCE OF DISSIPATION LAWS ON THE CALCULATION OF TURBULENT BOUNDARY LAYERS WITH PRESSURE RISE
D. ALTHAUS (Stuttgart Univ., Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X) vol. 17, no. 4 Aug. 1993 p. 253-256. refs
Copyright
For calculations of boundary layers by integral methods which use the energy equation, a closure-relation for the energy dissipation is needed. The choice of this empirical law can have strong influence on the result, especially on boundary layers with pressure gradients. This is demonstrated by calculations of layers with a constant shape factor which are approximately so-called equilibrium layers. Their velocity distributions are calculated by an integral method using different CD-relations and with empirical formulas for equilibrium layers for comparison. Author (revised)

A94-10749
A SIMPLE AND EFFICIENT SOLUTION FOR THE RIEMANN PROBLEM [EIN EINFACHES UND EFFIZIENTES VERFAHREN ZUR LOESUNG DES RIEMANN-PROBLEMS]
M. SCHLEICHER (Eidgenoessisches Flugzeugwerk, Emmen, Switzerland) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X) vol. 17, no. 4 Aug. 1993 p. 265-269. In GERMAN refs
Copyright
A simple solution for the one-dimensional Riemann problem is presented. The method is based on a parametric representation of waves and shocks. For waves as well as for shocks the same parameter, that is the relative change of density is used. Implemented in an Euler solver for the calculation of the fluxes the method turns out to be very efficient because the solution of the Riemann problems becomes almost free of iterations.

A94-10799
A SYSTEMATIC COMPUTATION SCHEME OF PAR-WIG CRUISING PERFORMANCE
SHIGENORI ANDO (Tokushima Bunri Univ., Kagawa, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811) vol. 36, no. 112 Aug. 1993 p. 92-106. refs
A systematic computation scheme is presented for PAR-WIG cruising performance, on a FORTRAN program. It is suitable for implementation on PCs. Effects of many parameters on the transportation efficiency are explored. Two concepts are presented in three views and artist impressions. One is a smallest single-crewman vehicle for experiment, sports, or pleasure. The other is a large vehicle for civil transportation. Both have twin hulls, which are quite suitable for installing a 'SMALL-TAIL-WIG' or 'WIG-let' to establish longitudinal attitude stability.
Author (revised)

A94-10885
ANNUAL REVIEW OF FLUID MECHANICS. VOL. 25
JOHN L. LUMLEY, ED. (Cornell Univ., Ithaca, NY), MILTON VAN DYKE, ED. (Stanford Univ., CA), and HELEN L. REED, ED. (Arizona State Univ., Tempe) Palo Alto, CA Annual Reviews, Inc. 1993 653 p. For individual items see A94-10886 to A94-10893 (ISBN 0-8243-0725-9) Copyright
Attention is given to such topics as the history of Poiseuille's law, the structure and stability of laminar flames, resonant interactions among surface water waves, and the aerodynamics of horizontal-axis wind turbines. Consideration is also given to computational methods for the aerodynamic design of aircraft components, surface waves and coastal dynamics, boundary mixing and arrested Ekman layers, order parameter equations for patterns, perspectives on hypersonic viscous flow research, and the impact of drops on liquid surfaces and the underwater noise of rain.
AIAA

A94-11090
HOLOGRAPHIC INTERFEROMETRY AND MOIRE DEFLECTOMETRY FOR VISUALIZATION AND ANALYSIS OF LOW-GRAVITY EXPERIMENTS ON LASER MATERIALS PROCESSING
ERIC HARVEY, MICHEL BOUCHARD, and PIERRE LANGLOIS (Inst. National d'Optique, Sainte-Foy, Canada) Optical Engineering (ISSN 0091-3286) vol. 32, no. 9 Sept. 1993 p. 2143-2155. Research supported by Canadian Space Agency refs
Copyright
The use of two optical diagnostic techniques for the visualization of low-gravity experiments is described. The analysis of requirements relevant to the low-gravity environment led to the choice of real-time holographic interferometry and moire deflectometry as suitable optical visualization techniques. An optical setup designed to operate in the KC-135 aircraft is described. An interactive fringe analysis system is also presented. Fringe center lines are extracted using a special one-dimensional algorithm. The reconstruction of physical parameters from axisymmetrical objects is achieved using direct and inverse Abel transforms on moire and interferometric fringe fields. The applicability of the optical diagnostic techniques to the visualization of laser processing with liquids and solids in a low-gravity environment is demonstrated and experimental results on laser beam interaction with plastic, quartz, and water are presented.

A94-11349*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACTIVE CONTROL OF NONLINEAR-NONSTATIONARY RESPONSE AND RADIATION OF A PANEL-STRINGER STRUCTURE NEAR A SUPERSONIC JET
LUCIO MAESTRELLO (NASA, Langley Research Center, Hampton, VA) Oct. 1993 16 p. AIAA, Aeroacoustics Conference, 15th, Long Beach, CA, Oct. 25-27, 1993 refs
(AIAA PAPER 93-4338) Copyright
This paper is on the control of nonlinear-nonstationary vibration of an aircraft-type frame-stringer structure and the acoustic radiation resulting from high levels of excitation by a nearby supersonic model jet exhaust. The objective of the control is to reduce the acoustic fatigue and the interior noise in a high-speed aircraft. Control of the structural response is achieved by actively forcing the structure with an actuator at the shock oscillation frequency whose amplitude is locked into a self-control cycle. This controller follows the amplitude modulation that results from the rotation and counter-rotation of the jet column. Results show that the peak level of the power in the structural response due to shock impingement is reduced by a factor of 63, corresponding to a power level reduction of 18 dB. As a result, new broadband components emerge with at least four harmonics contributing to the broadening of the response spectrum. At accelerating and decelerating supersonic speeds, the exhaust from the jet induces higher transient loading on the nearby flexible structure due to the occurrence of multiple shocks from the jet. Author (revised)

A94-11350*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ON ACOUSTIC RADIATION FROM A VIBRATING PANEL

ABDELKADER FRENDI (Analytical Services and Materials, Inc., Hampton, VA), LUCIO MAESTRELLO, JAY ROBINSON (NASA, Langley Research Center, Hampton, VA), and ALVIN BAYLISS (Northwestern Univ., Evanston, IL) Oct. 1993 17 p. AIAA, Aeroacoustics Conference, 15th, Long Beach, CA, Oct. 25-27, 1993 refs

(Contract NAS1-19700; NAS1-18605; NAS1-19480; NSF MSS-91-02981)

(AIAA PAPER 93-4367) Copyright

An experimental and numerical study of the response and radiation from an acoustically loaded aircraft panel is presented. In the experiment, the panel is excited by a normally incident, harmonic wave. Measurements of the panel response and the resulting transmitted pressure are made in both the near- and acoustic far-fields. The numerical computations model the experiment and in particular account for the full coupling between the panel and the surrounding three dimensional acoustic fluid. The results demonstrate that for a sufficiently high excitation level, the panel response becomes nonlinear. The nonlinearity is characterized by the appearance of harmonics and subharmonics in the power spectral densities of the panel motion and consequently in the resulting acoustic radiation. The primary characteristic of the far-field acoustic radiation is the increase in harmonic content relative to the fundamental and subharmonics with increasing distance from the panel. This is shown to be a result of linear and weakly nonlinear wave propagation effects. The numerical results show that the radiated far-field pressure is strongly dependent on the position of the measurement point with respect to the panel center. The experimental and numerical results are in good qualitative agreement.

A94-11368

AIRCRAFT GENERATION AND DISTRIBUTION SYSTEMS; PROCEEDINGS OF THE CONFERENCE, LONDON, UNITED KINGDOM, OCT. 14, 1992

London Royal Aeronautical Society 1992 97 p. For individual items see A94-11369 to A94-11375

(ISBN 1-85768-060-X) Copyright

The papers presented in this volume provide an overview of recent developments in aircraft electric power generation and distribution systems. In particular, attention is given to airline requirements on aircraft electrical power generation and distribution, matching today's technology to the electric power requirements, and flexible alternatives to constant frequency systems. Papers are also presented on load management, solid state relays, and the Boeing 777 electrical system. AIAA

A94-11370

MATCHING TODAY'S TECHNOLOGY TO THE ELECTRIC POWER REQUIREMENT

DENNIS KRAMER (Sundstrand Aerospace, Rockford, IL) *In* Aircraft generation and distribution systems; Proceedings of the Conference, London, United Kingdom, Oct. 14, 1992 London Royal Aeronautical Society 1992 p. 2.1-2.10.

Copyright

The factors that must be considered in order to select the optimum electric power generation system for the aircraft are examined. First, full conversion systems (i.e., all bus power delivered at 400 Hz) are considered. The benefits of partial power conversion systems are then examined. It is noted that the types of aircraft loads (e.g., fans, motors, galleys, heating, and avionics), their location, and their percentage of the total connected load play a major role in determining the optimum type of the power generation system. AIAA

A94-11372

FLEXIBLE ALTERNATIVES TO CONSTANT FREQUENCY SYSTEMS

JOHN STEWART-WILSON (Lucas Aerospace, Ltd., Hemel Hempstead, United Kingdom) *In* Aircraft generation and distribution systems; Proceedings of the Conference, London, United Kingdom, Oct. 14, 1992 London Royal Aeronautical Society 1992 p. 4.1-4.10.

Copyright

The use of hybrid systems in which variable frequency is used as generated, with a proportion being converted to constant frequency by electronic conversion, is examined as a flexible alternative to constant frequency systems. Here, some practical solutions to the technical issues raised by adopting the more flexible approach to electrical system generation are presented. In particular, attention is given to the frequency ranges used, impact on aircraft equipment, motor-driven equipment, transformer rectifier units, lighting, and avionics. The discussion also covers fan-assisted galley ovens, system architecture, special airworthiness requirements, and power quality. AIAA

A94-11373

ELECTRICAL POWER GENERATION SYSTEMS - COMBAT AIRCRAFT PERSPECTIVE

R. MOELLER (Deutsche Aerospace AG, Munich, Germany) *In* Aircraft generation and distribution systems; Proceedings of the Conference, London, United Kingdom, Oct. 14, 1992 London Royal Aeronautical Society 1992 p. 5.1-5.23.

Copyright

The electrical power generation system requirements of combat aircraft are briefly examined. In particular, attention is given to customer requirements, development of the installed electrical power in aircraft, electrical load analysis for designing the power generation system, and definition of aircraft electrical power supply characteristics and consumer qualities. The discussion also covers reliability requirements for power generation systems, design of a power generation system, control and protection equipment in power generation systems, and helicopter electrical power systems. AIAA

A94-11374

LOAD MANAGEMENT

IAN MOIR (Smiths Industries Aerospace, Cheltenham, United Kingdom) *In* Aircraft generation and distribution systems; Proceedings of the Conference, London, United Kingdom, Oct. 14, 1992 London Royal Aeronautical Society 1992 p. 6.1-6.9. refs

Copyright

The development of the Electrical Load Management System (ELMS) for the Boeing 777 aircraft is reviewed. The discussion covers the overall design of the system, its principal components, and the functions it provides. Some of the additional system drivers, such as autoland electrical system partitioning and dispatch reliability, are outlined, and their effect on the system architecture is examined. The key technologies used in the development of the ELMS include smart high power contactors, ARING 629 data buses, the Motorola 68020 processor combined with Ada software, dedicated ASICs, and modular architecture for improved maintainability. AIAA

A94-11598

EVAPORATION AND CONVECTION FROM GLASS MELTS UNDER LOW AND HIGH G - DROP SHAFT AND AIRCRAFT EXPERIMENTS

MASAKI MAKIHARA, JUNJI HAYAKAWA (Government Industrial Research Inst., Ikeda, Japan), CHANDRA S. RAY, and DELBERT E. DAY (Missouri-Rolla Univ., Rolla) JASMA - Japan Society of Microgravity Application, Journal (ISSN 0915-3616) vol. 9, no. 3 1992 p. 186-194. In JAPANESE refs

Copyright

Evaporation and convection experiments on a 80PbO-20B2O3 (mol pct) melt held on a platinum wire were conducted under microgravity in a drop shaft (490 m free fall, 10 exp -4 g, 10 sec) and on an aircraft (10 exp -2 g, 20 sec). Companion experiments were also conducted at 2 g by banking the aircraft at 60 deg. Material evaporated from the melt on the platinum wire in a radial direction in the drop shaft experiments and condensed as small spherical particles on the glass enclosure. The gravity level affected the convection pattern of the evaporated material (particles) in the aircraft experiments. The small glass particles collected on the surface of the glass enclosure were analyzed with a scanning electron microscope and electron probe microanalyzer. Uniform spherical particles (from 0.2 to 0.3 micron) were produced under microgravity, while deformed particles of variable diameter (from 0.1 to 1 micron) were produced under 2 g. Author (revised)

A94-11602

MELTING AND SOLIDIFICATION OF AL-PB-BI ALLOY IN SHORT-DURATION MICROGRAVITY STUDIED USING AN AIRPLANE

HITOSHI KITAGUCHI and KAZUMASA TOGANO (National Research Inst. for Metals, Tsukuba, Japan) JASMA - Japan Society of Microgravity Application, Journal (ISSN 0915-3616) vol. 9, no. 4 1992 p. 257-265. In JAPANESE refs

Copyright

The Al-Pb-Bi system is a typical system with immiscible two-liquid solutions. Above the monotectic reaction temperature, Al-rich liquid solution and (Pb, Bi)-rich liquid solution coexist in the equilibrium. In this molten state, (Pb, Bi)-rich liquid drops can easily segregate gravitationally because of a large difference in density between two liquid solutions. On the other hand, in microgravity, there is no gravitational segregation and uniform dispersion of (Pb, Bi)-rich particles can be expected. In this paper, a microstructural study on Al-Pb-Bi alloy melted and solidified in a microgravity environment and in a terrestrial one is reported. The microgravity experiment was carried out by utilizing a parabolic flight of an airplane (Mitsubishi, MU-300). In this flight experiment, a microgravity environment with a duration of about 20 seconds was obtained. Another objective of this study is to establish a basic technique for high-temperature and short-duration experiments in microgravity. Author (revised)

A94-11603

FLUID BEHAVIOR IN A RECTANGULAR CELL IN THE CASE OF PARABOLIC FLIGHT OF AN AIRPLANE

SHOICH YOSHIHARA, MITURU OHNISHI, TANYA SIENKO, HISAO AZUMA (National Aerospace Lab., Chofu, Japan), and SEIZO ISHIKURA (Japan Space Utilization Promotion Center, Tokyo) JASMA - Japan Society of Microgravity Application, Journal (ISSN 0915-3616) vol. 9, no. 4 1992 p. 266-274. In JAPANESE refs

Copyright

The Convection Diffusion Unit (CDU) which is planned to be flown in 1994 aboard the IML-2 mission will use electrolysis and a pH indicator to track diffusion and fluid flow within an experimental container. This paper presents results from a set of preliminary low-gravity experiments used to confirm the effectiveness of this method for tracing fluid motions. The pitch of the airplane as well as acceleration along all three axes were measured, and a visualization of the fluid was obtained, in which movement was clearly indicated by the dye. Large rotations of the fluid were observed not only during the parabolic sections of the flight, but before and after as well. Magnitudes of the rotations were clearly seen to differ according to the pitch of the nose, the acceleration of the airplane, and the density distribution of the liquid. Author (revised)

A94-11848

ADVANCEMENTS IN AUTOMATIC FASTENING TECHNOLOGY

Aerospace Engineering (ISSN 0736-2536) vol. 13, no. 9 Sept. 1993 p. 7-9.

Copyright

An account is given of the design features and operational capabilities of the Gemcor wing-fastening system, which employs a six-position upper head assembly to achieve high fastener-positioning accuracy. The head apparatus is controlled by a closed-loop mechanism employing a linear encoder and precision linear guide bearings. Attention is given to the role of the drill and ream/shave spindle, the capacitance hole probe, the coldworking tool, and the bucking ram employed; statistical process control is applied throughout. AIAA

A94-11850

FOIL BEARINGS FOR GAS TURBINE ENGINES

Aerospace Engineering (ISSN 0736-2536) vol. 13, no. 9 Sept. 1993 p. 15-19.

Copyright

Foil bearings develop mechanical interactions which, through the generation of Coulomb damping, affect the dynamic stiffness and damping (DSD) characteristics of the bearing. An account is presently given of a test apparatus and program instituted to measure DSD characteristics. Attention is given to the foil bearing design parameters which primarily influence the dynamic stability of the bearing and the rotor it bears. The Taguchi test method, a fractional-factorial technique, was used to analyze the effects of bearing design parameters on DSD. AIAA

A94-11981

EVALUATION OF COOLING CONCEPTS FOR HIGH POWER AVIONICS APPLICATIONS

E. M. FLYNN (McDonnell Douglas Corp., Saint Louis, MO) Oct. 1992 13 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs

(Contract F33615-90-C-2054)

(SAE PAPER 921942) Copyright

Evaluations were made of emerging cooling technologies having potential to remove 100 W/sq cm steady state heat dissipation while holding chip junction temperature to 90 C. Several constraints were imposed on the cooler due to the intended application of cooling fighter aircraft electronics. Constraints included a practical lower limit on coolant supply temperature, the preference for a nontoxic, nonflammable, and nonfreezing coolant, the need to minimize weight and volume, and operation in an accelerating environment. Evaluation factors included aircraft system impact, cooler development status, reliability and maintainability, safety, etc. This paper describes the cooling concepts and assessments made as to their relative performance in a fighter aircraft environment. Author (revised)

A94-11983

ARTERIAL HEAT PIPE PERFORMANCE IN A TRANSIENT HEAT FLUX AND BODY FORCE ENVIRONMENT

KIRK L. YERKES and JERRY E. BEAM (USAF, Wright Lab., Wright-Patterson AFB, OH) Oct. 1992 18 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs

(SAE PAPER 921944) Copyright

This paper reports on the effects of transient transverse and axial acceleration forces with step changes in input power on the performance of a flexible copper/water arterial heat pipe. Transient transverse accelerations were generated using a centrifuge table to simulate acceleration forces typifying high performance aircraft maneuvering. These transients consisted of step changes, steady periodic, and burst cycles in the transverse acceleration forces. Steady periodic and burst cycle transverse accelerations had frequencies of 0.01 and 0.03 Hz with peak-to-peak values of 1.1 to 9.8 g. Partial depriming of the artery, pooling of the unconstrained working fluid, and fluid sloshing were found to have a significant impact on the heat transport potential and transient behavior of the heat pipe. Repriming of the heat pipe under thermal load while being subjected to transient transverse accelerations was also demonstrated.

A94-11985

FULL RANGE PAWL AND RATCHET CLUTCH

KEITH D. ZOBOTT and DARREL W. BURCH (AlliedSignal Aerospace, Torrance, CA) Oct. 1992 8 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992

(SAE PAPER 921946) Copyright

The full-range pawl-and-ratchet clutch will permit very versatile operation of an air turbine starter. The need for a full-range pawl-and-ratchet clutch arises from various aircraft anomalies that may lead to ordinary clutch failures and therefore cause unnecessary delays for commercial as well as military aircraft. Air turbine starters containing a full-range pawl-and-ratchet clutch permit running engagement starts of aircraft jet engines at any speed from zero to above 10,000 rpm. The starter automatically disengages from the engine after completing the start and spins down to zero rpm. The concept embodied in the full-range pawl-and-ratchet clutch will provide a new generation of aircraft starters and represents a revolutionary advancement in the state of the art for air turbine starters.

A94-11986
DESIGN IMPROVEMENTS IN AIR TURBINE START SYSTEMS
G. A. FARNSWORTH, C. W. PLEVICH, and K. DURNAL (AlliedSignal Aerospace, Torrance, CA) Oct. 1992 9 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992
(SAE PAPER 921947) Copyright

The main engine air turbine start system, which typically consists of an air turbine staxter and starter control valve, is a key contributor to aircraft dispatch reliability. Evolving aircraft propulsion systems have resulted in more aggressive operational environments, thus providing the impetus to improve the design of the start systems to enhance their durability and aid in improving both dispatch reliability and system responsiveness.

A94-11987
HYDRAZINE ENGINE START SYSTEM AIR START PERFORMANCE AND CONTROLS SIZING
ANDREW T. JOHNSON (AlliedSignal Aerospace, Torrance, CA) Oct. 1992 16 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921948) Copyright

Hydrazine has been used as an energy source in many applications to fuel in-flight main engine starting. In a current application, an existing hydrazine engine start system (ESS) design was adapted to meet new fuel control requirements. This paper presents a brief system description, historical context, and the motivating factors for the hydrazine controls changes and three case studies of controls design and analysis from the ESS program. Author (revised)

A94-11988
TURBINE WHEEL RELATIVE TEMPERATURE AT FREERUN CONDITIONS
DAVID M. MATHIS (AlliedSignal Aerospace, Torrance, CA) Oct. 1992 10 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(Contract F34601-90-C-1423)
(SAE PAPER 921949) Copyright

Analytical predictions and laboratory measurements were made for the relative total temperature experienced at the tip diameter of a radial-inflow turbine used in an air turbine starter (ATS). The predictions showed that at freerun conditions the blade tip temperature would be significantly higher than the turbine inlet temperature. Tests to confirm this prediction were performed on an ATS modified to accept an optical pyrometer. The pyrometer was focused on the suction side of the blade at the tip radius. Blade temperature measurements conducted at the maximum attainable speed of the ATS verified the prediction to be within the error of the pyrometer measuring system.

A94-11990
ANALYTICAL EVALUATION OF SERVOVALVES FOR FLIGHT SIMULATOR MOTION BASES
ENDRE A. MAYER Oct. 1992 11 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 921952) Copyright

This paper describes an analytical model suitable to study the effects of servovalve characteristics on flight simulator performance. The model considers flow non-linearities, servovalve edge sharpness, and lap conditions. The analytical model predicts the magnitude of the acceleration bump at velocity reversals. In addition it can calculate motion base terminal velocities from servovalve characteristics and load conditions. The analysis offers a powerful tool to optimize servovalve characteristics for best simulator performance.

A94-12011
ADVANCED DIAGNOSTICS RESEARCH FOR HIGH SPEED AERODYNAMIC TESTING
LINDA G. SMITH, CHARLES TYLER, and JOHN D. SCHMISSEUR (USAF, Wright Lab., Wright-Patterson AFB, OH) Oct. 1992 12 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Research supported by USAF refs
(SAE PAPER 922007) Copyright

Laser induced fluorescence, Rayleigh scattering, chermiluminescence, phase shift holographic interferometry, and optically smart surfaces are techniques being developed for use in the Wright Laboratory supersonic wind tunnels. These advanced diagnostics techniques will be used to provide quantitative point measurements of density, pressure, temperature, velocity, and surface strain for use in basic aerodynamic research and validation of computational fluid dynamics codes.

A94-12027
BIDIRECTIONAL STRINGER-STIFFENED PANEL BUCKLING PROCEDURES AND APPLICATION TO OPTIMUM AIRCRAFT STRUCTURES
RON D'VARI and KRISHNA HOFFMAN (Douglas Aircraft Co., Long Beach, CA) Oct. 1992 22 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 refs
(SAE PAPER 922036) Copyright

The analysis and design of stringer-stiffened skin panels of aircraft structures in an advanced design-definition stage are presently undertaken by an equivalent orthotropic membrane finite-element (EOMFE) procedure that is implemented with a large-scale aeroelastic design optimization program. A buckling criterion is invoked which decomposes the problem of evaluating the buckling stress allowables into three basis types: longitudinal, lateral, and in-plane shear. Three illustrative problems are solved analytically on the basis of a finite Fourier series representation of the buckling displacement. AIAA

A94-12055
FLOW VISUALIZATION OF HELICOPTER BLADE TIP VORTICES - A QUANTITATIVE TECHNIQUE TO DETERMINE THE TRAJECTORY AND THE POSITION OF THE TIP VORTEX PATTERN OF A MODEL ROTOR
E. MERCKER and KURT PENGEL (German-Dutch Wind Tunnel, Emmeloord, Netherlands) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

A visualization has been conducted of the tip vortex pattern of a descending model helicopter rotor, using a system that employs a continuous single-laser light sheet, a triggerable fast-motion video camera, a powerful strobe-light, and an oil smoke generator. The laser light sheet can be cast in any desired cross-section perpendicular to the plane by means of a two-degree-of-freedom traverse system. A reference grid was placed in the plane of the light sheet after the rotor and airstream were stopped, in order to quantify the distance between a given blade and the corresponding tip vortices. AIAA

A94-12109
SIMULTANEOUS TREATMENT OF FLEXION AND TORSION IN A GLOBAL MODAL APPROACH FOR THE CALCULATION OF BLADE DEFORMATIONS IN THE COMPREHENSIVE ROTOR CODE R85
BERNARD BENOIT and GILLES ARNAUD (Eurocopter France, Marignane) Sep. 1992 8 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by DRET refs

An effort has been made to take into account torsion-related rotor blade deformation in the comprehensive rotor simulation code designated R85. The method used combines flexing and torsion in arriving at vibration modes. The equations of motion are in the form of an energetic rather than force-balance approach, in order to minimize the number of unknowns. Blade deformation is obtained by solving the Lagrange equations. AIAA

A94-12198
INCOMPRESSIBLE FLOW IN CONTRACTING DUCTS
J. C. GIBBINGS (Liverpool Univ., United Kingdom) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 967 Aug.-Sept. 1993 p. 230-246. refs
Copyright

This paper describes the incompressible flow through contracting ducts as used in wind tunnel circuits. The value of the velocity gradients that are critically adverse to the boundary layer development are specified and the contraction profile is derived for 2D flow. Solutions to the flow through 3D contractions of circular, square, and square to rectangle shape are obtained. These lead to simple rules for scaling the profile of 2D flow to provide 3D shapes having short lengths with the required velocity distributions. The development of both laminar and turbulent boundary layers is calculated to provide criteria for the avoidance of separation.
Author (revised)

A94-12239
CHARACTERISTICS OF METAL-POLYMERIC BEARINGS OF BLADE DRAG HINGES, REALIZED ON COAXIAL HELICOPTERS
A. Z. VORONKOV and N. A. TRIFONOVA (Kamov Helicopter Scientific and Technology Co., Russia) 1992 11 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

Problems associated with the measurement of the moment values of metal-polymer dry sliding bearings used in the blade drag hinges of coaxial helicopters are briefly reviewed. The moment values of these bearings are usually measured during ground resonance helicopter tests; reproducing similar test conditions in the laboratory on a test rig, however, is a difficult task. Here, an algorithm is proposed which may be used to determine the characteristics of metal-polymer bearings under ground resonance test conditions in the region close to the boundary area of the allowable moment values. AIAA

A94-12267
SIMULTANEOUS RASTER AND CALLIGRAPHIC CRT PROJECTION SYSTEM FOR FLIGHT SIMULATION
THOMAS L. MARTZALL (VITAL Advanced Display Systems Group, Saint Charles, MO) *In* Electroluminescent materials, devices, and large-screen displays; Proceedings of the Meeting, San Jose, CA, Feb. 1, 2, 1993 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1993 p. 292-299.
Copyright

The presently reported development of a simultaneous raster and calligraphic projection system with a reliable, maintainable and cost-effective solution to current demand for ultrahigh resolution flight-simulator system displays, enhancing scene content over existing sequential raster/calligraphic systems while meeting all design requirements. The additional time available in this simultaneous raster system can be used for additional raster/polygon computation time or reduced clock speeds, as well as to support larger fields of view and reduced visual anomalies due to aliasing. AIAA

A94-12287
TRIAL OF A SLANT VISUAL RANGE MEASURING DEVICE
JURGEN STREICHER (DLR, Inst. fuer Optoelektronik, Oberpfaffenhofen, Germany), C. MUENKEL (Hagenuk GmbH, Hamburg, Germany), and H. BORCHARDT (German Meteorological Service, Hamburg, Germany) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572) vol. 10, no. 5 Oct. 1993 p. 718-724. refs
Copyright

Each year fog at airports renders some landing operations either difficult or impossible. In such instances, visibility is the most important information for the pilot of a landing aircraft. Visibility may be constant, decreasing, or increasing with respect to the altitude; however, it is not possible to distinguish this with existing airport sensors. This paper describes a new technique for measuring slant visual range that makes use of a slant scanning device, an eye-safe laser radar. This device has been tested by the German Meteorological Service in Quickborn, Germany, over a period of one year. A comparison with commercial visibility sensors shows that it is possible to measure visibilities with the slant-looking laser radar in the range from 50 m up to 2000 m and to even distinguish inhomogenities like ground fog. Statistics of the Quickborn measurements show that the atmosphere in that region is not homogeneous in 38 percent of fog situations, which would at the present lead to a redistribution of the air traffic. The first installation of this instrument at the Hamburg airport is described.

A94-12290
A TECHNIQUE TO ACCOUNT FOR THE MISALIGNMENT OF PYRANOMETERS INSTALLED ON AIRCRAFT
L. BANNEHR and R. SCHWIESOW (NCAR, Boulder, CO) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572) vol. 10, no. 5 Oct. 1993 p. 774-777. refs
Copyright

Misalignment of pyranometers used for airborne measurements can lead to serious errors in the determination of downwelling radiation flux. The magnitude of these errors depends strongly on the elevation angle of the sun. This note presents an iterative numerical procedure for determining the angles of misalignment of upward-facing pyranometers. Deviations in pitch and roll of the instrument with respect to the aircraft's INS must be added to the pitch and roll angles measured by the INS before the radiometric data are corrected for the attitude of the aircraft. For successful determination of the two angles of deviation, a calibration flight must be performed in which the aircraft flies in at least three directions at the same altitude under clear skies and above any haze.

A94-12346
EFFECT OF LOCALIZED BENDING AT THROUGH-FLAWS IN PRESSURIZED COMPOSITE CYLINDERS
KEVIN J. SAEGER (Inst. for Defense Analyses, Alexandria, VA) and PAUL A. LAGACE (MIT, Cambridge, MA) Journal of Aerospace Engineering (ISSN 0893-1321) vol. 6, no. 4 Oct. 1993 p. 381-393. AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Pt. 2, p. 966-972. Previously cited in issue 11, p. 1697, Accession no. A90-29320 refs
Copyright

A94-12376* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STUDIES IN TURBULENCE
THOMAS B. GATSKI, ED. (NASA, Langley Research Center, Hampton, VA), SUTANU SARKAR, ED., and CHARLES G. SPEZIALE, ED. (ICASE; NASA, Langley Research Center, Hampton, VA) New York Springer-Verlag 1992 615 p. For individual items see A94-12377 to A94-12409
(ISBN 0-387-97613-2) Copyright

Various papers on turbulence are presented. Individual topics addressed include: modeling the dissipation rate in rotating turbulent flows, mapping closures for turbulent mixing and reaction, understanding turbulence in vortex dynamics, models for the structure and dynamics of near-wall turbulence, complexity of turbulence near a wall, proper orthogonal decomposition, propagating structures in wall-bounded turbulence flows. Also discussed are: constitutive relation in compressible turbulence, compressible turbulence and shock waves, direct simulation of compressible turbulence in a shear flow, structural genesis in wall-bounded turbulence flows, vortex lattice structure of turbulent shear slows, etiology of shear layer vortices, trilinear coordinates in fluid mechanics. AIAA

A94-12397
INTERACTION BETWEEN CHEMICAL REACTION AND TURBULENCE IN SUPERSONIC NONPREMIXED H2-AIR COMBUSTION
R. VILLASENOR, J.-Y. CHEN, and R. W. PITZ (Vanderbilt Univ.,

Nashville, TN) *In* Studies in turbulence New York Springer-Verlag 1992 p. 357-370. Research supported by DOE refs
(Contract NSF CBT-86-57131)
Copyright
A numerical model for supersonic turbulent nonpremixed hydrogen-air jet flames is developed for exploring the interaction between chemical reaction and turbulence. The numerical code employs an implicit finite-volume, lower-upper successive overrelaxation scheme for solving density-averaged Navier-Stokes equations with chemical reactions in axisymmetric flows. The effects of turbulence on chemical reaction are included by approximations appropriate in the limit of weak turbulence. Comparison of numerical results with and without the influence of turbulence on the chemical kinetics reveals that even under the condition of weak turbulence, the effect of turbulence on chemistry can be significant. Author (revised)

A94-12402
CONDITIONALLY SAMPLED VORTICITIES AND NEAR-WALL TURBULENCE STRUCTURE
KWING-SO CHOI (British Maritime Technology, Teddington, United Kingdom) *In* Studies in turbulence New York Springer-Verlag 1992 p. 447-460. Research supported by British Aerospace, PLC and Department of Trade and Industry of United Kingdom refs
Copyright
Vorticity maps of the turbulent boundary layer over the riblet surface during the near-wall burst, an event associated with a downwash of high-momentum fluid giving rise to a high wall-skin friction, were constructed using experimental data obtained in a wind tunnel at a constant adverse pressure gradient condition. They seem to support the conceptual model of near-wall turbulence activities proposed by Choi, depicting a downwash sequence close to the wall in an early part of the near-wall burst, followed by an up-wash sequence away from the wall. The following downwash sequence was found to be shifted in spanwise direction by a half spacing of the near-wall structure, suggesting that the near-wall bursts take place in a staggered fashion. Author (revised)

A94-12413* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PROCESSING INFRARED IMAGES OF AIRCRAFT LAPJOINTS
HAZARI SYED (Analytical Services and Materials, Inc., Hampton, VA), WILLIAM P. WINFREE, and K. E. CRAMER (NASA, Langley Research Center, Hampton, VA) *In* Thermosense XIV; Proceedings of the International Conference on Thermal Sensing and Imaging Diagnostic Applications, Orlando, FL, Apr. 22-24, 1992 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1992 p. 171-177. refs
(Contract NAS1-19236)
Copyright
Techniques for processing IR images of aging aircraft lapjoint data are discussed. Attention is given to a technique for detecting disbonds in aircraft lapjoints which clearly delineates the disbonded region from the bonded regions. The technique is weak on unpainted aircraft skin surfaces, but can be overridden by using a self-adhering contact sheet. Neural network analysis on raw temperature data has been shown to be an effective tool for visualization of images. Numerical simulation results show the above processing technique to be an effective tool in delineating the disbonds. AIAA

A94-12415
AUTOMATIC DEFECTS RECOGNITION IN COMPOSITE AEROSPACE STRUCTURES FROM EXPERIMENTAL AND THEORETICAL ANALYSIS AS PART OF AN INTELLIGENT INFRARED THERMOGRAPHIC INSPECTION SYSTEM
D. DAVID, J. Y. MARIN, and H. TRETOUT (Dassault Aviation, Saint-Cloud, France) *In* Thermosense XIV; Proceedings of the International Conference on Thermal Sensing and Imaging Diagnostic Applications, Orlando, FL, Apr. 22-24, 1992 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1992 p. 182-193. Research supported by DRET refs
Copyright
An original concept for IR thermography nondestructive testing is validated. The principles of image and data processing investigated and developed as well as the utilization of AI should be transposable to other nondestructive techniques such as ultrasounds and X-rays. It is shown that modeling can be used in different ways to play a great part in the detection, the interpretation, and the sizing of the defects. The original concept lies in the comparison of experimental data with theoretical ones in order to identify regions of abnormal behavior related to defects. A Laplace transforms analytical method is successfully implemented in the case of composite materials such as graphite epoxy to identify a set of thermal parameters which contributes to the expertise. This approach is extended to a more complicated composite material such as Kevlar, which presents semitransparent characteristics. This modeling technique, which expresses experimental data in terms of thermal parameters, makes it possible to increase SNR and reduce the number of thermal images to be processed. AIAA

A94-12422
INFRARED IMAGING OF MICROWAVE SOURCES
MILTON R. SEILER, JOHN L. HASELWOOD, and LARRY A. STOCKUM (Battelle, Columbus, OH) *In* Thermosense XIV; Proceedings of the International Conference on Thermal Sensing and Imaging Diagnostic Applications, Orlando, FL, Apr. 22-24, 1992 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1992 p. 296-307. refs
Copyright
An IR imaging technique for testing phased array radars at the system level in the field has been defined and demonstrated in a laboratory test setup. The technique uses a thin radar absorbing film material which is placed near the antenna structure to create thermal patterns which are viewed by an infrared imaging sensor. The thin film sheet resistance can be controlled to vary the absorption, reflection, and sheet temperature characteristics. The infrared image is calibrated radiometrically to provide measures of the microwave power density. Additionally, the thermal profiles show the effect of phasing differences between adjacent antenna elements. This paper describes the predicted and measured thermal characteristics of the absorbing material for a particular S-band waveguide source. This demonstration has shown the feasibility of using an imaging infrared sensor to provide rapid diagnostic evaluation of a phased array antenna.

A94-12423* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIRABLE FEATURES OF AN INFRARED IMAGING SYSTEM FOR AERODYNAMIC RESEARCH
ROBERT E. WRIGHT, JR. (NASA, Langley Research Center, Hampton, VA), CHITH K. PURAM (Vigyan, Inc., Hampton, VA), and KAMRAN DARYABEIGI (NASA, Langley Research Center, Hampton, VA) *In* Thermosense XIV; Proceedings of the International Conference on Thermal Sensing and Imaging Diagnostic Applications, Orlando, FL, Apr. 22-24, 1992 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1992 p. 315-324. refs
(Contract NAS1-18585)
Copyright
Advantage of non-intrusiveness, capability for field measurement, and increased availability of IR imaging systems have resulted in their wider use for aerodynamic research. However, certain difficulties persist while using currently available systems for such applications. A critical evaluation of the IR imaging systems is presented on the basis of the state-of-the-art of IR imaging technology and experiences in wind tunnel and flight testing at NASA's Langley Research Center. The requirements for using IR thermography as a measurement tool in aerodynamic research are examined in terms of range, sensitivity, and accuracy of temperature measurement, temporal and spatial resolution, and features of target. Deficiencies of present IR imaging systems are

identified, and user precautions to avoid such problems by proper selection and operation of these units are suggested. Different aspects of imager performance such as imager optics, video capabilities, and environmental tolerance are discussed. Electronic data recording and image processing hardware and software requirements are evaluated. Slit response tests and spatial resolution are discussed with the objective of obtaining reliable, accurate, and meaningful information from IR thermography measurements for aerodynamic studies. Author (revised)

A94-12504

MODAL ANALYSIS FOR DISORDERED PERIODIC OR NEARLY PERIODIC STRUCTURES

WEIDE LUO and HAO WANG (Fudan Univ., Shanghai, China) *In* International Modal Analysis Conference, 10th, San Diego, CA, Feb. 3-7, 1992, Proceedings. Vol. 1 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 606-611. refs

Copyright

An investigation of modal analysis for disordered periodic or nearly periodic structures is presented. An eigenvalue surface determined by two parameters of coupled pendulums is shown, and thus an interpretation of mode localization is given. For general complex continuous structures, the concepts of 'coupling value R', 'mistuning value Delta', and (R, Delta) parameter plane are proposed. As an example, a mistuned assembly of bladed disk is studied; dimensionless frequency loci curves are plotted. The authors suggest that one can predict the occurrence of mode localization in accordance with the region in (R, Delta) plane where the structure locates. This paper also discusses the suitable computational methods of modal analysis for disordered coupled structures. An analytical solution of modes of mistuned pendulums-chain in weak coupling condition is shown.

Author (revised)

A94-12510

HIGH FREQUENCY POWER FLOW IN STRUCTURES

J. D. PALMER, E. J. WILLIAMS, and C. H. J. FOX (Nottingham Univ., United Kingdom) *In* International Modal Analysis Conference, 10th, San Diego, CA, Feb. 3-7, 1992, Proceedings. Vol. 1 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 701-707. Research supported by Rolls-Royce, PLC and Associates refs

Copyright

This paper considers dynamic response and power flow in structures in high frequency, modally rich regimes where conventional structural finite element calculations may become uneconomic. An alternative approach, based on an analogy between vibrational and thermal energy transmission is presented. One of the principal advantages of the method lies in its ability to use a conventional structural finite element mesh, developed originally for low frequency analysis, to extend power flow predictions into higher frequency regions.

A94-12516

USING OPTIMIZATION FOR BALANCING FLEXIBLE ROTORS

V. STEFFEN, JR. and H. B. LACERDA (Uberlandia Federal Univ., Brazil) *In* International Modal Analysis Conference, 10th, San Diego, CA, Feb. 3-7, 1992, Proceedings. Vol. 2 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 810-815. refs

Copyright

Optimization techniques are used for balancing flexible rotors: modal information is used to reduce the number of experimental readings and global strain energy minimization is used to determine correction masses and their corresponding angle positions. Optimization results are compared to those obtained using influence coefficients. Experimental results validate the simulations procedures.

A94-12519 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DYNAMIC TESTING AND ANALYSIS OF EXTENSION-TWIST-COUPLED COMPOSITE TUBULAR SPARS

RENEE C. LAKE (U.S. Army, Aerostructures Directorate; NASA, Langley Research Center, Hampton, VA), AMIR P. IZAPANAH (Vigyan, Inc.; NASA, Langley Research Center, Hampton, VA; NASA, Ames Research Center, Moffett Field, CA), and ROBERT M. BAUCON (NASA, Langley Research Center, Hampton, VA) *In* International Modal Analysis Conference, 10th, San Diego, CA, Feb. 3-7, 1992, Proceedings. Vol. 2 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 879-885. refs

Copyright

The results from a study aimed at improving the dynamic and aerodynamic characteristics of composite rotor blades through the use of extension-twist elastic coupling are presented. A set of extension-twist-coupled composite tubular spars, representative of the primary load carrying structure within a helicopter rotor blade, was manufactured using four plies of woven graphite/epoxy cloth 'prepreg.' These spars were non-circular in cross section design and were therefore subject to warping deformations. Three cross-sectional geometries were developed: square, D-shape, and flattened ellipse. Results from free-free vibration tests of the spars were compared with results from normal modes and frequency analyses of companion shell-finite-element models developed in MSC/NASTRAN. Five global or 'non-shell' modes were identified within the 0-2000 Hz range for each spar. The frequencies and associated mode shapes for the D-shape spar were correlated with analytical results, showing agreement within 13.8 percent. Frequencies corresponding to the five global mode shapes for the square spar agreed within 9.5 percent of the analytical results. Five global modes were similarly identified for the elliptical spar and agreed within 4.9 percent of the respective analytical results.

Author (revised)

A94-12531

TRANSIENT AND STABILITY ANALYSIS OF LARGE SCALE ROTOR-BEARING SYSTEM WITH STRONG NONLINEAR ELEMENTS BY THE MODE SUMMATION-TRANSFER MATRIX METHOD

ZHIPING GU (Xian Inst. of Technology, China) *In* International Modal Analysis Conference, 10th, San Diego, CA, Feb. 3-7, 1992, Proceedings. Vol. 2 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 1040-1045. refs

Copyright

This paper extends Riccati transfer matrix method to the transient and stability analysis of large scale rotor-bearing systems with strong nonlinear elements, and proposes a mode summation-transfer matrix method, in which the field transfer matrix of a distributed mass uniform shaft segment is obtained with the aid of the idea of mode summation and Newmark beta formulation, and the Riccati transfer matrix method is adopted to stablize the boundary value problem of the nonlinear systems. In this investigation, the real nonlinearity of the strong nonlinear elements is considered, not linearized, and the advantages of the Riccati transfer matrix are retained. So, this method is especially applicable to analyze the transient response and stability of large-scale rotor-bear systems with strong nonlinear elements. One example, a single-spool rotating system with strong nonlinear elements, is given. The obtained results show that this method is superior to that of Gu and Chen (1990) in accuracy, stability, and economy.

Author (revised)

A94-12536

SYSTEM DYNAMICS SIMULATION BASED ON STRUCTURAL MODIFICATION ANALYSIS USING RESPONSE TECHNIQUES

TEIK C. LIM and GLEN C. STEYER (Structural Dynamics Research Corp., Milford, OH) *In* International Modal Analysis Conference, 10th, San Diego, CA, Feb. 3-7, 1992, Proceedings. Vol. 2 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 1153-1158. refs

Copyright

In an earlier paper, a practical numerical simulation scheme based on the structural modification analysis using response technique (SMART) (Lim and Steyer (1991) was proposed for system dynamics simulation over a wide high frequency spectrum. It is a composite dynamic impedance method which assembles the total system equations of motion using constrained FEMs of low modal density components and experimental frequency response function models of unrestrained high modal density components. In this paper, the proposed response technique is revisited. Using a numerical example, SMART is shown to be superior to the complex vector method. The complex vector method is used in engineering practice for predicting approximate dynamic response of one component due to external dynamic forces on another connecting component. It ignores the dynamic coupling among connected components. For systems with weakly coupled components, SMART reduces to the complex vector method. Further, a hybrid system dynamics simulation approach based on a mixture of SMART and the complex vector method is developed for analyzing systems with both strong and weak dynamic couplings. The advantage of this hybrid approach is the inversion of smaller sub-matrices from experimental components which improves computational efficiency and reduces the risk of measurement error magnification. Author (revised)

A94-12544
TRANSIENT RESPONSE OF ACCELERATING ROTOR SYSTEMS
P. S. HEYNS and E. STARKER (Pretoria Univ., South Africa) *In* International Modal Analysis Conference, 10th, San Diego, CA, Feb. 3-7, 1992, Proceedings. Vol. 2 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 1389-1392. refs
Copyright

A simple but versatile and effective methodology to investigate the transient response of accelerating rotor systems is presented. The rotor is identified in terms of its free-free modal characteristics, and is supported through bearings modelled in terms of state dependent force models. Typical rotor phenomena like unbalance forces and gyroscopic moments are treated as pseudo-external forces.

A94-12651* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FLIGHT-VEHICLE MATERIALS, STRUCTURES, AND DYNAMICS - ASSESSMENT AND FUTURE DIRECTIONS. VOL. 4 - TRIBOLOGICAL MATERIALS AND NDE
ROBERT L. FUSARO, ED. (NASA, Lewis Research Center, Cleveland, OH) and J. D. ACHENBACH, ED. (Northwestern Univ., Evanston, IL) New York American Society of Mechanical Engineers 1993 433 p. For individual items see A94-12652 to A94-12673
(ISBN 0-7918-0662-6) Copyright

The present volume on tribological materials and NDE discusses liquid lubricants for advanced aircraft engines, a liquid lubricant for space applications, solid lubricants for aeronautics, and thin solid-lubricant films in space. Attention is given to the science and technology of NDE, tools for an NDE engineering base, experimental techniques in ultrasonics for NDE and material characterization, and laser ultrasonics. Topics addressed include thermal methods of NDE and quality control, digital radiography in the aerospace industry, materials characterization by ultrasonic methods, and NDE of ceramics and ceramic composites. Also discussed are smart materials and structures, intelligent processing of materials, implementation of NDE technology on flight structures, and solid-state weld evaluation. AIAA

A94-12657 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MAGNETIC BEARINGS - STATE OF THE ART
DAVID P. FLEMING (NASA, Lewis Research Center, Cleveland, OH) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 4 - Tribological materials and NDE New York American Society of Mechanical Engineers 1993 p. 133-148. Previously announced in STAR as N91-25413 refs
(Contract RTOP 505-63-5B)
Copyright

Magnetic bearings have existed for many years, at least in theory. Earnshaw's theorem, formulated in 1842, concerns stability of magnetic suspensions, and states that not all axes of a bearing can be stable without some means of active control. In Beam's widely referenced experiments, a tiny (1/64 in diameter) rotor was rotated to the astonishing speed of 800,000 rps while it was suspended in a magnetic field. Despite a long history, magnetic bearings have only begun to see practical application since about 1980. The development that finally made magnetic bearings practical was solid state electronics, enabling power supplies and controls to be reduced in size to where they are now comparable in volume to the bearings themselves. An attempt is made to document the current (1991) state of the art of magnetic bearings. The referenced papers are large drawn from two conferences publications published in 1988 and 1990 respectively.

A94-12658
INTRODUCTION - THE SCIENCE AND TECHNOLOGY OF NDE
J. D. ACHENBACH (Northwestern Univ., Evanston, IL) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 4 - Tribological materials and NDE New York American Society of Mechanical Engineers 1993 p. 153-166. refs
Copyright

NDE is an emerging engineering discipline encompassing quantitative measurement techniques, physical models for computational analysis, statistical considerations, quantitative design of measurement systems, and reliability analyses. Attention is here given to the development status of such NDE procedures as LF and HF eddy currents, sonic and ultrasonics, X-ray radiography, neutron radiography, magnetic particle methods, laser-based optical methods, X-ray diffraction, thermal-wave imaging, and acoustic emission. AIAA

A94-12665* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACOUSTIC EMISSION MEASUREMENTS OF AEROSPACE MATERIALS AND STRUCTURES
WOLFGANG SACHSE (Cornell Univ., Ithaca, NY) and MICHAEL R. GORMAN (U.S. Naval Postgraduate School, Monterey, CA) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 4 - Tribological materials and NDE New York American Society of Mechanical Engineers 1993 p. 263-280. Research supported by U.S. Navy and NASA refs
Copyright

A development status evaluation is given for aerospace applications of AE location, detection, and source characterization. Attention is given to the neural-like processing of AE signals for graphite/epoxy. It is recommended that development efforts for AE make connections between the material failure process and source dynamics, and study the effects of composite material anisotropy and inhomogeneity on the propagation of AE waves. Broadband, as well as frequency- and wave-mode selective sensors, need to be developed. AIAA

A94-12666
MATERIALS CHARACTERIZATION BY ULTRASONIC METHODS
R. B. THOMPSON (Iowa State Univ. of Science and Technology, Ames) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 4 - Tribological materials and NDE New York American Society of Mechanical Engineers 1993 p. 281-298. refs
Copyright

Ultrasonic techniques are capable of high sensitivity to material structure and are applicable to all symmetries. Attention is given to ultrasonic detection capabilities with respect to grain size, preferred grain orientation, porosity, second-phase content, solid-state bonds, and fatigue and stress phenomena. Prospectively, superior interpretation of experimental data will require a deeper understanding of beam propagation; current techniques for stress measurement yield poor resolution, which may be significantly improved with suitable tomographic techniques. AIAA

A94-12673
IMPLEMENTATION OF NDE TECHNOLOGY ON FLIGHT STRUCTURES
WARD D. RUMMEL *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 4 - Tribological materials and NDE New York American Society of Mechanical Engineers 1993 p. 385-400. refs
Copyright
After presenting a development history of NDE implementation, and evaluating successes and failures to date in this field, an account is given of prospective developments required for the implementation of improved NDE for flight structures. Attention is given to the NDE-implementation challenges to be faced by researchers, engineering education, industry, and government agencies. Future requirements for improved life-cycle value addition to flight structures through NDE are noted. AIAA

A94-12676 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLIGHT-VEHICLE MATERIALS, STRUCTURES, AND DYNAMICS - ASSESSMENT AND FUTURE DIRECTIONS. VOL. 5 - STRUCTURAL DYNAMICS AND AEROELASTICITY
AHMED K. NOOR, ED. (Virginia Univ.; NASA, Langley Research Center, Hampton) and SAMUEL L. VENNERI, ED. (NASA, Washington) New York American Society of Mechanical Engineers 1993 521 p. For individual items see A94-12677 to A94-12698
(ISBN 0-7918-0663-4) Copyright
Various papers on flight vehicle materials, structures, and dynamics are presented. Individual topics addressed include: general modeling methods, component modeling techniques, time-domain computational techniques, dynamics of articulated structures, structural dynamics in rotating systems, structural dynamics in rotorcraft, damping in structures, structural acoustics, structural design for control, structural modeling for control, control strategies for structures, system identification, overall assessment of needs and benefits in structural dynamics and controlled structures. Also discussed are: experimental aeroelasticity in wind tunnels, aeroservoelasticity, nonlinear aeroelasticity, aeroelasticity problems in turbomachines, rotary-wing aeroelasticity with application to VTOL vehicles, computational aeroelasticity, structural dynamic testing and instrumentation. AIAA

A94-12682
STRUCTURAL DYNAMICS IN ROTORCRAFT
JOHN DUGUNDJI (MIT, Cambridge, MA) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 5 - Structural dynamics and aeroelasticity New York American Society of Mechanical Engineers 1993 p. 61-66. refs
Copyright
Recent advances in the structural dynamics of rotorcraft are briefly reviewed. Attention is given to blade equations, aerodynamic loading, isolated blade response, rotor/fuselage interaction, active control of blades, and structural optimization. Directions for future research are suggested. AIAA

A94-12691
AEROELASTICITY
TERRENCE A. WEISSHAAR (Purdue Univ., West Lafayette, IN) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 5 - Structural dynamics and aeroelasticity New York American Society of Mechanical Engineers 1993 p. 147-150.
Copyright
A summary is presented of the papers on aeroelasticity published in this volume. The significance of the topic of aeroelasticity for aerospace engineering is briefly discussed. AIAA

A94-12694
NONLINEAR AEROELASTICITY
EARL H. DOWELL (Duke Univ., Durham, NC) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 5 - Structural dynamics and aeroelasticity New York American Society of Mechanical Engineers 1993 p. 213-239. refs
Copyright
The physical domain of nonlinear aeroelasticity is considered. The consequences of nonlinearity for constructing mathematical models are discussed. Representative results on the flutter of airfoils in transonic flow, the flutter of airfoils at high angle of attack, the flutter of an airfoil with free-play structural nonlinearities, nonlinear fluid oscillator models in bluff body aeroelasticity, and flutter of plates and shells are presented. Some considerations for the future are outlined. AIAA

A94-12776
NUMERICAL METHODS IN STRUCTURAL MECHANICS [CHISLENNYE METODY STROITEL'NOJ MEKHANIKI]
I. F. OBRAZTSOV, ED. Moscow Moskovskij Aviatsionnyj Institut 1990 76 p. In RUSSIAN *For individual items see* A94-12777 to A94-12788
Copyright
The papers contained in this volume focus on numerical, numerical-analytical, and theoretical methods for dealing with strength, stability, and dynamics problems in the design of the structural elements of flight vehicles. Topics discussed include the solution of homogeneous boundary value problems for systems of ordinary differential equations modified by a difference factorization method, a study of the rupture strength of a welded joint between plates, singular solutions in mixed problems for a wedge and a half-strip, and a thermoelasticity problem for an open-profile cylindrical shell with a localized temperature field. AIAA

A94-12784
USING STRENGTH CONDITIONS IN THE FORM OF INEQUALITIES IN THE DESIGN OF RIVETED JOINTS FOR PLANE STRUCTURAL ELEMENTS OF AIRCRAFT [ISPOL'ZOVANIE USLOVIJ PROCHNOSTI V FORME NERAVENSTV PRI PROEKTIROVANII ZAKLEPOCHNYKH SOEDINENIJ PLOSKIKH EHLEMENTOV AVIATSIONNYKH KONSTRUKTSIJ]
V. V. PAPKO *In* Numerical methods in structural mechanics Moscow Moskovskij Aviatsionnyj Institut 1990 p. 48-55. In RUSSIAN
Copyright
An analysis is made of the strength and various failure modes of riveted joints in plane structural elements. The strength conditions of the joint elements are described in terms of inequalities. The acceptable values of the joint parameters are then selected for points within the regions defined by the inequalities. The uniqueness of the solution is achieved by imposing additional constraints (e.g., weight, size, and process-related factors). AIAA

A94-12817
HEAT TRANSFER AND HYDRODYNAMICS ON THE CONVEX AND CONCAVE SURFACES GAS TURBINE NOZZLE RINGS WITH INTENSE SECONDARY AND VORTEX FLOWS [TEPLOOBMEN I GIDRODINAMIKA NA VYPUKLOJ I VOGNUTOJ POVERKHNOSTYAKH SOPLOVYKH APPARATOV GAZOVYKH TURBIN S INTENSIVNYMI VTORICHNYMI I VIKHREVYMI TECHENIYAMI]
A. A. KHALATOV, A. A. AVRAMENKO, L. V. SYSKOV, M. A. LITVINENKO, and S. A. KHALATOV (ANU, Inst. Tekhnicheskoj Teplofiziki, Kiev, Ukraine) Promyshlennaya Teplotekhnika (ISSN 0204-3602) vol. 14, no. 4-6 July-Dec. 1992 p. 3-14. In RUSSIAN refs
Copyright
Results of an experimental study of hydrodynamics and local heat transfer on the convex and concave surfaces of nozzle ring blades of low relative height are reported. The effect of secondary and vortex flows on heat transfer is determined; similarity equations are obtained for the heat transfer coefficients. Attention is also

given to the effect of the initial temperature inhomogeneity on distributions of flow temperature and heat transfer coefficients in the blade passage. AIAA

A94-12819
A THERMOMETRIC METHOD FOR MONITORING THE HEAT INSULATION COATINGS OF FLIGHT VEHICLES [TEPLOMETRICHESKIJ METOD KONTROLYA TEPLOZASHCHITNYKH POKRYTIJ LETATEL'NYKH APPARATOV]
V. F. VISHNYAK, O. I. DIDENKO, and N. M. KONDAK (ANU, Inst. Tekhnicheskoj Teplofiziki, Kiev, Ukraine) Promyshlennaya Teplotekhnika (ISSN 0204-3602) vol. 14, no. 4-6 July-Dec. 1992 p. 104-109. In RUSSIAN
Copyright
A method is proposed for determining the coordinates of damage in the heat shield coatings of flight vehicles. The method is based on measuring the density of heat flows through the vehicle skin before and after the damage. Results of calculations for two- and three-dimensional models are presented for a range of damage shapes, sizes and depths. AIAA

A94-12825
HEAT AND MASS TRANSFER IN THE STRUCTURAL ELEMENTS OF AIRCRAFT ENGINES [TEPLO- I MASSOOBMEN V EHLEMENTAKH KONSTRUKTSII DVIGATELEJ LETATEL'NYKH APPARATOV]
V. K. KOSHKIN, ED. Moscow Moskovskij Aviatsionnyj Institut 1990 88 p. In RUSSIAN No individual items are abstracted in this volume
Copyright
The papers presented in this volume deal with a variety of heat and mass transfer problems related to the operation of aircraft. Topics discussed include an experimental study of the effect of the nozzle exit angle on the trajectory and dimensions of a jet issuing in a cross stream, estimation of the strength characteristics of a composite material based on a fabric made of high-modulus fibers, ablation under conditions of discontinuous changes of surface heat flow, and the problem of reducing the contact thermal resistance. Papers are also presented on gas flow in a duct with porous walls, mass composition of a flow desorbed from the surface, and analysis of errors in thermocouple measurements of the wall temperature oscillation amplitude. AIAA

A94-12866
A HYDRODYNAMIC JOURNAL BEARING TEST RIG WITH DYNAMIC MEASUREMENT CAPABILITIES
RONALD D. FLACK (Virginia Univ., Charlottesville), GREGORY J. KOSTRZEWSKY (Reliance Electric, Columbus, IN), and DAVID V. TAYLOR (KTB Consultants, Wakefield, RI) STLE Tribology Transactions (ISSN 0569-8197) vol. 36, no. 4 Oct. 1993 p. 497-509. ASME and STLE, Tribology Conference, San Diego, CA, Oct. 19-21, 1992 Research supported by ROMAC Industrial Research Program refs
Copyright
A bearing test rig was developed to characterize the static and dynamic properties of hydrodynamic journal bearings. Static measurement capabilities include operating eccentricity, pressure and thermal boundary conditions, and continuous circumferential pressure and film thickness profiles at multiple axial planes. Dynamic stiffness and damping coefficient measurements are achieved using steady state harmonic excitations generated by a two-axis shaker system. All essential data for a complete understanding of one particular bearing can be collected simultaneously. To ensure high quality results, the rig was designed to minimize the influence of measurement uncertainties on the derived dynamic coefficients. Complete details are described. The rig is configured to test bearings with 70 mm bore diameters at speeds up to 2500 rpm and loads up to 6000 N. The data reduction technique is presented along with typical results at one steady operating position for a three-lobe bearing which demonstrate the reproducibility and dependability of the data. For the reported data, dynamic stiffness and damping values for three independent sets of data are within 13 percent at worst and usually within 3 percent. Typical uncertainties are less than 10 percent for stiffness and less than 30 percent for damping.

A94-12871
EFFECTS OF VAPOR CAVITATION AND FLUID INERTIA ON THE FORCE COEFFICIENTS OF A SQUEEZE FILM DAMPER. I - ANALYSIS OF A LONG SFD
SI Y. JUNG and JOHN M. VANCE (Texas A & M Univ., College Station) STLE Tribology Transactions (ISSN 0569-8197) vol. 36, no. 4 Oct. 1993 p. 597-604. Research supported by Texas A & M Univ refs
Copyright
The effect vapor cavitation on the pressure distribution and the force coefficients of a long squeeze film damper executing circular centered orbits is studied in association with the Swift-Stieber cavitation boundary conditions. The existence of vapor cavitation significantly decreases the whole of the pressure distribution. A modified Reynolds equation is solved analytically for a long squeeze film damper to investigate the effect of fluid inertia on cavitated pressure profiles. Increasing fluid inertia tends to extend the region of cavitation to the minimum film gap and to reduce the pressure. The corresponding damping and inertia force coefficients are presented for varying positions of cavitation inception and termination. Experimental comparisons are presented in Part II.

A94-12888
THE BOUNDARY LAYER [POGRANICHNYJ SLOJ]
N. M. BELYANIN, ED. Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya (TsIAM, Trudy, No. 1252) 1990 164 p. In RUSSIAN For individual items see A94-12889 to A94-12900
Copyright
The papers contained in this volume focus on the characteristics of viscous gas flow with particular reference to jet engines. Specific topics discussed include the calculation of discontinuous solutions for boundary layer equations, viscous flow in the region of collision of nonparallel jets, calculation of boundary layers in nozzles with heat transfer and high stagnation parameters, and using the boundary layer theory for calculating separated flows. Papers are also presented on the boundary layer on a partially moving surface, calculation of changes of the mean total pressure in a duct with constant mixing characteristics, and consideration of changes in vorticity along the flow line. AIAA

A94-12906* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FATIGUE FRACTURE IN THIN PLATES SUBJECTED TO TENSILE AND SHEARING LOADS - CRACK TIP FIELDS, J INTEGRAL AND PRELIMINARY EXPERIMENTAL RESULTS
ALAN T. ZEHNDER, MARK J. VIZ, and ANTHONY R. INGRAFFEA (Cornell Univ., Ithaca, NY) *In* International Congress on Experimental Mechanics, 7th, Las Vegas, NV, June 8-11, 1992, Proceedings. Vol. 1 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 44-50. refs
(Contract NAG1-1311; NSF DMR-88-18558)
Copyright
In one scenario of a crack in an airplane fuselage, the crack is subjected to cyclic tensile and out of plane shearing loads. To predict the fatigue crack growth in such a situation, experiments are being performed to measure the crack growth rate in laboratory specimens subjected to similar loadings. The mechanics of this problem are reviewed, the energy release rate is calculated and designs for an experiment are discussed along with some preliminary experimental observations.

A94-12918
APPLICATION OF THE STRAIN GAGE-HOLE DRILLING METHOD TO AIRCRAFT TRANSPARENCIES
THOMAS J. WHITNEY and GREGORY J. STENGER (Dayton Univ., OH) *In* International Congress on Experimental Mechanics, 7th, Las Vegas, NV, June 8-11, 1992, Proceedings. Vol. 1 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p.

205-212. refs
(Contract F33615-84-C-3404)
Copyright

The laminated F-16 canopy is used as an example to illustrate the application of the strain gage-hole drilling method to aircraft transparencies. A device for implementing the method in aircraft transparencies has been designed and fabricated. The result obtained is an accuracy of +/- 10 percent in stress measurement for this device. The device would also be capable of drilling holes in many other surfaces or components containing multiple curvature. Measurements made in selected full-scale canopies showed stress levels induced by residual manufacturing stresses, installation, and cockpit pressurizing to be relatively low compared to laboratory craze thresholds. AIAA

A94-12936

FOURTH DIMENSIONAL EFFECTS IN THE COLD EXPANSION OF LARGE HOLES IN THICK ALUMINIUM AIRCRAFT MATERIAL USING PHOTOSTRESS AND STRAIN GAUGES

E. W. O'BRIEN (British Aerospace Airbus, Ltd., Bristol, United Kingdom) *In* International Congress on Experimental Mechanics, 7th, Las Vegas, NV, June 8-11, 1992, Proceedings. Vol. 1 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 537-542. refs
Copyright

Fatigue protection by the application of cold expansion by the 'split sleeve and mandrel' system to holes in aircraft components and other high performance structures has become common practice for sizes up to 15 mm diameter. Recent advances particularly in large aircraft mean that the process is now applied to holes up to twice that size. Theoretical analyses of the stress field surrounding cold expanded holes have been developed over many years, involving very complex close form solution estimates based on the resultant balance between hi-axial plastic and elastic deformation. Experimental stress analysis techniques reveal that the 2D solutions of the past are inadequate to describe stress fields around the larger sizes of holes. In fact for a full description of the strain state of the expanded hole the fourth dimension of time must be considered. The effects of high strain rates discovered in the experiments is also examined with respect particularly to 7010 aluminum, which has sponsored a tool modification program.

A94-12937

PHOTOELASTIC STRESS ANALYSIS OF A PATTERN OF OBLIQUE HOLES IN JET ENGINE HARDWARE

LARRY J. MEYER and H. J. MACKE *In* International Congress on Experimental Mechanics, 7th, Las Vegas, NV, June 8-11, 1992, Proceedings. Vol. 1 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 550-555. refs
Copyright

Oblique holes are frequently used to provide cooling passages in various jet engine parts, such as combustors or hollow airfoils. It is often desirable to have the axes of such holes machined at a small oblique angle relative to the hardware surface. The frozen-stress photoelastic studies reported in this paper were part of the design process on cooled combustors. In relation to previous analyses, this paper presents relatively small oblique angles between the hole axis and the plate surface, relatively large thickness to diameter ratios, and a staggered pattern of holes. Both tensile and bending loads were applied. The most notable effects revealed were the unexpectedly high values and rates of increase in the highly localized concentrations as the oblique angle decreases. Results are compared with those of previous investigators.

A94-12954

PHOTOELASTIC STUDY OF SHRINKAGE FITTED COMPONENTS FOR A GASTURBINE ENGINE

T. V. GOVINDARAJU (Sri M. Visvesvaraya Inst. of Technology, Bangalore, India), H. MAHESHAPPA (PES Inst. of Technology, Bangalore, India), N. GOVINDARAJU (U.V. College of Engineering, Bangalore, India), and G. GARGESA (R.V. College of Engineering, Bangalore, India) *In* International Congress on Experimental Mechanics, 7th, Las Vegas, NV, June 8-11, 1992, Proceedings. Vol. 2 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 904-908. refs
Copyright

A 3D photoelastic model of shrink-fitted components of a gas turbine engine such as low-pressure main shaft and compressor adopter shaft (or hub) are used to perform a photo-elastic investigation of shrink-fitted components for different relative thickness ratio and different contact length ratio. The relative rigidity of the hub is found to increase as the relative thickness ratio increases, and the relative rigidity is found to increase as the contact length ratio decreases. An optimization of the geometry of the shrinkage-fitted components is also obtained. AIAA

A94-12957

SINUSOIDAL PHASE MODULATING IN ESPI FOR VIBRATION PATTERN MEASUREMENT

BENHAN DONG, DAMING QIU, and PENGFEI GAO (Shenyang Aeroengine Research Inst., China) *In* International Congress on Experimental Mechanics, 7th, Las Vegas, NV, June 8-11, 1992, Proceedings. Vol. 2 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 966-970. refs
Copyright

Electronic Speckle Pattern Interferometry (ESPI) for the measurement of a vibration pattern based on phase modulating is presented. The subtraction of adjacent two time average image with a phase shifting which is modulated in the object beam shifting which is the object beam are continuously operated. The real time fringe of vibrating pattern with visibility is given. The principle is discussed and experimental results are presented.

A94-12982

FIBER OPTIC BASED VELOCIMETRY FOR THE INVESTIGATION OF HIGH VELOCITY TURBULENCE

BRUCE PETERS, DAVE KALIN, and LORI BROOKS (Teledyne Brown Engineering, Huntsville, AL) *In* International Congress on Experimental Mechanics, 7th, Las Vegas, NV, June 8-11, 1992, Proceedings. Vol. 2 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 1334-1340. refs
(Contract DASG60-87-C-0042)
Copyright

In support of ongoing aero-optic research, experimental data is needed in order to anchor and validate computer based models. A common technique to obtain velocity information is Laser Doppler Velocimetry (LDV). LDV employs seed particles suspended within the fluid to track the flow field and measure the flow velocity. However, in a supersonic regime, the large size and mass of the particles relative to the high flow velocities, reduces the ability of the particles to accurately track the flow. Therefore, the authors combined fiber optics with laser velocimetry to develop a novel nonintrusive, nonseeding technique that utilizes the optical scattering properties inherent in the turbulent structures themselves to obtain velocity information on the supersonic turbulent flow field. The fiber optic components are near pointwise sensors that permit multiple detectors, yet can be easily coupled to discrete high speed photodiodes to maintain flexibility in the data acquisition system. The concept has been experimentally demonstrated and the data was used to statistically compute a mean flow velocity. Close correlation between Computational Fluid Dynamics (CFD) generated velocities and experimental results confirms that the technique provides a nonintrusive method of accurately measuring the velocity of small scale, supersonic turbulent structures.

A94-13144

CLASSIFICATION OF PHASE PORTRAITS IN THE PROBLEM OF BODY MOTION IN A RESISTING MEDIUM IN THE PRESENCE OF A LINEAR DAMPING MOMENT [KLASSIFIKATSIYA FAZOVYKH PORTRETOV V ZADACHE O DVIZHENII TELA V SOPROTIVLYAYUSHCHEJSYA SREDE PRI NALICHII LINEJNOGO DEMPFIRUYUSHCHEGO MOMENTA]

M. V. SHAMOLIN Prikladnaya Matematika i Mekhanika (ISSN

0032-8235) vol. 57, no. 4 July-Aug. 1993 p. 40-49. In RUSSIAN refs
Copyright
A qualitative analysis is presented for a dynamic system describing a model version of the problem of plane-parallel motion of a body in a medium with jet or separated flows in the case where the medium-body interaction is concentrated on a part of the body in the shape of a flat plate. The interaction force is normal to the plate, and the force application point depends on the angle of attack only. Mechanical and topological analogs with a pendulum in the path of an incoming flow are discussed. AIAA

N94-10038# Robert Gordon's Inst. of Tech., Aberdeen (Scotland). School of Applied Sciences.
QUANTIFYING DISBOND AREA
D. W. LOWDEN *In* ESA, Advanced Materials for Lightweight Structures p 223-228 Oct. 1992
Copyright Avail: CASI HC A02/MF A04
Disbonds simulated in a composite helicopter rotor blade were profiled using eddy currents. The method is inherently accurate and reproducible. An algorithm is described for calculating disbond margin. Disbond area is estimated assuming in-service disbondments exhibit circular geometry. ESA

N94-10055# Maschinenfabrik Augsburg-Nuernberg A.G., Munich (Germany).
STRUCTURAL MATERIAL, MANUFACTURE, AND DESIGN REQUIREMENTS FOR HIGH-TEMPERATURE FASTENERS FOR SPACE PLANE TECHNOLOGIES
P. AGATANOVIC and M. DOGIGLI *In* ESA, Advanced Materials for Lightweight Structures p 325-332 Oct. 1992
Copyright Avail: CASI HC A02/MF A04
The design of high temperature refractory alloy fasteners for Hermes is addressed. Principles of fastener design, implications of material selection and processing, and requirements for coating selection are reviewed. Methods for calculation of fastener preload and the possible sources of preload loss (including thermal expansion mismatch) are discussed. In particular, the need for a systems approach to the development of the whole joint concept is stressed, and the potential of numerical analysis techniques, such as finite elements, to support such an approach is illustrated. ESA

N94-10364# National Aerospace Lab., Tokyo (Japan). Computational Sciences Div.
A GRID GENERATION METHOD TO CALCULATE THE FLOW FIELD IN A THREE-DIMENSIONAL CASCADE OF BLADES [SANJIGEN YOKURETSU NAGARE KEISAN NO TAMENO KOUSHI KEISEI]
KENJI INOUE May 1992 10 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1158; JTN-93-80435; DE93-767978) Avail: CASI HC A02/MF A01
A method is described for generating boundary fitted grids to calculate the flow field across a three dimensional cascade of blades placed radially in the axially symmetric space between the hub and casing. Successive application of a series of stretching and conformal transformation maps one-period domain of the cascade onto a box in computational space. The grid in physical space is then obtained by inverse transformation of the grid points in computational space, being an H-type grid and having a periodicity which includes the inclination of grid lines at the periodic boundary. Author (NASDA)

N94-10365# National Aerospace Lab., Tokyo (Japan). Computational Sciences Div.
SOLVING THE INVERSE PROBLEM FOR INCOMPRESSIBLE POTENTIAL FLOW THROUGH TWO-DIMENSIONAL CASCADES [NIJIGEN YOKURETSU WO SUGIRU HIASSHUKU POTENSHARU NAGARE NO GYAKUMONDAI]
KENJI INOUE Jun. 1992 12 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1162; JTN-93-80436; DE93-767979) Avail: CASI HC A03/MF A01
A method to solve the inverse problem for incompressible potential flow through two-dimensional cascades is described. This method enables the determination of blade profiles which realize a flow possessing the prescribed surface speed distribution, solidity, and incident angle. The employed method reduces the problem to one for conformal mappings, with the unknown coefficients used in the mappings being determined by computational numerical iterations. A sample calculation is conducted for a representative compressor cascade having known flow conditions, and the cascade's original configuration is well simulated. In addition, the method is also applied to obtain blade profiles for the same surface speed distribution but at a different solidity or incident angle. Author (NASDA)

N94-10400*# Pratt and Whitney Aircraft, East Hartford, CT.
AGBT ADVANCED COUNTER-ROTATING GEARBOX DETAILED DESIGN REPORT Report, Aug. 1984 - Jan. 1987
D. C. HOWE, C. V. SUNDT, and A. H. MCKIBBON Oct. 1988 164 p
(Contract NAS3-24342; RTOP 535-03-22)
(NASA-CR-180883; NAS 1.26:180883) Avail: CASI HC A08/MF A02
An Advanced Counter-Rotating (CR) Gearbox was designed and fabricated to evaluate gearbox efficiency, durability and weight characteristics for emerging propfan-powered airplanes. Component scavenge tests showed that a constant volume collector had high scavenge effectiveness, which was uneffected by added airflow. Lubrication tests showed that gearbox losses could be reduced by controlling the air/oil mixture and by directing the oil jets radially, with a slight axial component, into the sun/planet gears. Author

N94-10613# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
ENVIRONMENTALLY SAFE AND EFFECTIVE PROCESSES FOR PAINT REMOVAL [LES PROCEDES EFFICACES ET ECOLOGIQUES POUR L'ENLEVEMENT DES PEINTURES]
Mar. 1993 133 p The 75th meeting was held in Lindau, Germany, 7-8 Oct. 1992
(AGARD-R-791; ISBN-92-835-0705-3) Copyright Avail: CASI HC A07/MF A02
Paint stripping and repainting of aircraft surfaces are required periodically during the operating lifetime of an aircraft. Historically, paint removal has been achieved with chemical strippers. These materials often contain toxic components and create hazardous working conditions. It is necessary to ensure that alternate paint removal techniques are available that can be performed in a cost effective, environmentally safe manner without causing damage to aircraft surfaces.

N94-10614# Naval Air Warfare Center, Warminster, PA. Aircraft Div.
PAINT REMOVAL ACTIVITIES IN THE US NAVY
JOSEPH KOZOL *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 5 p Mar. 1993
Copyright Avail: CASI HC A01/MF A02
Use of methylene chloride and phenol based chemical strippers for aircraft paint removal generates large quantities of hazardous waste and creates health and safety problems for operating personnel. This paper presents an overview of the U.S. Navy's activities in the investigation and implementation of alternate paint stripping methods which will minimize or eliminate hazardous waste and provide a safe operating environment. Alternate paint removal methods under investigation by the Navy at the present time include use of non-hazardous chemical paint removers, xenon flashlamp/CO2 pellets, lasers and plastic media. Plastic media blasting represents a mature technology in current usage for aircraft paint stripping and is being investigated for determination of its effects on Navy composite aircraft configurations. Author (revised)

N94-10615# Defence Research Establishment Pacific, Victoria (British Columbia).
PAINT REMOVAL ACTIVITIES IN CANADA
TERRY FOSTER *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 3 p Mar. 1993
Copyright Avail: CASI HC A01/MF A02

Paint removal activities currently under way in Canada include: research and development of laser paint stripping; development and commercialization of a new blasting medium based on wheat starch; commercialization of a new blasting medium and process using crystalline ice blasting for paint removal and surface cleaning; and the development of automated and robotic systems for paint stripping applications. A specification for plastic media blasting (PMB) of aircraft and aircraft components is currently being drafted by NDHQ for use by the Canadian Armed Forces (CAF) and contractors involved in coating removal for the CAF. Defense Research Establishment Pacific (DREP) is studying the effects of various blast media on coating removal rates, and minimizing the possibility of damage to substrates other than aluminum such as graphite epoxy composite and Kevlar. The effects of plastic media blasting on liquid penetrant detection of fatigue cracks is also under investigation. Author (revised)

N94-10616# Delegation Generale de l'Armement, Toulouse (France).
PROCEDURES WITHOUT DANGER TO THE ENVIRONMENT AND EFFICIENCY (PSDEE) FOR THE REMOVAL OF PAINT. POINT ON THE FRENCH ACTIVITIES CONCERNING THE REMOVAL OF PAINT [PROCEDES SANS DANGER POUR L'ENVIRONNEMENT ET EFFICACES (PSDEE) POUR L'ENLEVEMENT DES PEINTURES. POINT SUR LES ACTIVITIES FRANCAISES CONCERNANT L'ENLEVEMENT DES PEINTURES]
PIERRE GAUTHIER *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 6 p Mar. 1993 In ENGLISH and FRENCH
Copyright Avail: CASI HC A02/MF A02

The text presents a synthesis of the activities and subjects of French interest in new techniques for the removal of paint in the civil and military air transport sector. Transl. by FLS

N94-10617# Dornier Luftfahrt G.m.b.H., Friedrichshafen (Germany).
PAINT REMOVAL ACTIVITIES IN GERMANY
R. HOLBEIN and G. ARNOLDS-MAYER *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 5 p Mar. 1993
Copyright Avail: CASI HC A01/MF A02

To replace paint removing chemicals containing chlorinated hydrocarbons several alternative paint stripping methods have been developed or are under study in Germany: high pressure water stripping; plastic media blasting; use of alcalic and acid activated softeners; CO2 pellet blasting; and laser application. Author (revised)

N94-10618# Royal Air Force, Harrogate (England). Surface Finish Support Authority.
THE DEVELOPMENT OF ALTERNATIVE PAINT REMOVAL TECHNIQUES IN THE RAF
M. HARTLEY and M. WEEDING *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 8 p Mar. 1993
Copyright Avail: CASI HC A02/MF A02

Personnel safety and environmental legislation is forcing the removal of chemical removers. The RAF chose the Plastic Media Stripping process as their alternative. During testing of the process a number of problem areas and additional advantages were highlighted. Solution to the problems are discussed and the advantages quantified. Author (revised)

N94-10619# Fokker B.V., Amsterdam (Netherlands).
OPERATIONAL ASPECTS OF F.16 PLASTIC MEDIA BLASTING, AS CARRIED OUT BY FOKKER AIRCRAFT SERVICES
FRANK POT *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 3 p Mar. 1993
Copyright Avail: CASI HC A01/MF A02

In 1987, Fokker Aircraft Services started F.16 air-intake paint removal by means of Plastic Media Blasting (PMB). Especially for this process, a robot has been developed. In a later stage, complete exterior PMB-paint removal has been tested and successfully adopted. The paint removal is carried out in the scope of a thorough corrosion control program. The requirement that all the paint must be removed in order to allow this control program to be carried out properly, leads to severe masking complications. The process parameters are relatively conservative, because of the requirement that absolutely no anodic layer damage is permitted. Following PMB paint removal, corrosion is removed using aluminum oxide blasting. Finally, a highly flexible polyurethane paint system is applied, based upon TT-P-2760 Koroflex primer. To summarize the process, it can be stated that the plastic media blasting itself is straightforward. Proper masking is difficult to perform though, compounded by special customer requirements such as open panel edges. Author (revised)

N94-10620# Aerospatiale, Toulouse (France).
USE OF ROBOTS FOR AIRCRAFT DRY STRIPPING VIA PLASTIC MEDIA BLASTING
E. GILLARD *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 6 p Mar. 1993
Copyright Avail: CASI HC A02/MF A02

In order to meet constant financial and reliability concerns, European manufacturers have introduced more and more composite materials on their aircraft. In addition to fairings for which the use of composites has become absolutely necessary, composites are used on each new program for structures which are more and more highly loaded and sophisticated. Similarly to metallic structures, an external paint scheme is applied to these composite structures to protect them from ultraviolet rays, provide general corrosion resistance and allow the airlines to customize their aircraft. Conventional stripping methods using chemical strippers cannot be used as many impregnation resins do not resist chemical strippers. Aerospatiale has endeavored to find new efficient methods that are easy to implement, cause no damage and are applicable both to metallic and composite structures. Dry stripping via plastic media blasting has formed the subject of many tests. These tests proved that such stripping was compatible with the objectives but required automation of the process for large airframe stripping. Author

N94-10621# German Air Force, Cologne (Germany). Support Command.
GERMAN AIR FORCES EXPERIENCES WITH PLASTIC MEDIA BLASTING AND FUTURE REQUIREMENTS
MATTHIAS STOERMER *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 14 p Mar. 1993
Copyright Avail: CASI HC A03/MF A02

German Air Force (GAF) has been researching a method of paint removal for a couple of years to replace the chemical method still in use. This is to improve corrosion prevention, environmental protection and health care. With the support of German aerospace company MBB and the University of the Armed Forces in Munich GAF selected Plastic Media Blasting (PMB) as the most suitable method. Having a stripping facility for the entire aircraft at MBB Manching already in existence, GAF decided that the next step forward to gain more experiences is to establish a smaller 'stripping cabin' at an air force base. This cabin is suitable for stripping removable parts and components of aircraft and equipment with the max. size of a half dismantled TORNADO wing. With these gained experiences GAF will be in position to formulate the specific requirements for an entire on-base aircraft stripping plant which will be suitable for F-4's, TORNADO's and EFA's, too. Author (revised)

N94-10622# Air Force Logistics Command, Hill AFB, UT.
PLASTIC MEDIA BLASTING ACTIVITIES AT HILL AIR FORCE BASE

J. D. CHRISTENSEN *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 2 p Mar. 1993
Copyright Avail: CASI HC A01/MF A02

Hill Air Force Base in Utah developed plastic media blasting (PMB) paint removal process for removing paint from Air Force aircraft. The development of the process involved extensive testing of various abrasives and subsequent parameters to end up with an approved production process. Hill AFB has been using PMB in a production mode since 1985, and completely discontinued chemical stripping of airframes in 1989. We have recently installed and began operating a fully automated PMB facility that utilizes two nine-axis robots to strip an aircraft. This system has enabled us to further reduce the manhours required to strip an aircraft, and also allowed us to remove the employee from the blasting atmosphere into a control room. We have, and will continue to realize, significant environmental and economic savings by using PMB. Hill is also actively involved with the development of future paint stripping technologies. Derived from text

N94-10623# Wright Lab., Eglin AFB, FL. Manufacturing Technology Directorate.
LARGE AIRCRAFT ROBOTIC PAINT STRIPPING (LARPS) SYSTEM AND THE HIGH PRESSURE WATER PROCESS
DAVID W. SEE, SCOTT A. HOFACKER (United Technologies Corp., Huntsville, AL.), M. ANTHONY STONE (United Technologies Corp., Huntsville, AL.), and DARCY HARBAUGH (United Technologies Corp., Huntsville, AL.) *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 21 p Mar. 1993
(Contract F33615-91-C-5708)
Copyright Avail: CASI HC A03/MF A02

The aircraft maintenance industry is beset by new Environmental Protection Agency (EPA) guidelines on air emissions, Occupational Safety and Health Administration (OSHA) standards, dwindling labor markets, Federal Aviation Administration (FAA) safety guidelines, and increased operating costs. In light of these factors, the USAF's Wright Laboratory Manufacturing Technology Directorate and the Aircraft Division of the Oklahoma City Air Logistics Center initiated a MANTECH/REPTECH effort to automate an alternate paint removal method and eliminate the current manual methylene chloride chemical stripping methods. This paper presents some of the background and history of the LARPS program, describes the LARPS system, documents the projected operational flow, quantifies some of the projected system benefits and describes the High Pressure Water Stripping Process. Certification of an alternative paint removal method to replace the current chemical process is being performed in two phases: Process Optimization and Process Validation. This paper also presents the results of the Process Optimization for metal substrates. Data on the coating removal rate, residual stresses, surface roughness, preliminary process envelopes, and technical plans for process Validation Testing will be discussed. Author (revised)

N94-10624# International Technical Associates, Inc., Santa Clara, CA.
AUTOMATED LASER PAINT STRIPPING (ALPS) UPDATE
PAUL LOVOI *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 12 p Mar. 1993
Copyright Avail: CASI HC A03/MF A02

To date, the DoD has played a major role in funding a number of paint stripping programs. Some technologies have proven less effective than contemplated. Others are still in the validation phase. Paint stripping is one of the hottest issues being addressed by the finishing industry since the Environmental Protection Agency (EPA) has mandated that chemical stripping using methylene chloride/phenolic type strippers be stopped. The DoD and commercial aircraft companies are hard-pressed to find an alternative. Automated laser paint stripping has been identified as a technique for removing coatings from aircraft surfaces. International Technical Associates (InTA) was awarded a Navy contract for an automated laser paint stripping system (ALPS) that will remove paint from metallic and composite substrates. For the program, which will validate laser paint stripping, InTA will design, build, test, and install a system for fighter-sized aircraft at both the Norfolk and North Island (San Diego) Aviation Depots. Derived from text

N94-10625# Deutsche Lufthansa A.G., Hamburg (Germany). Structural Engineering Dept.
AQUASTRIP (TM): AN INNOVATIVE PAINT REMOVAL TECHNOLOGY
J. VOLKMAR *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 10 p Mar. 1993
Copyright Avail: CASI HC A02/MF A02

Environmental, safety and health issues, forced operators to search for an alternative paint removal process. High pressure water jetting and new integrated paint and stripper systems are Lufthansa's answer to this challenge. AQUASTRIP complies with the specification requirements. In order to receive approval from airframe manufacturers and authorities the process has undergone an extensive research program since 1988. An operation window was established, to enable maximum of safety during operation on metal and composite surfaces. Even though AQUASTRIP is a hybrid process and requires technological investment, it is well on the way to prove its innovative, ecological and economical character in first large scale applications under realistic conditions. Its potential has already been reflected by patents and trademarks, which were registered in conjunction with the development of AQUASTRIP and the vital interest for cooperative work on the process development and other potential utilization. Author (revised)

N94-10626# Defence Research Establishment Pacific, Victoria (British Columbia).
PAINT REMOVAL AND SURFACE CLEANING USING ICE PARTICLES
TERRY FOSTER and S. VISAISOUK (Ice Blast International Corp., Victoria, British Columbia.) *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 10 p Mar. 1993
Copyright Avail: CASI HC A02/MF A02

Research into the possibility of using ice particles as a blast medium was first initiated at Defence Research Establishment Pacific (DREP) in an effort to develop a more environmentally acceptable paint removal method. A paint removal process was also required that could be used in areas where normal grit blasting could not be used due to the possibility of the residual blasting grit contaminating machinery and other equipment. As a result of this research a commercial ice blasting system was developed by RETECH. This system is now being used to remove paint from substrates that cannot be easily blasted by conventional techniques and also to clean soiled or contaminated surfaces. The problems involved in the development of an ice blast system, and its components and their functions are described. Due to the complexity of paint removal using ice blasting, parameters such as air pressure, ice particle size and ice particle flow rate were studied and adjusted to suit the nature of the particular coating and substrate of interest. The mechanism of paint removal by ice particles has also been investigated. A theoretical model has been developed to explain the different paint removal mechanisms such as erosion by abrasion and erosion by fracture as they relate to ice blasting. Finally, the use of ice blasting to removal paint from a variety of substrates is presented as well as examples of surface cleaning and surface decontamination. Author

N94-10627# Defence Research Establishment Pacific, Victoria (British Columbia).
PAINT REMOVAL USING WHEAT STARCH BLAST MEDIA
TERRY FOSTER and JOHN OESTREICH (Ogilvie Mills Ltd., Montreal, Quebec.) *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 9 p Mar. 1993
Copyright Avail: CASI HC A02/MF A02

A review of the Wheat Starch Blasting technology is presented. Laboratory evaluations covering Almen Arc testing on bare 2024-T3 aluminum and magnesium, as well as crack detection on 7075-T6 bare aluminum, are discussed. Comparisons with Type V plastic media show lower residual stresses are achieved on aluminum and magnesium with wheat starch media. Dry blasting effects on the detection of cracks confirms better crack visibility with wheat starch media versus Type V or Type II plastic media. Testing of wheat starch media in several composite test programs, including fiberglass, Kevlar, and graphite-epoxy composites, showed no fiber damage. Process developments and production experience at the first U.S. aircraft stripping facility are also reviewed. Corporate and regional aircraft are being stripped in this three nozzle dry blast hanger. Author

N94-10628# KLM Aerocarto, Schiphol (Netherlands). Central Engineering Dept.
IATA TASKFORCE: PAINTSTRIPPING
THOMAS MOOY *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 5 p Mar. 1993
Copyright Avail: CASI HC A01/MF A02

In 1990 the International Air Transport Association (IATA) established a task force to stimulate the development of alternatives for chemical stripping of commercial aircraft. The IATA TaskForce Paintstripping objectives are: to identify the most promising, current alternatives for short term implementation; to prepare a document containing requirements for the development of alternatives; to stimulate the information exchange. After the September 1992 meeting the TaskForce will report back to IATA. The most tangible result of the TaskForce is the IATA Guidelines containing requirements for the qualification of stripping processes. Author (revised)

N94-10629# Imperial Chemical Industries Ltd., Duesseldorf (Germany). Aerospace Coatings.
SELECTIVELY STRIPPABLE PAINT SCHEMES
R. STEIN, D. THUMM, and ROGER W. BLACKFORD (Imperial Chemical Industries Ltd., Slough, England.) *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 4 p Mar. 1993
Copyright Avail: CASI HC A01/MF A02

In order to meet the requirements of more environmentally acceptable paint stripping processes many different removal methods are under evaluation. These new processes can be divided into mechanical and chemical methods. ICI has developed a paint scheme with intermediate coat and fluid resistant polyurethane topcoat which can be stripped chemically in a short period of time with methylene chloride free and phenol free paint strippers. Author

N94-10674* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
COOLED SPOOL PISTON COMPRESSOR Patent
BRIAN G. MORRIS, inventor (to NASA) 24 Aug. 1993 11 p Filed 29 Dec. 1992 Supersedes N93-19331 (31 - 6, p 1550)
(NASA-CASE-MSC-22020-1; US-PATENT-5,238,372; US-PATENT-APPL-SN-998062; US-PATENT-CLASS-417-393; US-PATENT-CLASS-417-404; INT-PATENT-CLASS-F04B-35/00)
Avail: US Patent and Trademark Office

A hydraulically powered gas compressor receives low pressure gas and outputs a high pressure gas. The housing of the compressor defines a cylinder with a center chamber having a cross-sectional area less than the cross-sectional area of a left end chamber and a right end chamber, and a spool-type piston assembly is movable within the cylinder and includes a left end closure, a right end closure, and a center body that are in sealing engagement with the respective cylinder walls as the piston reciprocates. First and second annual compression chambers are provided between the piston enclosures and center housing portion of the compressor, thereby minimizing the spacing between the core gas and a cooled surface of the compressor. Restricted flow passageways are provided in the piston closure members and a path is provided in the central body of the piston assembly, such that hydraulic fluid flows through the piston assembly to cool the piston assembly during its operation. The compressor of the present invention may be easily adapted for a particular application, and is capable of generating high gas pressures while maintaining both the compressed gas and the compressor components within acceptable temperature limits.
Official Gazette of the U.S. Patent and Trademark Office

N94-10706 Mechanical Technology, Inc., Latham, NY.
DEVELOPMENT OF PASSIVE SUPERCONDUCTING BEARINGS. PHASE 3 Final Report
DANTAM K. RAO 14 May 1993 100 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract SDIO84-89-C-0043)
(AD-A266050; MTI-93TR26) Avail: CASI HC A05

This report documents the development of a passive superconducting bearing that is used to levitate relatively heavy rotors. This bearing was used to levitate a 7 lb rotor and spin at speeds of up to 12,000 rpm. The success of this effort indicates that the superconducting bearings have the potential for transition from a mere laboratory curiosity to a functional bearing component in a wider range of practical applications such as cryoturbopumps, miniature cryocoolers, and magnetic refrigerators. In addition, several configurations using superconductors to support loads along a single axis were investigated. The effort was directed to identify a specific configuration that offers a very high stiffness. DTIC

N94-10791# Wright Lab., Wright-Patterson AFB, OH. Materials Directorate.
DEVELOPMENT AND ANALYSIS OF INSULATION CONSTRUCTIONS FOR AEROSPACE WIRING APPLICATIONS
GEORGE A. SLENSKI and LYNN M. WOODFORD (McDonnell-Douglas Corp., Saint Louis, MO.) *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 303-312 Mar. 1993
(Contract F33615-89-C-5605)
Avail: CASI HC A02/MF A03

The Wright Laboratory Materials Directorate at WPAFB, Ohio recently completed a research and development program under contract with the McDonnell Douglas Aerospace Company, St. Louis, Missouri. Program objectives were to develop wire insulation performance requirements, evaluate candidate insulations, and prepare preliminary specification sheets on the most promising candidates. Aircraft wiring continues to be a high maintenance item and a major contributor to electrically-related aircraft mishaps. Mishap data on aircraft show that chafing of insulation is the most common mode of wire failure. Improved wiring constructions are expected to increase aircraft performance and decrease costs by reducing maintenance actions. In the laboratory program, new insulation constructions were identified that had overall improved performance in evaluation tests when compared to currently available MIL-W-81381 and MIL-W-22759 wiring. These insulations are principally aromatic polyimide and crosslinked ethylene tetrafluoroethylene (ETFE), respectively. Candidate insulations identified in preliminary specification sheets were principally fluoropolymers with a polyimide inner layer. Examples of insulation properties evaluated included flammability, high temperature mechanical and electrical performance, fluid immersion, and susceptibility to arc propagation under applied power chafing conditions. Potential next generation wire insulation materials are also reviewed. Author (revised)

N94-10861# National Aerospace Lab., Tokyo (Japan). Aircraft Aerodynamics Div.
NUMERICAL WIND TUNNEL PROJECT AND COMPUTATIONAL FLUID DYNAMICS AT NATIONAL AEROSPACE LABORATORY, JAPAN
NAOKI HIROSE Jul. 1992 13 p
(ISSN 0452-2982)
(NAL-TM-648T; JTN-93-80449; DE93-793615) Avail: CASI HC A03/MF A01

The National Aerospace Laboratory (NAL) is the only research organization under the Science and Technology Agency which performs aerospace research in Japan, with NAL being actively involved in conducting Computational Fluid Dynamic (CFD) and supercomputer research and development. This paper summarizes the Numerical Wind Tunnel Project and associated CFD work carried out by NAL. Author (NASDA)

N94-10937*# California Univ., San Diego, La Jolla. Dept. of *Applied Mechanics and Engineering Sciences.*
NASTRAN MODELING OF FLIGHT TEST COMPONENTS FOR UH-60A AIRLOADS PROGRAM TEST CONFIGURATION Final Report
FLORENTINO R. IDOSOR and FRIEDER SEIBLE Feb. 1993 173 p Original contains color illustrations
(Contract NCC2-712)
(NASA-CR-193614; NAS 1.26:193614; SSRP-93/03) Avail: CASI HC A08/MF A02; 9 functional color pages

Based upon the recommendations of the UH-60A Airloads Program Review Committee, work towards a NASTRAN remodeling effort has been conducted. This effort modeled and added the necessary structural/mass components to the existing UH-60A baseline NASTRAN model to reflect the addition of flight test components currently in place on the UH-60A Airloads Program Test Configuration used in NASA-Ames Research Center's Modern Technology Rotor Airloads Program. These components include necessary flight hardware such as instrument booms, movable ballast cart, equipment mounting racks, etc. Recent modeling revisions have also been included in the analyses to reflect the inclusion of new and updated primary and secondary structural components (i.e., tail rotor shaft service cover, tail rotor pylon) and improvements to the existing finite element mesh (i.e., revisions of material property estimates). Mode frequency and shape results have shown that components such as the Trimmable Ballast System baseplate and its respective payload ballast have caused a significant frequency change in a limited number of modes while only small percent changes in mode frequency are brought about with the addition of the other MTRAP flight components. With the addition of the MTRAP flight components, update of the primary and secondary structural model, and imposition of the final MTRAP weight distribution, modal results are computed representative of the 'best' model presently available. Author

N94-11014# Rutgers - The State Univ., New Brunswick, NJ. Dept. of Mechanical and Aerospace Engineering.
THEORETICAL INVESTIGATION OF 3-D SHOCK WAVE TURBULENT BOUNDARY LAYER INTERACTIONS Interim Report, 1 Mar. - 30 Sep. 1992
DOYLE D. KNIGHT 30 Nov. 1993 56 p
(Contract AF-AFOSR-0266-86)
(AD-A265275; RU-TR-MAE-184-F; AFOSR-93-0357TR) Avail: CASI HC A04/MF A01

The research concerns the understanding of 3-D shock wave/turbulent boundary-layer interactions. The research effort during the current period focused on the following areas: (1) the 3-D double fin (crossing shock) interaction at Mach 8.3 for symmetric 15 deg fins; (2) the 3-D crossing shock interaction at Mach 4 for symmetric 15 deg fins; and (3) the 3-D triple (triple shock) interaction at Mach 8.3 for 10 deg fins. DTIC

N94-11084*# Michigan Univ., Ann Arbor. Radiation Lab.
RADIATION AND SCATTERING BY CAVITY-BACKED ANTENNAS ON A CIRCULAR CYLINDER Semiannual Report, Feb. - Aug. 1993
LEO C. KEMPEL and JOHN L. VOLAKIS Jul. 1993 69 p
(Contract NAG1-1478)
(NASA-CR-193409; NAS 1.26:193409; UM-030601-1-T) Avail: CASI HC A04/MF A01

Conformal arrays are popular antennas for aircraft and missile platforms due to their inherent low weight and drag properties. However, to date there has been a dearth of rigorous analytical or numerical solutions to aid the designer. In fact, it has been common practice to use limited measurements and planar approximations in designing such non-planar antennas. The finite element-boundary integral method is extended to scattering and radiation by cavity-backed structures in an infinite, metallic cylinder. In particular, the formulation specifics such as weight functions, dyadic Green's function, implementation details, and particular difficulties inherent to cylindrical structures are discussed. Special care is taken to ensure that the resulting computer program has low memory demand and minimal computational requirements. Both scattering and radiation parameters are computed and validated as much as possible. Author (revised)

N94-11132*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A PRELIMINARY STUDY ON ICE SHAPE TRACING WITH A LASER LIGHT SHEET
CAROLYN R. MERCER, MARIO VARGAS, and JOHN R. OLDENBURG Aug. 1993 11 p
(Contract RTOP 505-68-10)
(NASA-TM-105964; E-7375-1; NAS 1.15:105964) Avail: CASI HC A03/MF A01

Preliminary work towards the development of an automated method of measuring the shape of ice forming on an airfoil during wind tunnel tests has been completed. A thin sheet of light illuminated the front surfaces of rime, glaze, and mixed ice shapes and a solid-state camera recorded images of each. A maximum intensity algorithm extracted the profiles of the ice shapes and the results were compared to hand tracings. Very good general agreement was found in each case. Author

N94-11156 McGill Univ., Montreal (Quebec).
MECHANICAL ANALYSIS OF PARALLEL MANIPULATORS WITH SIMULATION, DESIGN, AND CONTROL APPLICATIONS Ph.D. Thesis
OU MA 1991 278 p
(ISBN-0-315-72013-1) Avail: Univ. Microfilms Order No. DANN72013

The kinematics and dynamics for the purposes of analysis, control, simulation, and design of general platform-type parallel manipulators are discussed. Two new methods of direct kinematics for displacement analysis are proposed. Velocity and acceleration analyses for general kinematic architectures are fully studied. Furthermore, kinematic singularities are classified based on their nature. Architecture singularities and architecture conditioning are deeply studied and incorporated into design strategies, along with design examples. Moreover, formulation singularities are also given due attention with case studies. In dynamics modeling, the method of the natural orthogonal complement is applied such that the resulting models are structurally algorithmic, computationally efficient, and numerically robust - essential properties for the implementation of more sophisticated control strategies. Efficient inverse and direct dynamics algorithms are developed based on the dynamics models in both joint space and Cartesian space. The algorithms were implemented with a general software package that is available for dynamics control and motion simulation of platform manipulators. As practical applications, the dynamics modeling and simulation of some commercial flight simulators are included. Finally, the concept of dynamic isotropy is introduced, which allows one to evaluate the motion/force performance of a manipulator with respect to control and simulation. Application strategies of this concept to some robotics problems such as design, trajectory planning, and inverse kinematics are discussed along with examples. Dissert. Abstr.

N94-11256*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A RESEARCH PROGRAM FOR IMPROVING HEAT TRANSFER PREDICTION FOR THE LAMINAR TO TURBULENT TRANSITION REGION OF TURBINE VANES/BLADES
FREDERICK F. SIMON Aug. 1993 35 p Presented at the Workshop on End-State Boundary Layer Transition, Blue Mountain Lake, NY, 15-18 Aug. 1993; sponsored by Syracuse Univ.
(Contract RTOP 505-62-52)
(NASA-TM-106278; E-8015; NAS 1:15:106278) Avail: CASI HC A03/MF A01

A program sponsored by NASA for the investigation of the heat transfer in the transition region of turbine vanes and blades with the objective of improving the capability for predicting heat transfer is described. The accurate prediction of gas-side heat transfer is important to the determination of turbine longevity, engine performance, and developmental costs. The need for accurate predictions will become greater as the operating temperatures and stage loading levels of advanced turbine engines increase. The present methods for predicting transition shear stress and heat transfer on turbine blades are based on incomplete knowledge and are largely empirical. To meet the objective of the NASA program, a team approach consisting of researchers from government, universities, a research institute, and a small business is presented. The research is divided into the areas of experiments, direct numerical simulations (DNS), and turbulence modeling. A summary of the results to date is given for the above research areas in a high-disturbance environment (bypass transition) with a discussion of the model development necessary for use in numerical codes. Author (revised)

N94-11340# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. for Flight Guidance.
FIBER-OPTIC INTERFEROMETRIC STRAIN GAUGE FOR SMART STRUCTURES APPLICATIONS: FIRST FLIGHT TESTS
N. FUERSTENAU, D. D. JANZEN, and W. SCHMIDT *In* AGARD, Smart Structures for Aircraft and Spacecraft 6 p Apr. 1993
Copyright Avail: CASI HC A02/MF A04

Initial flight tests of a fiber-optic strain gauge (OSG) based on a double-polarization Michelson interferometer with incremental readout via fringe counting were performed. The passive quadrature demodulation technique allows for balanced interferometer arms, exhibiting partial self temperature compensation. A bent reference (R) arm approach for the sake of isolation of the R-arm from the strain to be measured was tested for the first time. The sensor was surface adhered on a carbon fiber reinforced plastic plate which, in turn, was screwed to the main wing spar of a Cessna C207A aircraft. Strain was measured under different flight conditions and compared to the readout of a conventional resistive strain gauge (ESG). Good agreement with the theoretical predictions as well as with the readout of the ESG was observed for short term (of the order of minutes) quasistatic strain measurements despite large vibration induced noise. The Fourier spectra of the time series exhibited also good agreement between ESG and OSG with respect to the dynamical response up to at least 250 Hz. The measurement range and stability of the present experimental setup is limited by polarization instabilities which partly are due to anisotropic transverse stress effects at the adhered fiber sections. Longer term dc strain measurements require carefully controlled isotropic adhesion conditions and miniaturized optomechanical components with improved mechanical stability. Author

N94-11498# Centre d'Etudes et de Recherches, Toulouse (France). Aerothermodynamics Dept.
BOUNDARY LAYER TRANSITION: PREDICTION AND WIND TUNNEL SIMULATION
D. ARNAL *In* AGARD, Stability in Aerospace Systems 12 p Feb. 1993
Copyright Avail: CASI HC A03/MF A03

This paper gives a survey of theoretical and experimental results related to the problem of boundary layer transition; emphasis is given on applications of practical prediction methods. In the first part of the paper, it is shown that the linear stability theory can provide a good estimate of the transition location if the free stream disturbance level is low enough; the difficulties to properly simulate free flight conditions in ground facilities is underlined. The second part of the paper is devoted to the problem of boundary layer tripping in the presence of large external disturbances; in this case, the linear theory no longer applies and empirical criteria need to be developed. Derived from text

N94-11607# Argonne National Lab., IL. Materials and Components Technology Div.
IMPROVEMENT OF AZIMUTHAL HOMOGENEITY IN PERMANENT-MAGNET BEARING ROTORS
J. R. HULL, T. D. ROSSING, T. M. MULCAHY, and K. L. UHERKA 23 Oct. 1992 3 p Presented at the International Magnetics Conference, Stockholm, Sweden, 13-16 Apr. 1993
(Contract W-31-109-ENG-38)
(DE93-009954; ANL/MCT/CP-77835; CONF-930416-2) Avail: CASI HC A01/MF A01

Permanent magnets that are levitated and rotating over a bulk high-temperature superconductor (HTS) form the basis of many superconducting bearing designs. Experiments have shown that the rotational-loss 'coefficient of friction' for thrust bearings of this type can be as low as 8 x 10(exp -6). While the loss mechanisms of such bearings are not well understood, the azimuthal homogeneity of the rotating permanent magnet is believed to play an important role in determining the loss. One possible loss mechanism is magnetic hysteresis in the HTS, where the energy loss E per cycle is derived from the critical state model and given by E = K (Delta B)(sup 3)/J(sub c) where K is a geometric coefficient, Delta B is the variation in magnetic field at the surface of the HTS experienced during a rotation of the levitated magnet, and J(sub c) is the critical current density of the HTS. It is clear that a small decrease in Delta B (i.e., decreasing the azimuthal inhomogeneity of the rotating magnetic field) could have profound effects on decreasing E and the rotational coefficient of friction. The role of Delta B is also expected to be significant in reducing losses from eddy currents and other mechanisms. Low rotational losses in HTS bearings have been demonstrated only for levitated masses of several grams. For practical bearings, it is important to obtain these low losses with larger levitated masses. There are two main routes toward decreasing Delta B. The first is to improve the alignment of the magnetic particles during fabrication and to maintain close tolerances on grinding angles during manufacture of the permanent magnet. The second, the subject of this paper, is to provide correctional procedures after the magnet is fabricated. DOE

N94-11859# Aircraft Research Association Ltd., Bedford (England).
SAUNA: A SYSTEM FOR GRID GENERATION AND FLOW SIMULATION USING HYBRID STRUCTURED/UNSTRUCTURED GRIDS
P. N. CHILDS, J. A. SHAW, A. J. PEACE, and J. M. GEORGALA May 1992 9 p Presented at the First European Computational Fluid Dynamics Conference, Brussels, Belgium, 7-11 Sept. 1992 Original contains color illustrations
(Contract SLS41B/2437)
(ARA-MEMO-370) Avail: CASI HC A02/MF A01

The development of a flow simulation facility for predicting the aerodynamics of complex configurations wherein the grid is composed of both structured and unstructured regions is described. Issues relating to the generation and analysis of such grids and to the accurate and efficient computation of both inviscid and viscous flows thereon are considered. Further the development of a comprehensive post-processing and visualization facility is explored. Techniques are illustrated throughout by application to realistic aircraft geometries. Author (revised)

N94-11865# Woods Hole Oceanographic Inst., MA.
VORTEX-INDUCED FORCES ON OSCILLATING BLUFF CYLINDERS Ph.D. Thesis
RAMNARAYAN GOPALKRISHNAN Feb. 1993 254 p
(Contract N00014-89-C-0179; N00014-92-J-1726; NSF OCE-85-11431; NA90AA-D-SG424)
(AD-A265056; WHOI-92-38) Avail: CASI HC A12/MF A03

Vortex-induced forces and the consequent vibration of long cylindrical structures are important for a large number of engineering applications; the complexity of the underlying physical mechanisms is such that this is one of the canonical problems of fluid mechanics. Vortex shedding force varies in frequency and magnitude along the length of the structure causing the response at any point to be amplitude-modulated in space and time. The focus is on the measurement, via forced-oscillation experiments, of the vortex-induced lift and drag forces acting on circular cylinders undergoing sinusoidal and amplitude-modulated oscillations. Basic concepts on vortex formation and vortex-induced vibrations, a review of the existing literature, and details of the experimental apparatus and data processing methods are presented. Stationary and sinusoidal oscillation tests are presented. Several novel properties are described, among them the role of the lift force phase angle in causing the amplitude-limited nature of VIV, and use of the lift force excitation region in contrast with the often-quoted but quite different lift force lock-in region. Next, a comprehensive data error analysis and a simple VIV prediction scheme are described. New data on amplitude-modulated oscillations are presented. The concept of control of the mean wake velocity profile via the control of the major vortical feature is explored with possible applications being the reduction of the in-line wake velocity and alteration of the wake signature. DTIC

N94-12294*# Stanford Univ., CA. Center for Turbulence Research.
DIRECT SIMULATION OF COMPRESSIBLE WALL-BOUNDED TURBULENCE
GARY N. COLEMAN *In its* Annual Research Briefs, 1992 p 139-144 Jan. 1993
Avail: CASI HC A02/MF A04

When analyzing many turbulent flows, the effects of compressibility can be neglected. Even some relatively high-speed flows, such as boundary layers generated by a supersonic aircraft, produce turbulent statistics that are similar to those found for the incompressible case. There are other situations, however, in which the non-zero divergence of the turbulence leads to behavior that is fundamentally different from that found at constant density. Examples include flows created by internal combustion engines, hypersonic flight, and supersonic combustion. It is with instances such as these that this project is concerned. In particular, we are interested in the effects of compressibility on turbulence near a smooth solid constant temperature surface; our primary objective is an increased physical understanding that can be used to improve turbulence models of wall-bounded compressible flows. With this in mind, we have begun a direct numerical simulation (DNS) study of turbulence in a plane channel. Because all of the relevant spatial and temporal scales are to be resolved, the simulations require no subgrid scale parameterization. The DNS code developed by Buell to study compressible plane Couette flow was modified to solve the compressible Navier-Stokes equations in the plane channel. The channel was chosen over the Couette flow for two reasons: (1) to avoid using the very large streamwise domains needed to adequately capture the large Couette vortical structures; and (2) to make use of previous experience by considering the compressible version of a well established case and isolate finite Mach number effects by comparing to the incompressible channel. Author (revised)

N94-12295*# Stanford Univ., CA. Center for Turbulence Research.
DIRECT NUMERICAL SIMULATION OF HOT JETS
MARC C. JACOB *In its* Annual Research Briefs, 1992 p 145-160 Jan. 1993
Avail: CASI HC A03/MF A04

The ultimate motivation of this work is to investigate the stability of two dimensional heated jets and its implications for aerodynamic sound generation from data obtained with direct numerical simulations (DNS). As pointed out in our last report, these flows undergo two types of instabilities, convective or absolute, depending on their temperature. We also described the limits of earlier experimental and theoretical studies and explained why a numerical investigation could give us new insight into the physics of these instabilities. The aeroacoustical interest of these flows was also underlined. In order to reach this goal, we first need to succeed in the DNS of heated jets. Our past efforts have been focused on this issue which encountered several difficulties. Our numerical difficulties are directly related to the physical problem we want to investigate since these absolutely or almost absolutely unstable flows are by definition very sensitive to the smallest disturbances and are very likely to reach nonlinear saturation through a numerical feedback mechanism. As a result, it is very difficult to compute a steady laminar solution using a spatial DNS. A steady state was reached only for strongly co-flowed jets, but these flows are almost equivalent to two independent mixing layers. Thus they are far from absolute instability and have much lower growth rates. Author (revised)

N94-12298*# Stanford Univ., CA. Center for Turbulence Research.
REYNOLDS STRESS CLOSURE MODELING IN WALL-BOUNDED FLOWS
PAUL A. DURBIN *In its* Annual Research Briefs, 1992 p 185-197 Jan. 1993
Avail: CASI HC A03/MF A04

This report describes two projects. Firstly, a Reynolds stress closure for near-wall turbulence is described. It was motivated by the simpler k-epsilon-(v-bar(exp 2)) model described in last year's annual research brief. Direct Numerical Simulation of three-dimensional channel flow shows a curious decrease of the turbulent kinetic energy. The second topic of this report is a model which reproduces this effect. That model is described and used to discuss the relevance of the three dimensional channel flow simulation to swept wing boundary layers. Author (revised)

N94-12307*# Stanford Univ., CA. Center for Turbulence Research.
SUPERFLUID TURBULENCE
DAVID C. SAMUELS *In its* Annual Research Briefs, 1992 p 291-301 Jan. 1993
Avail: CASI HC A03/MF A04

At low temperatures (below 5 Kelvin), helium is a liquid with a very low kinematic viscosity. It was proposed that wind tunnels could be built using liquid helium as the test fluid. The primary advantages of such wind tunnels would be a combination of large Reynolds numbers and a relatively small apparatus. It is hoped that this combination will allow the study of high Reynolds number flows in an academic setting. There are two basic types of liquid helium wind tunnels that can be built, corresponding to the two phases of liquid helium. The high temperature phase (between approximately 2 to 5 Kelvin) is called helium 1 and is a Navier-Stokes fluid. There are no unanswered scientific questions about the design or operation of a wind tunnel in the helium 1 phase. The low temperature phase (below approximately 2 Kelvin) of liquid helium is called helium 2. This is a quantum fluid, meaning that there are some properties of helium 2 which are directly due to quantum mechanical effects and which are not observed in Navier-Stokes fluids. The quantum effects that are relevant to this paper are: (1) helium 2 is well described as a superposition of two separate fluids called the superfluid and the normal fluid. The normal-fluid component is a Navier-Stokes fluid and the superfluid is an irrotational Euler fluid; and (2) circulation in the superfluid exists only in quantized vortex filaments. All quantized vortex filaments have identical circulations kappa and core size a. The objective of the research at CTR was to develop an understanding of the microscopic processes responsible for the observed Navier-Stokes behavior of helium 2 flows. Author (revised)

N94-12571*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HYPERSONIC, NONEQUILIBRIUM FLOW OVER A CYLINDRICALLY BLUNTED 6 DEG WEDGE
PETER A. GNOFFO Aug. 1993 39 p
(Contract RTOP 506-40-91-02)
(NASA-TM-108994; NAS 1.15:108994) Avail: CASI HC A03/MF A01

The numerical simulation of hypersonic flow in chemical nonequilibrium over cylindrically blunted 6 degree wedge is described. The simulation was executed on a Cray C-90 with Program LAURA 92-vl. Code setup procedures and sample results, including grid refinement studies and variations of species number are discussed. This simulation relates to a study of wing leading edge heating on transatmospheric vehicles. Author

N94-12623*# Arizona State Univ., Flagstaff. Dept. of Mechanical and Aerospace Engineering.
CURVATURE EFFECTS IN THREE-DIMENSIONAL BOUNDARY LAYERS
R.-S. LIN and H. L. REED (Tohoku Univ., Sendai, Japan.) *In* NAL, Proceedings of the 9th and 10th NAL Workshop on Investigation and Control of Boundary-Layer Transition p 51-53 Nov. 1992 Sponsored by NASA. Langley Research Center
Avail: CASI HC A01/MF A02

The effect of including wall and streamline curvature terms in swept-wing boundary-layer stability calculations is studied. The linear disturbance equations are cast on a fixed, body-intrinsic, curvilinear coordinate system. Those nonparallel terms which contribute mainly to the streamline-curvature effect are retained in this formulation and approximated by their local finite-difference values. Convex wall curvature has a stabilizing effect, while streamline curvature is destabilizing. Author (NASDA)

N94-12777# Cambridge Univ. (England). Dept.of Engineering.
VIB3D: METHOD FOR CALCULATING 3-D UNSTEADY FLOW THROUGH TURBOMACHINERY BLADES
LI HE and J. D. DENTON Jan. 1993 43 p
(ISSN 0309-6521)
(CUED/A-TURBO/TR.128) Avail: CASI HC A03/MF A01

This report consists of two parts. In the first part, the brief features and user's guide for the basic version of VIB3D are presented. In the second part, the features and user's guide for STAG3D, a program for a rotor-stator stage solution are described. Author (revised)

N94-12803*# Computational Fluid Dynamics Research Corp., Huntsville, AL. Research and Development Services and Software.
A COMPUTER MODEL FOR LIQUID JET ATOMIZATION IN ROCKET THRUST CHAMBERS Final Report, 22 May 1989 - 21 Nov. 1991
M. G. GIRIDHARAN, J. G. LEE, A. KRISHNAN, H. Q. YANG, E. IBRAHIM, S. CHUECH, and A. J. PRZEKWAS 31 Dec. 1991 143 p Original contains color illustrations
(Contract NAS8-38425; SBIR-11.04-6576C)
(NASA-CR-194194; NAS 1.26:194194; CFDRC-4041/1) Avail: CASI HC A07/MF A02; 5 functional color pages

The process of atomization has been used as an efficient means of burning liquid fuels in rocket engines, gas turbine engines, internal combustion engines, and industrial furnaces. Despite its widespread application, this complex hydrodynamic phenomenon has not been well understood, and predictive models for this process are still in their infancy. The difficulty in simulating the atomization process arises from the relatively large number of parameters that influence it, including the details of the injector geometry, liquid and gas turbulence, and the operating conditions. In this study, numerical models are developed from first principles, to quantify factors influencing atomization. For example, the surface wave dynamics theory is used for modeling the primary atomization and the droplet energy conservation principle is applied for modeling the secondary atomization. The use of empirical correlations has been minimized by shifting the analyses to fundamental levels. During applications of these models, parametric studies are performed to understand and correlate the influence of relevant parameters on the atomization process. The predictions of these models are compared with existing experimental data. The main tasks of this study were the following: development of a primary atomization model; development of a secondary atomization model; development of a model for impinging jets; development of a model for swirling jets; and coupling of the primary atomization model with a CFD code. Derived from text

N94-12821# Sandia National Labs., Albuquerque, NM.
DESIGN AND TESTING OF PLANAR MAGNETIC MICROMOTORS FABRICATED BY DEEP X RAY LITHOGRAPHY AND ELECTROPLATING
H. GUCKEL (Wisconsin Univ., Madison.), T. R. CHRISTENSON (Wisconsin Univ., Madison.), K. J. SKROBIS (Wisconsin Univ., Madison.), J. KLEIN (Wisconsin Univ., Madison.), and M. KARNOWSKY 1993 5 p Presented at the 7th International Conference on Solid State Sensors and Actuators, Japan, 13-15 May 1993
(Contract DE-AC04-76DP-00789)
(DE93-012856; SAND-93-1006C; CONF-9305186-1) Avail: CASI HC A01/MF A01

The successful design and testing of a three-phase planar integrated magnetic micromotor is presented. Fabrication is based on a modified deep X-ray lithography and electroplating or LIGA process. Maximum rotational speeds of 33,000 rpm are obtained in air with a rotor diameter of 285 microns and do not change when operated in vacuum. Real time rotor response is operated with an integrated shaft encoder. Long lifetime is evidenced by testing to over 5(10)(sup 7) rotation cycles without changes in performance. Projected speeds of the present motor configuration am in the vicinity of 100 krpm and are limited by torque ripple. Higher speeds, which are attractive for sensor applications. require constant torque characteristic excitation as is evidenced by ultracentrifuge and gyroscope design. Further understanding of electroplated magnetic material properties will drive these performance improvements. DOE

N94-12874*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STRAIN SENSING TECHNOLOGY FOR HIGH TEMPERATURE APPLICATIONS
W. DAN WILLIAMS Washington Aug. 1993 11 p Presented at the AIAA 4th International Aerospace Planes Conference, Orlando, FL, 1-4 Dec. 1992
(Contract RTOP 505-62-50)
(NASA-TM-4498; E-7650; NAS 1.26:4498) Avail: CASI HC A03/MF A01

This review discusses the status of strain sensing technology for high temperature applications. Technologies covered are those supported by NASA such as required for applications in hypersonic vehicles and engines, advanced subsonic engines, as well as material and structure development. The applications may be at temperatures of 540 C (1000 F) to temperatures in excess of 1400 C (2500 F). The most promising technologies at present are the resistance strain gage and remote sensing schemes. Resistance strain gages discussed include the BCL gage, the LaRC compensated gage, and the PdCr gage. Remote sensing schemes such as laser based speckle strain measurement, phase-shifling interferometry, and x-ray extensometry are discussed. Present status and limitations of these technologies are presented. Author (revised)

N94-13066*# High Technology Corp., Hampton, VA.
TRANSITION PREDICTION AND CONTROL IN SUBSONIC FLOW OVER A HUMP
JAMAL A. MASAD and VENKIT IYER (Vigyan Research Associates, Inc., Hampton, VA.) Washington NASA Sep. 1993 57 p
(Contract NAS1-19299; NAS1-19672; RTOP 537-03-23-03)
(NASA-CR-4543; NAS 1.26:4543) Avail: CASI HC A04/MF A01

The influence of a surface roughness element in the form of a two-dimensional hump on the transition location in a two-dimensional subsonic flow with a free-stream Mach number up to 0.8 is evaluated. Linear stability theory, coupled with the N-factor transition criterion, is used in the evaluation. The mean flow over the hump is calculated by solving the interacting boundary-layer equations; the viscous-inviscid coupling is taken into consideration, and the flow is solved within the separation bubble. The effects of hump height, length, location, and shape; unit Reynolds number; free-stream Mach number, continuous suction level; location of a suction strip; continuous cooling level; and location of a heating strip on the transition location are evaluated. The N-factor criterion predictions agree well with the experimental correlation of Fage; in addition, the N-factor criterion is more general and powerful than experimental correlations. The theoretically predicted effects of the hump's parameters and flow conditions on transition location are consistent and in agreement with both wind-tunnel and flight observations. Author

N94-13073*# Vigyan Research Associates, Inc., Hampton, VA.
THREE-DIMENSIONAL BOUNDARY-LAYER PROGRAM (BL3D) FOR SWEPT SUBSONIC OR SUPERSONIC WINGS WITH APPLICATION TO LAMINAR FLOW CONTROL
VENKIT IYER Washington NASA Aug. 1993 133 p
(Contract NAS1-19672; RTOP 537-03-23-03)
(NASA-CR-4531; NAS 1.26:4531) Avail: CASI HC A07/MF A02

The theory, formulation, and solution of three-dimensional, compressible attached laminar flows, applied to swept wings in subsonic or supersonic flow are discussed. Several new features and modifications to an earlier general procedure described in NASA CR 4269, Jan. 1990 are incorporated. Details of interfacing the boundary-layer computation with solution of the inviscid Euler equations are discussed. A description of the computer program, complete with user's manual and example cases, is also included. Comparison of solutions with Navier-Stokes computations with or without boundary-layer suction is given. Output of solution profiles and derivatives required in boundary-layer stability analysis is provided. Author (revised)

N94-13117# European Space Agency, Paris (France).
FUNDAMENTAL STUDY OF SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTIONS WITH PASSIVE CONTROL IN TRANSONIC FLOWS
REYNALD BUR (Office National d'Etudes et de Recherches Aerospatiales, Paris, France.) May 1993 270 p Transl. into ENGLISH of Etude fondamentale sure le controle passif de l'interaction onde de choc/couche limite turbulente en ecoulement transsonique (Paris, France, ONERA), 1991 p 1-238 Original language document announced as N92-19932
(ESA-TT-1278; ONERA-NT-1991-9; ETN-93-94583) Avail: CASI HC A12/MF A03

The techniques for controlling shock wave/turbulent boundary layer interaction are reviewed. A passive control device makes it possible to improve the performance of airfoils at transonic velocities. An interaction subjected to passive control was performed in a transonic channel. The flow is described by means of Schlieren visualization, measurements of pressure on the walls of the duct and two dimensional laser velocimetry. A momentum balance carried out in the control region made it possible to infer configurations for which the friction drag is reduced by comparison with the reference case without control. The theoretical study is based on a boundary layer type approach using the first order Prandtl equations. Experimental results obtained for the reference case and a case with control are compared. ESA

N94-13501# Societe Europeenne de Propulsion, Vernon (France). Div. Grosse Propulsion a Liquides.
RESIDUAL CONTACT RESTRAINTS IN CRYOGENICS [CONTRAINTES RESIDUELLES DE CONTACT EN AMBIANCE CRYOTECHNIQUE]
J. F. CRETEGNY and J. M. DEMONICAULT 1992 22 p In FRENCH Presented at Colloque Contraintes Residuelles, Luso-Bucaco, Portugal, 28-30 Apr. 1992
(ETN-93-94375) Avail: CASI HC A03/MF A01

The use of residual stress measurements to evaluate the state of cryogenic turbomachines, whose surfaces are worn by the working conductions in dry contact, is addressed. Their contribution to the understanding of the reasons of possible ruptures is considered. It is stated that residual stress measurements should be used as a complementary tool rather than as input data for models. It is shown, thanks to two examples concerning the ball bearings and splines of the liquid hydrogen turbopump of the Vulcain engine, what can be expected from such techniques. Total exploitation of the results has still to be done, but preliminary results are quite encouraging. ESA

N94-13521 Concordia Univ., Montreal (Quebec). Dept. of Mechanical Engineering.
TECHNIQUES FOR IMPROVING THE PERFORMANCE OF A SIMPLIFIED ELECTRONIC FUEL CONTROLLER WITH INCREMENTAL ACTUATION FOR SMALL GAS TURBINE ENGINES Ph.D. Thesis
ANTANIOS IOANNOU GEORGANTAS Apr. 1990 273 p
(ISBN-0-315-56062-2; CTN-93-60719) Copyright Avail: Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC/MF

Concepts are introduced which improve the performance of an inexpensive electronic fuel control unit for small gas turbine engines suitable for use in small aircraft and helicopters. A conventional hydromechanical fuel control unit is modified and adapted for digital electronic control. The conversion involves the replacement of the pneumatic computing and actuating mechanism with digital computation and incremental electronic actuation of a flow metering valve. A mathematical model of the unit is developed, implemented, and validated. The model is used for simulation and study of the system dynamics. Some new methods are applied in the design and development of a digital controller. An optimization scheme for tuning the controller is formulated and implemented experimentally. As a next step toward improvement of the simple electronic fuel controller, a concept of two electronic actuators, one operating the metering valve and the other a bypass valve, is introduced and investigated. Higher flexibility and faster transient response, as compared to the conventional system and the single actuator unit, are demonstrated. The possibility of a backup scheme in case of failure of one of two actuating mechanisms is also discussed. Author (CISTI)

N94-13527# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
PHOTOGRAMMETRIC METHODS FOR TRAJECTORY MEASUREMENTS
A. J. L. WILLEKENS 15 Apr. 1991 33 p Presented at the SFTE 4th European Mini Symposium, Rome, Italy, 1991
(NLR-TP-91166-U; ETN-93-94336; AD-B169706L) Avail: CASI HC A03/MF A01

A photogrammetric method for trajectory measurements in flight testing at short range is discussed. A theoretical overview of the method used is given, this being a combination of a camera and equipment on board of the aircraft like Global Positioning System (GPS) or inertial navigation system and a baro-altimeter. On the ground a minimum of equipment is required: only surveyed ground control points are needed. The accuracy further depends strongly on the method used, so different methods are discussed. Operational aspects also are important for the selected method. The resulting method is relatively simple, quite accurate, and can be used under many different conditions. The practical aspects are discussed in chronological order. This illustrates how the method evolved from a simple camera and equally simple calculations to the equipment nowadays. The manual work involved decreased with each amelioration. Some operational aspects of the new system are discussed. Based on today's system, some remarks of future evolutions can be made. Here is the question whether and where can the Charge Coupled Device (CCD) (video) camera replace the film used today. This question has more than only technical relevance: operational issues are equally important. ESA

N94-13565 Institute for Aerospace Research, Ottawa (Ontario). Structures and Materials Lab.
SHEAR BUCKLING OF FIBER METAL LAMINATES: COMPARISON BETWEEN ORTHOTROPIC AND ANISOTROPIC PLATE MODELS USING FINITE ELEMENT METHOD
S. KRISHNAKUMAR Jul. 1993 44 p
(LTR-ST-1934; CTN-93-60861) Avail: Issuing Activity (Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC)

The finite element method is used to compare the results provided by two approaches for the simulation of shear buckling of anisotropic fiber metal laminates, ARALL and GLARE. Two different load cases are studied: uniform shear stresses along the boundary, as is usually employed in theoretical analyses; and shear displacement along one edge of a plate, as is normally the case under test conditions. The orthotropic approximation yields solutions that are independent of the sign of the applied stresses and have only a mild variation with changes in the orientation of the reinforcing fibers. The influence of anisotropy is much larger in the case of applied shear displacement than in the uniform stress case, for all laminates except the pseudo-isotropic GLARE3 material. A reversal of the applied load direction can alter the buckling strength by a factor of 2.5 for this load condition. In unidirectional laminates subjected to in-plane shear displacement, the orthotropic model overestimates the buckling load by about 55 percent in some cases, and underestimates it by nearly 40 percent in others. In the case of GLARE3, the difference between the anisotropic solution and the orthotropic model is less than 2 percent. Author (CISTI)

N94-13569 Pennsylvania State Univ., University Park.
NUMERICAL SIMULATIONS OF UNSTEADY FLOWS IN TURBOMACHINES Ph.D. Thesis
DANIEL JOSEPH DORNEY 1992 314 p
Avail: Univ. Microfilms Order No. DA9311624

The performance of axial and centrifugal turbomachines is significantly affected by the presence of unsteady and viscous flow mechanisms. Most contemporary design systems, however, use steady or linearized unsteady inviscid flow analyses to generate new blade shapes. In an effort to increase the understanding of unsteady viscous flows in turbomachinery blade rows, and to determine the limitations of linearized inviscid flow analyses, a two-part investigation was conducted. In the first portion of this investigation, a nonlinear viscous flow analysis was developed for the prediction of unsteady flows in two dimensional axial turbomachinery blade rows. The boundary conditions were formulated to allow the specification of vortical, entropic and acoustic excitations at the inlet, and acoustic excitations at exit, of a cascade. Numerical simulations were performed for flat plate and compressor exit guide vane cascades, and the predicted results were compared with solutions from classical linearized theory and linearized inviscid flow analysis. The unsteady pressure fields predicted with the current analysis showed close agreement with the linearized solutions for low to moderate temporal frequency vortical and acoustic excitations. As the temporal frequency of the excitations was increased, nonlinear effects caused discrepancies to develop between the linearized and Navier-Stokes solution sets. The inclusion of viscosity had a significant impact on the unsteady vorticity field, but only a minimal effect on the unsteady pressure field. In the second part of this investigation, a quasi-three-dimensional Navier-Stokes analysis was modified and applied to flows in centrifugal turbomachinery blade rows. Inviscid and viscous flow simulations were performed for a centrifugal impeller at three operating conditions. By comparing the predicted and experimental circumferential distributions of the relative frame velocity and flow angle downstream of the impeller, it was hypothesized that in the experiments the end secondary flows energize the impeller suction surface boundary making the local flow behave like an inviscid fluid. The performance curve generated from the viscous calculations showed close agreement with the experimental data. Author

N94-13574 Pennsylvania State Univ., University Park.
AN EXPERIMENTAL INVESTIGATION OF SHOCK WAVE/VORTEX INTERACTION Ph.D. Thesis
LOUIS NICHOLAS CATTAFESTA, III 1992 279 p
Avail: Univ. Microfilms Order No. DA9311604

Although shock wave/vortex interaction is a basic and important fluid dynamics problem, very little research has been conducted on this topic. Therefore, a detailed experimental study of the interaction between a supersonic streamwise turbulent vortex and a shock wave has been carried out at the Penn State Gas Dynamics Laboratory. A vortex is produced by replaceable swirl vanes located upstream of the throat of various converging-diverging nozzles. The supersonic vortex is then injected into either a coflowing supersonic stream or ambient air. The structure of the isolated vortex is investigated in a supersonic wind tunnel using miniature, fast-response, five-hole and total temperature probes and in a free jet using Laser Doppler Velocimetry. The cases tested have unit Reynolds numbers in excess of 25 million per meter, axial Mach numbers ranging from 2.5 to 4.0, and peak tangential Mach numbers from 0 (i.e. a pure jet) to about 0.7. The results show that the typical supersonic wake-like vortex consists of a non-isentropic, rotational core, where the reduced circulation distribution is self-similar, and an outer isentropic, irrotational region. The vortex core is also a region of significant turbulent fluctuations. Radial profiles of turbulent kinetic energy and axial-tangential Reynolds stress are presented. The interactions between the vortex and both oblique and normal shock waves are investigated using nonintrusive optical diagnostics (i.e. schlieren, Planar Laser Scattering, and Laser Doppler Velocimetry). Of the various types, two Mach 2.5 overexpanded-nozzle Mach-disc interactions are examined in detail. Below a certain vortex strength, a 'weak' interaction exists in which the normal shock is perturbed locally into an unsteady 'bubble' shock near the vortex axis, but vortex breakdown (i.e. a stagnation point) does not occur. For stronger vortices, a random unsteady 'strong' interaction results that causes vortex breakdown. The vortex core reforms downstream of the rear stagnation point, and the reduced circulation distribution once again becomes self-similar in this region. A new model of this interaction is proposed. Finally, a curve defining the approximate limits of supersonic vortex breakdown is presented. Author

N94-13726# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
SOME COMPUTATIONAL TOOLS FOR THE ANALYSIS OF THROUGH CRACKS IN STIFFENED FUSELAGE SHELLS
C. C. RANKIN (Lockheed Missiles and Space Co., Palo Alto, CA.), F. A. BROGAN (Lockheed Missiles and Space Co., Palo Alto, CA.), and E. RIKS Oct. 1992 24 p Original contains color illustrations
(LR-701; ETN-93-94419) Avail: CASI HC A03/MF A01

A method for computing the energy release rate for cracks of varying length in a typical stiffened metallic fuselage under general loading conditions is presented. Reliable analytical methods that predict the structural integrity and residual strength of aircraft fuselage structures containing cracks are needed to help to understand the behavior of pressurized stiffened shells with damage, to determine the safe life of such a shell. The models used in the simulation are derived from an extensive analysis of a fuselage barrel section subjected to operational flight loads. Energy release rates are computed as a function of the length of the crack, its location, and the crack propagation mode. ESA

N94-13730# McDonnell-Douglas Missile Systems Co., Saint Louis, MO.
HIGH FLUX HEAT EXCHANGER Interim Report, 1 Oct. 1990 - 29 Oct. 1991
EDWARD M. FLYNN and MICHAEL J. MACKOWSKI Jan. 1993 49 p
(Contract F33615-90-C-2054)
(AD-A266341; WL-TR-93-2027) Avail: CASI HC A03/MF A01

This interim report documents the results of the first two phases of a four-phase program to develop a high flux heat exchanger for cooling future high performance aircraft electronics. Phase 1 defines future needs for high flux heat removal in advanced military electronics systems. The results are sorted by broad application categories: (1) commercial digital systems, (2) military data processors, (3) power processors, and (4) radar and optical systems. For applications expected to be fielded in five to ten years, the outlook is for steady state flux levels of 30-50 W/sq cm for digital processors and several hundred W/sq cm for power control applications. In Phase 1, a trade study was conducted on emerging cooling technologies which could remove a steady state chip heat flux of 100 W/sq cm while holding chip junction temperature to 90 C. Constraints imposed on heat exchanger design, in order to reflect operation in a fighter aircraft environment, included a practical lower limit on coolant supply temperature, the preference for a nontoxic, nonflammable, and nonfreezing coolant, the need to minimize weight and volume, and operation in an accelerating environment. The trade study recommended the

Compact High Intensity Cooler (CHIC) for design, fabrication, and test in the final two phases of this program. DTIC

N94-13790*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DYNAMIC FORMS. PART 1: FUNCTIONS
GEORGE MEYER and G. ALLAN SMITH Aug. 1993 86 p
(Contract RTOP 505-64-52)
(NASA-TP-3397; A-93078; NAS 1.60:3397) Avail: CASI HC A05/MF A01

The formalism of dynamic forms is developed as a means for organizing and systematizing the design control systems. The formalism allows the designer to easily compute derivatives to various orders of large composite functions that occur in flight-control design. Such functions involve many function-of-a-function calls that may be nested to many levels. The component functions may be multiaxis, nonlinear, and they may include rotation transformations. A dynamic form is defined as a variable together with its time derivatives up to some fixed but arbitrary order. The variable may be a scalar, a vector, a matrix, a direction cosine matrix, Euler angles, or Euler parameters. Algorithms for standard elementary functions and operations of scalar dynamic forms are developed first. Then vector and matrix operations and transformations between parameterization of rotations are developed in the next level in the hierarchy. Commonly occurring algorithms in control-system design, including inversion of pure feedback systems, are developed in the third level. A large-angle, three-axis attitude servo and other examples are included to illustrate the effectiveness of the developed formalism. All algorithms were implemented in FORTRAN code. Practical experience shows that the proposed formalism may significantly improve the productivity of the design and coding process.
Author (revised)

N94-13803# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
FATIGUE AND RESIDUAL STRENGTH CHARACTERISTICS OF FIBER METAL LAMINATES SUBJECTED TO INCIDENTAL DAMAGE
ROBERT FREDELL, AD VLOT, and MARC VERBRUGGEN (Structural Laminates Co., Alcoa Center, PA.) Dec. 1992 23 p Presented at 1992 USAF Aircraft Structural Integrity Program Conference, San Antonio, TX, 1-3 Dec. 1992
(LR-708; ETN-93-94425) Avail: CASI HC A03/MF A01

The fatigue and residual strength characteristics of the fiber metal laminates GLARE and ARALL, following damage typically encountered in the service environment, were investigated. Comparative impact tests showed a gereral trend of increasing impact resistance from carbon thermoplastic composites (poorest) to ARALL, monolithic aluminum 2024-T3, and GLARE 3 (best). Fatigue and residual strength tests carried out on impact and scratch damaged fiber metal laminates demonstrated the excellent tolerance of laminates to in-service damage. The extremely slow crack growth characteristics of laminates were not deteriorated by scratches. Impacts which caused perforations in GLARE and ARALL continued to exhibit the extremely slow fatigue crack growth for which the laminates are known. Repair criteria based on the blunt notch strength of the laminates have been proposed for in-service damage to riveted fiber metal laminate structures. Techniques used for the repair of aluminium structures can apply to laminates. ESA

N94-13815*# Eloret Corp., Sunnyvale, CA.
DEVELOPMENT OF AN AUTOMATED FILM-READING SYSTEM FOR BALLISTIC RANGES
LESLIE A. YATES 1992 13 p
(Contract NCC2-583)
(NASA-CR-194398; NAS 1.26:194398) Avail: CASI HC A03/MF A01

Software for an automated film-reading system that uses personal computers and digitized shadowgraphs is described. The software identifies pixels associated with fiducial-line and model images, and least-squares procedures are used to calculate the positions and orientations of the images. Automated position and orientation readings for sphere and cone models are compared to those obtained using a manual film reader. When facility calibration errors are removed from these readings, the accuracy of the automated readings is better than the pixel resolution, and it is equal to, or better than, the manual readings. The effects of film-reading and facility-calibration errors on calculated aerodynamic coefficients is discussed. Author

N94-13861# Institute for Aerospace Research, Ottawa (Ontario). Structures and Materials Lab.
REVIEW OF CANADIAN AERONAUTICAL FATIGUE WORK, 1991-1993
D. L. SIMPSON, comp. 10 May 1993 95 p Presented at the 23rd Conference of the International Committee on Aeronautical Fatigue
(LTR-ST-1932; CJ5-07; CTN-93-60835) Avail: CASI HC A05/MF A01

Detailed reviews are presented of research into aeronautical fatigue conducted by private companies, universities, and government research institutions in Canada over the 1991-1993 period. Research projects are described in the areas of full-scale tests of aircraft and components, loads monitoring and measurement, fracture mechanics and crack propagation, composite materials and structures, and the fatigue and damage tolerance of gas turbine engines. CISTI

N94-13874 Southampton Univ. (England). Inst. of Sound and Vibration Research.
PISTON ENGINE INTAKE AND EXHAUST SYSTEM DESIGN
P. O. A. L. DAVIES Jul. 1993 58 p Limited Reproducibility: *More than 20% of this document may be affected by microfiche quality*
(ISVR-TR-222) Copyright Avail: Issuing Activity

The aim of intake and exhaust system design is to control the transfer of acoustic energy from the sources and its emission by the system with minimal loss of engine performance. A rational design process depends on the adoption of a design methodology based on predictive modeling of acoustic behavior. Virtually any system geometry can be modeled by breaking it down to a sequence of simple elements or chambers. An initial design layout is then produced with simple parametric models of individual element behavior. This design is then refined to prototype level by systematic modification of detail using realistic assessments of system performance in its operational environment. Following prototype validation by practical testing, further necessary development is again assisted by predictive modeling. The application of appropriate procedures is illustrated by a series of practical examples. These concern improvements in interior noise by control of intake noise, of vehicle performance by reducing flow losses, of the environment by control of exhaust emissions, and lastly with the control of flow noise. The report concludes with a brief outline of current and new developments involving integrated design procedures. Author (revised)

N94-13889# Sandia National Labs., Albuquerque, NM.
A PERSPECTIVE ON AVS IN AN ENGINEERING SCIENCES ENVIRONMENT
M. W. GLASS 1993 10 p Presented at the Application Visualization System (AVS) 1993 Users Group Meeting, Orlando, FL, 24-26 May 1993
(Contract DE-AC04-76DP-00789)
(DE93-015011; SAND-93-1002C; CONF-9305168-3) Avail: CASI HC A02/MF A01

At Sandia National Laboratories, the Engineering Sciences Center has made a commitment to integrate the Application Visualization System (AVS) into our computing environment as the primary tool for scientific visualization. AVS will be used on an everyday basis by a broad spectrum of users ranging from the occasional computer user to AVS module developers. Additionally, AVS will be used to visualize structured grid, unstructured grid, gridless, 1D, 2D, 3D, steady-state, transient, computational, and experimental data. The following is one user's perspective on how

AVS meets this task. Several examples of how AVS is currently being utilized will be given along with some future directions.
DOE

N94-13929# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
A SURVEY OF CRACK PATH STABILITY CRITERIA AND THEIR APPLICATION TO CRACK FLAPPING PHENOMENA IN STIFFENED STRUCTURES
K. J. J. M. ZAAL Sep. 1992 153 p
(LR-681; ETN-93-94005) Avail: CASI HC A08/MF A02

In unstiffened and stiffened cylindrical shells, longitudinal cracks are known to flap. Above a certain length, the cracks no longer propagate in the longitudinal direction but turn towards a circumferentially oriented direction. In a pressurized fuselage, this type of U shaped crack could enable a controlled decompression in case of accidental damage or rapid growth of a fatigue crack. Both the T stress criterion of Cotterell and Rice and the criterion of Finnie and Saith can predict the directional stability of the path a crack is following. The predictions of both criteria to experimental results of Swift are compared. The crack path stability criterion of Finnie and Saith seems to emerge as the best available crack path stability criterion. The criterion is material dependent. In combination with a geometrical nonlinear finite element analysis, it may be the first candidate for someone studying directional stability of cracks.
ESA

N94-13931# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
COMPRESSIVE BUCKLING OF CURVED, ANISOTROPIC PANELS STIFFENED IN TWO DIRECTIONS. PART 1: DERIVATION OF THE GOVERNING EQUATIONS
J. L. VEROLME Aug. 1992 44 p
(LR-694; ETN-93-94006) Avail: CASI HC A03/MF A01

A designer's tool for calculating the compressive buckling of aircraft fuselage panels is described. The technique applied is an extension of the adjacent equilibrium criterion from which information about the initial postbuckling behavior is obtained. The basic equations, on which most of the modules of the tool are based, are derived using the energy method. Stability equations in the out of plane coordinate and Airy's stress function, together with jump and boundary conditions, are obtained. The assumptions made are listed. The physical behavior of fuselage panels in compression is treated.
ESA

N94-13945# Carleton Univ., Ottawa (Ontario).
AN EXPERIMENTAL INVESTIGATION INTO THE DAMAGE RESISTANCE AND COMPRESSION-AFTER-IMPACT STRENGTH OF T800H/3900-2
H. VIETINGHOFF, C. POON (Institute for Aerospace Research, Ottawa, Ontario.), P. V. STRAZNICKY, and R. GOULD (Institute for Aerospace Research, Ottawa, Ontario.) Jan. 1993 93 p
Original contains color illustrations
(LTR-ST-1909; CTN-93-60764) Avail: CASI HC A05/MF A01

An experimental investigation was conducted into impact behavior of a Toray T800H/3900-2 material system, a system representative of the most recent generation of toughened graphite-epoxy composites selected for use in several new airframes. In the investigation, test specimens featuring quasi-isotropic and midplane symmetric layup with 24 plies were fabricated and impacted at five different impact energy levels, resulting in damage ranging from barely visible to severe. Damage was characterized using nondestructive and destructive inspection, including ultrasound and x-ray techniques, and the specimens were then compressively loaded to failure. The carefully controlled set of experiments resulted in a detailed three dimensional characterization of the damage induced in the selected laminate layup for a range of impact energies. Compression after impact testing resulted in a correlation of impact energy and damage area with residual compressive strength. The results will be used to calibrate and test the analytical prediction methods being developed as part of a project on impact resistance and tolerance of composite materials, and as reference data on the material system.
Author (CISTI)

N94-13986# Technische Univ., Delft (Netherlands). Structures and Material Lab.
MSD IN FUSELAGE LAP JOINTS: REQUIREMENTS FOR INSPECTION INTERVALS FOR TYPICAL FUSELAGE LAP JOINT PANELS WITH MULTIPLE SITE DAMAGE M.S. Thesis
G. P. WIT Jul. 1992 160 p
(LR-697; ETN-93-94009) Avail: CASI HC A08/MF A02

Inspection of failed aircraft structures and fractography on fatigue specimens showed that after a high number of flights, cracks can appear simultaneously in riveted lap joints. When these crack tips approach each other, a mutual interaction causes an unexpected fast crack growth and new coalescence of cracks. The term Multiple Site Damage (MSD) is used when the mutual interaction of two or more damages is noticeable. A model to predict the fatigue life of a riveted lap joint and the minimum necessary inspection interval for safe aircraft operation is presented. The program was developed to simulate the fatigue process and aircraft inspection. Input for this analysis are scatter data for initiation, the stress distribution between frames and the geometry of the structure. Methods that can be used to avoid accidents due to MSD are reviewed. A test program to support the analysis is described.
ESA

N94-14045# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany). Abt. Aerothermodynamik und Verbrennung.
TURBULENT PARTICLE DISPERSION IN CONFINED SWIRLING FLOWS Ph.D. Thesis - Ruhr Univ. [TURBULENTE PARTIKELDISPERSION IN EINGESCHLOSSENEN DRALLSTROEMUNGEN]
ERICH WALTER BLUEMCKE Apr. 1992 181 p In GERMAN
Original contains color illustrations
(ISSN 0939-2963)
(DLR-FB-92-32; ETN-93-93962) Avail: CASI HC A09/MF A02

Turbulent particle dispersion, a dominant transport phenomena in gas turbine combustion chambers, is investigated by numerical simulations. A physical model is evaluated using results from a model experiment. Besides averaged transport parameters the instantaneous transport phenomena are analyzed for monosized droplets in swirling flows relevant for gas turbine combustion chambers. A good agreement between measured and calculated data can be stated. A parameter variation evidences the impact of the detailed description of the characteristics of gas turbulence. A simulation procedure is established for promotion in solving the engineering problem of the design of gas turbine combustion chambers.
ESA

N94-14173# Calspan Corp., Arnold AFS, TN.
ELECTROMAGNETIC WAVE TEST
R. K. MATTHEWS and S. A. STEPANEK *In* VKI, Methodology of Hypersonic Testing 7 p 1993 Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
Copyright Avail: CASI HC A02/MF A03

Electromagnetic wave testing, which represents a relatively new test technique that involves the union of several disciplines (aerothermodynamics, electromagnetics, materials/structures, and advanced diagnostics) is introduced. The essence of this new technique deals with the transmission and possible distortion of electromagnetic waves (RF or IR) as they pass through the bow shock, flow field, and electromagnetic window of a missile flying at hypersonic speeds. Variations in gas density along the optical path can cause significant distortion of the electromagnetic waves and, therefore the missile seeker system may not effectively track the target. Two specific test techniques are described. The first example deals with the combining of a wind tunnel and an RF range while the second example discusses the complexities of evaluating IR seeker system performance.
ESA

N94-14443# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (Germany). Inst. fuer Physik der Atmosphaere.
TURBULENT DIFFUSION IN HOMOGENEOUS SHEAR FLOW WITH STABLE DENSITY STRATIFICATION Ph.D. Thesis - Tech. Univ. Munich [TURBULENTE DIFFUSION IN EINER HOMOGENEN SCHERSTROEMUNG MIT STABILER DICHTESCHICHTUNG]
HANS-JAKOB KALTENBACH Aug. 1992 157 p In GERMAN
(ISSN 0939-2963)
(DLR-FB-92-26; ETN-93-93957) Avail: CASI HC A08/MF A02

The mixing properties of homogeneous turbulent flows, which are influenced by stable density stratification and mean shear, are investigated using direct numerical simulation and large eddy simulation. The dependency of the components of the turbulence diffusivity tensor on the value of the Gradient Richardson number is demonstrated. Stable stratification reduces the vertical transport of species stronger than the horizontal transport. In cases with strong background stratification the Froude number plays an important role besides the Richardson number. Little different is found between direct simulation and large eddy simulation results. Both types of simulations are concluded to refer to the same order of magnitude of the Reynolds number. The results are sensitive to the value of the Prandtl number in cases with Richardson number greater than 0.25. ESA

N94-14445*# McGill Mfg. Co., Valparaiso, IN.
COMPUTER PROGRAM FOR ANALYSIS OF HIGH SPEED, SINGLE ROW, ANGULAR CONTACT, SPHERICAL ROLLER BEARING, SASHBEAN. VOLUME 1: USER'S GUIDE Final Report
ARUN K. AGGARWAL Sep. 1993 68 p Prepared for Sikorsky Aircraft, Stratford, CT
(Contract NAS3-25423; RTOP 505-63-36; DA PROJ. 1L1-62211-A-47-A)
(NASA-CR-191183; E-8089-VOL-1; NAS 1.26:191183; ARL-CR-82-VOL-1) Avail: CASI HC A04/MF A01

The computer program SASHBEAN (Sikorsky Aircraft Spherical Roller High Speed Bearing Analysis) analyzes and predicts the operating characteristics of a Single Row, Angular Contact, Spherical Roller Bearing (SRACSRB). The program runs on an IBM or IBM compatible personal computer, and for a given set of input data analyzes the bearing design for it's ring deflections (axial and radial), roller deflections, contact areas and stresses, induced axial thrust, rolling element and cage rotation speeds, lubrication parameters, fatigue lives, and amount of heat generated in the bearing. The dynamic loading of rollers due to centrifugal forces and gyroscopic moments, which becomes quite significant at high speeds, is fully considered in this analysis. For a known application and it's parameters, the program is also capable of performing steady-state and time-transient thermal analyses of the bearing system. The steady-state analysis capability allows the user to estimate the expected steady-state temperature map in and around the bearing under normal operating conditions. On the other hand, the transient analysis feature provides the user a means to simulate the 'lost lubricant' condition and predict a time-temperature history of various critical points in the system. The bearing's 'time-to-failure' estimate may also be made from this (transient) analysis by considering the bearing as failed when a certain temperature limit is reached in the bearing components. The program is fully interactive and allows the user to get started and access most of its features with a minimal of training. For the most part, the program is menu driven, and adequate help messages were provided to guide a new user through various menu options and data input screens. All input data, both for mechanical and thermal analyses, are read through graphical input screens, thereby eliminating any need of a separate text editor/word processor to edit/create data files. Provision is also available to select and view the contents of output files on the monitor screen if no paper printouts are required. A separate volume (Volume-2) of this documentation describes, in detail, the underlying mathematical formulations, assumptions, and solution algorithms of this program. Author (revised)

N94-14598# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
PROCEEDINGS OF THE FLUID DYNAMICS SYMPOSIUM IN HONOUR OF PROFESSOR R. NARASIMHA ON HIS 60TH BIRTHDAY
S. K. CHAKRABARTTY, ed., S. S. DESAI, ed., S. MAJUMDAR, ed., D. K. PRABHU, ed., S. K. SAXENA, ed., and P. N. SHANKAR, ed. Jul. 1993 212 p Symposium held in Bangalore, India, 9 Jul. 1993 Original contains color illustrations
(Contract NAL PROJ. CF-0-900)
(NAL-SP-9315) Avail: CASI HC A10/MF A03

This special report contains 19 papers presented at a symposium held in honor of Prof. R. Narasimha, Director of the National Aerospace Laboratories in Bangalore, India. The papers address research in the development of computational methods for the analysis and modeling of fluid dynamic phenomena.

N94-14599# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
A VERTEX-BASED FINITE-VOLUME ALGORITHM FOR THE NAVIER-STOKES EQUATIONS
S. K. CHAKRABARTTY and K. DHANALAKSHMI *In its* Proceedings of the Fluid Dynamics Symposium in Honour of Professor R. Narasimha on his 60th Birthday p 1-7 Jul. 1993
Avail: CASI HC A02/MF A03

A vertex-based, finite-volume algorithm has been developed to solve the Reynolds-averaged Navier-Stokes equations without thin-layer approximation. An explicit, five-stage Runge-Kutta, time-stepping scheme has been used for time integration along with different acceleration techniques to reach the steady state. A code employing multi-block grid structure has been developed. This code can accept any type of grid topology. As test cases, the turbulent flow past RAE-2822 and NACA-0012 airfoils, and the laminar flow past a cropped delta wing at ten degrees angle of attack have been computed and the results compared with available numerical and experimental results. The Baldwin-Lomax turbulence model has been used in the case of turbulent flows. Author

N94-14603# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
AN IMPLICIT FINITE VOLUME NODAL POINT SCHEME FOR THE SOLUTION OF TWO-DIMENSIONAL COMPRESSIBLE NAVIER-STOKES EQUATIONS
VIMALA DUTTA *In its* Proceedings of the Fluid Dynamics Symposium in Honour of Professor R. Narasimha on his 60th Birthday p 51-59 Jul. 1993
Avail: CASI HC A02/MF A03

An implicit finite volume nodal point scheme has been developed for solving the two-dimensional compressible Navier-Stokes equations. The numerical scheme is evolved by efficiently combining the basic ideas of the implicit finite-difference scheme of Beam and Warming (1978) with those of nodal point schemes due to Hall (1985) and Ni (1982). The 2-D Navier-Stokes solver is implemented for steady, laminar/turbulent flows past airfoils by using C-type grids. Turbulence closure is achieved by employing the algebraic eddy-viscosity model of Baldwin and Lomax (1978). Results are presented for the NACA-0012 and RAE-2822 airfoil sections. Comparison of the aerodynamic coefficients with experimental results for the different test cases presented here establishes the validity and efficiency of the method. Author

N94-14604# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
WALL INTERFERENCE STUDIES: REVISITED
R. GOPINATH *In its* Proceedings of the Fluid Dynamics Symposium in Honour of Professor R. Narasimha on his 60th Birthday p 61-68 Jul. 1993
Avail: CASI HC A02/MF A03

A brief review is made of the methods currently available for assessing and correcting the data for effects due to wall interference. Computational simulation of ventilated walls has been described. The DLR panel code available in the division is being modified to handle flow past a model with sting and support strut in a wind tunnel whose walls could be either solid, or, ventilated, or, open-jet. The effect of sting, strut, and walls on the model data is under study. Author

N94-14606# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.

NAVIER-STOKES SIMULATION OF TRANSONIC VORTEX FLOW OVER A DELTA WING

ANAND KUMAR *In its* Proceedings of the Fluid Dynamics Symposium in Honour of Professor R. Narasimha on his 60th Birthday p 77-89 Jul. 1993

Avail: CASI HC A03/MF A03

An explicit multi-stage Runge-Kutta time-stepping scheme with cell-centered finite volume spatial discretization is employed to solve three-dimensional, compressible Navier-Stokes equations. A novel variation for computation of viscous fluxes is used. Convergence to steady state is expedited through acceleration techniques. The vortex flow over a 65 degree cropped rounded leading edge delta wing is computed, and the results are compared with experimental data and Euler solution. Author

N94-14613# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.

DEVELOPMENT OF A GENERAL PURPOSE MULTIGRID ACCELERATED NAVIER-STOKES SOLVER

J. P. SINGH, D. SCHWAMBORN (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen, Germany.), and C. KLOPPMANN (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen, Germany.) *In its* Proceedings of the Fluid Dynamics Symposium in Honour of Professor R. Narasimha on his 60th Birthday p 167-179 Jul. 1993

Avail: CASI HC A03/MF A03

The present work describes the development of a fairly general purpose 2-D multigrid accelerated Reynolds-averaged Navier-Stokes solver. For turbulent flows the eddy viscosity is computed using the Baldwin-Lomax model. The code has been successfully used to compute a variety of flows like near-incompressible flows, subsonic flows, flows with massive separation around stall, flow past laminar flow airfoils with long laminar runs, transonic flows with moderate and strong shock, and at supersonic speeds. Results are in good agreement. This shows the robustness and wide applicability of the code. The convergence history in almost all these cases presents a fairly smooth curve with a steep drop to low residue levels. The present level of success in the computation of supersonic flows leads us to expect that this work is directly extendible to hypersonic flows without dissociation effects. Author

N94-14727*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A HOT DYNAMIC SEAL RIG FOR MEASURING HYPERSONIC ENGINE SEAL DURABILITY AND FLOW PERFORMANCE

JEFFREY H. MILLER (Sverdrup Technology, Inc., Brook Park, OH.), BRUCE M. STEINETZ, PAUL J. SIROCKY (Sverdrup Technology, Inc., Brook Park, OH.), and LAWRENCE A. KREN (Case Western Reserve Univ., Cleveland, OH.) Apr. 1993 11 p Presented at the 34th Structures, Structural Dynamics, and Materials Conference, La Jolla, CA, 19-21 Apr. 1993; sponsored by AIAA, ASME, AHS, and ASC See also A93-33916

(Contract RTOP 763-22-41)

(NASA-TM-106294; E-8031; NAS 1.15:106294; AIAA PAPER 93-1346) Avail: CASI HC A03/MF A01

A test fixture for measuring the dynamic performance of candidate high-temperature engine seal concepts was installed at NASA Lewis Research Center. The test fixture was designed to evaluate seal concepts under development for advanced hypersonic engines, such as those being considered for the National Aerospace Plane (NASP). The fixture can measure dynamic seal leakage performance from room temperature up to 840 C (1550 F) and air pressure differentials up to 690 kPa (100 psi). Performance of the seals can be measured while sealing against flat or distorted walls. In the fixture two seals are preloaded against the sides of a 30 cm (1 ft) long saber that slides transverse to the axis of the seals, simulating the scrubbing motion anticipated in these engines. The capabilities of this test fixture along with preliminary data showing the dependence of seal leakage performance on high temperature cycling are addressed. Author (revised)

N94-14827# Royal Aerospace Establishment, Farnborough (England). Aerodynamics and Propulsion Dept.

THE 3D PNEUMATIC AND 2D DYNAMIC PROBES: THEIR DEVELOPMENT AND SUBSEQUENT USE IN A TRANSONIC FAN

M. A. CHERRETT, J. D. BRYCE, and H. P. HODSON (Cambridge Univ., England.) 22 Dec. 1992 18 p Presented at the 11th International Symposium on Measuring Techniques for Transonic and Supersonic Flows in Cascades and Turbomachines, Munich, Germany, 14-15 Sep. 1992 Sponsored by Ministry of Defence, London, England, and Dept. of Trade and Industry, London, England

(RAE-TM-AERO/PROP-22; BR315905; ETN-93-94498)

Copyright Avail: CASI HC A03/MF A01

Three different three dimensional (3D) pneumatic probes--a four hole wedge probe, a stem pyramid probe, and a sting pyramid probe--were built and calibrated in detail, along with two dynamic yawmeters and a geometrically identical pneumatic yawmeter. The aerodynamic performance of the probes are discussed, and detailed steady state flow field measurements taken with the probes at stator exit in a transonic fan are compared. ESA

N94-14877# Aerospace Corp., El Segundo, CA. Engineering and Technology Group.

DOUBLE INLET PULSE TUBE CRYOCOOLER THEORY

HAROLD MIRELS 2 Feb. 1993 27 p

(AD-A266832; ATR-93(8399)-2) Avail: CASI HC A03/MF A01

An analytical model has been developed for the performance of a double inlet pulse tube cryocooler employing a stepped piston compressor. Numerical results are presented as a function of the area ratio of the stepped piston. The double inlet pulse tube cryocooler is shown to have more refrigeration power than the corresponding single inlet device. However, the increased refrigeration power is achieved at the cost of reduced thermal efficiency. DTIC

N94-15196# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.

SPECIAL COURSE ON SHOCK-WAVE/BOUNDARY-LAYER INTERACTIONS IN SUPERSONIC AND HYPERSONIC FLOWS [INTERACTIONS ENTRE ONDES DE CHOC ET COUCHES LIMITES DANS LES ECOULEMENTS SUPERSONIQUES ET HYPERSONIQUES]

Aug. 1993 298 p Course held in Rhode-Saint-Genese, Belgium, 24-28 May 1993; sponsored by VKI Original contains color illustrations

(AGARD-R-792; ISBN-92-835-0718-5) Copyright Avail: CASI HC A13/MF A03

Notes for the AGARD Fluid Dynamics Panel (FDP) Special Course on 'Shock-Wave/Boundary-Layer Interactions in Supersonic and Hypersonic Flows' are presented. The objective was to report on results from recent research programs providing a consolidated review of these activities and a sound basis for developing more reliable methodologies for future vehicle design. The course also provided a focused review of recent progress for swept interactions in both laminar and turbulent flows, including discussions: flowfield structure; scaling and similarity laws; effect of shock strength on flow feature; effect of shock generator geometry for a given shock strength; techniques for investigating swept interactions, particularly optical techniques; and contributions of numerical simulations to the understanding of swept interactions. The effects of turbulence and turbulence modeling on the flowfields are provided.

N94-15197*# Pennsylvania State Univ., University Park. Gas Dynamics Lab.
SWEPT SHOCK/BOUNDARY-LAYER INTERACTIONS: SCALING LAWS, FLOWFIELD STRUCTURE, AND EXPERIMENTAL METHODS
GARY S. SETTLES *In* AGARD, Special Course on Shock-Wave/Boundary-Layer Interactions in Supersonic and Hypersonic Flows 40 p Aug. 1993 Sponsored by NASA. Ames Research Center and AFOSR
Copyright Avail: CASI HC A03/MF A03
A general review is given of several decades of research on the scaling laws and flowfield structures of swept shock wave/turbulent boundary layer interactions. Attention is further restricted to the experimental study and physical understanding of the steady-state aspects of these flows. The interaction produced by a sharp, upright fin mounted on a flat plate is taken as an archetype. An overall framework of quasiconical symmetry describing such interactions is first developed. Boundary-layer separation, the interaction footprint, Mach number scaling, and Reynolds number scaling are then considered, followed by a discussion of the quasiconical similarity of interactions produced by geometrically-dissimilar shock generators. The detailed structure of these interaction flowfields is next reviewed, and is illustrated by both qualitative visualizations and quantitative flow images in the quasiconical framework. Finally, the experimental techniques used to investigate such flows are reviewed, with emphasis on modern non-intrusive optical flow diagnostics. Author

N94-15199# Rutgers - The State Univ., Piscataway, NJ. Dept. of Mechanical and Aerospace Engineering.
NUMERICAL SIMULATION OF 3-D SHOCK WAVE TURBULENT BOUNDARY LAYER INTERACTIONS
DOYLE D. KNIGHT *In* AGARD, Special Course on Shock-Wave/Boundary-Layer Interactions in Supersonic and Hypersonic Flows 32 p Aug. 1993
(Contract F49620-93-1-0005)
Copyright Avail: CASI HC A03/MF A03
The capability for numerical simulation of 3-D shock wave turbulent boundary layer interactions is assessed. Specific configurations examined include the sharp fin, blunt fin, cylinder/flare, swept compression corner and crossing shock. Future needs in improved computational methods, collaborative experimental/computational efforts and incorporation of knowledge of flowfield structure into more effective designs are discussed. Author (revised)

N94-15200*# Texas Univ., Austin. Center for Aeromechanics Research.
UNSTEADY PHENOMENA IN SHOCK WAVE/BOUNDARY LAYER INTERACTION
D. S. DOLLING *In* AGARD, Special Course on Shock-Wave/Boundary-Layer Interactions in Supersonic and Hypersonic Flows 46 p Aug. 1993 Sponsored by NASA. Lewis Research Center; NASA. Langley Research Center; ARO; and AFOSR
Copyright Avail: CASI HC A03/MF A03
A brief review is given of the unsteadiness of shock wave/turbulent boundary layer interaction. The focus is on interactions generated by swept and unswept compression ramps, by flares, steps and incident shock waves, by cylinders and blunt fins, and by glancing shock waves. The effects of Mach number, Reynolds number, and separated flow scale are discussed as are the physical causes of the unsteadiness. The implications that the unsteadiness has for interpreting time-average surface and flowfield data, and for comparisons of such experimental data with computation, is also briefly discussed. Finally, some suggestions for future work are given. It is clear that there are large gaps in the data base and that many aspects of such phenomena are poorly understood. Much work remains to be done. Author

N94-15431* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE 1988 COMPUTATIONAL FLUID DYNAMICS HIGHLIGHTS (Videotape)
1988 Videotape: 15 min. playing time, in color, with sound
(NASA-TM-109645; NONP-VT-93-190443) Avail: CASI VHS A01/BETA A22
This video highlights the 1988 CFD graphics which show zero gravity phenomena, boundary layers, aeroelasticity, rotor blades, stators, jet ground effects, the F-18, flow about the shuttle, hypersonic flow, and flow in an artificial heart. CASI

N94-15439# Mitre Corp., McLean, VA.
THE NEXT GENERATION WEATHER RADAR (NEXRAD)/AIR ROUTE SURVEILLANCE RADAR (ARSR) OPERATIONAL COMPARISON Final Report
BRIAN DUNBAR and JEFF MITTELMAN Jul. 1993 99 p Original contains color illustrations
(Contract DTFA01-93-C-00001)
(REPT-93W0000145; DOT/FAA/SE-93/4) Avail: CASI HC A05/MF A02
The National Weather Service (NWS), Federal Aviation Administration (FAA), and Department of Defense are in the process of fielding the Next Generation Weather Radars (NEXRAD). These doppler weather radars, also known as Weather Surveillance Radar (WSR)-88D, will be replacing the WSR-57 and WSR-74 weather radars in use today. The NEXRAD data will be used by the FAA's Advanced Automation System (AAS) in place of the Air Route Surveillance Radar (ARSR) weather data currently being used by air traffic controllers. Because the NEXRAD's scanning strategy is more time consuming than the ARSR's, there have been some concerns expressed within the FAA about using 'untimely' NEXRAD data in an Air Traffic Control (ATC) environment. In response to these concerns, the FAA's Center for Advanced Aviation System Development (CAASD) at MITRE conducted a study, under the sponsorship of the FAA's National Airspace System (NAS) System Engineering Service (ASE), to assess the relative ability of NEXRAD's and ARSR's to detect and present significant weather in order to determine the operational impact of using NEXRAD data in lieu of ARSR data. The NEXRAD/ARSR operational comparison study is documented. Author (revised)

N94-15445*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DEVELOPMENT OF THE SEEDING SYSTEM USED FOR LASER VELOCIMETER SURVEYS OF THE NASA LOW-SPEED CENTRIFUGAL COMPRESSOR FLOW FIELD
CHARLES A. WASSERBAUER (Sverdrup Technology, Inc., Brook Park, OH.) and MICHAEL D. HATHAWAY (Army Research Lab., Cleveland, OH.) Oct. 1993 14 p
(Contract RTOP 505-62-52)
(NASA-TM-4485; E-7810; NAS 1.15:4485) Avail: CASI HC A03/MF A01
An atomizer-based system for distributing high-volume rates of seed material was developed to support laser velocimeter investigations of the NASA Low-Speed Centrifugal Compressor flow field. The seeding system and the major concerns that were addressed during its development are described. Of primary importance were that the seed material be dispersed as single particles and that the liquid carrier used be completely evaporated before entering the compressor. Author (revised)

N94-15551*# Nevada Univ., Reno. Engineering Research and Development Center.
NUMERICAL INVESTIGATIONS IN THREE-DIMENSIONAL INTERNAL FLOWS Semiannual Status Report, 1 Jul. - 31 Dec. 1993
WILLIAM C. ROSE 1993 26 p
(Contract NCC2-507)
(NASA-CR-194594; NAS 1.26:194594) Avail: CASI HC A03/MF A01
In the present reporting period, the 3D version of the

OVERFLOW code was used to solve the flow within the internal portion of the supersonic inlet. The internal portion of this inlet is bounded by an inflow plane containing the leading edge of the sidewalls, the sidewalls, the ramp and cowl surfaces and an outflow plane just downstream of the minimum geometric area of the inlet. Boundary layer bleed was used in the two-dimensional calculations discussed in the previous progress report and that same bleed was applied in the present study. For reference, this bleed corresponds to locations designated as R2 and R3 in the Mach 5 inlet model test. Using the GRIDGEN code, a three dimensional grid was generated that accounted for the viscous effects expected to occur on the sidewall, as well as those known to occur on the ramp and cowl surfaces. The internal flow grid size was 141 streamwise by 101 cross stream by 71 in the lateral direction between sidewalls. Since the flow entering the inlet was not symmetrical, the inlet was solved from sidewall to sidewall (without using a symmetry plane). In addition to the short sidewalls proposed in the Langley geometry database, a set of shorter sidewalls was also investigated in the present study and was shown to have beneficial effects with respect to the flow distortion exiting the supersonic inlet. In addition to these calculations, additional 3D solutions using the OVERFLOW code were obtained for the flow downstream of the throat of the supersonic inlet, including a terminal shock wave system produced by a backpressured subsonic diffuser. Author

N94-15632# Naval Surface Warfare Center, Dahlgren, VA.
INCORPORATION OF BOUNDARY LAYER HEATING PREDICTIVE METHODOLOGY INTO NSWCDD AEROPREDICTION CODE
ROY M. MCINVILLE and FRANK G. MOORE Feb. 1993 67 p
(AD-A267000; NSWCDD/TR-93/29) Avail: CASI HC A04/MF A01

Methods have been incorporated into the Naval Surface Warfare Center, Dahlgren Division aeroprediction code to permit the computation of heat transfer rates and recovery temperatures as part of the high Mach number solution. A mass balance technique has been included to determine the correct boundary layer edge entropy to use along the surface of blunt bodies. Refinements were also made to the pressure prediction routines to remove discontinuities and improve overall results. Comparisons of results from the new methods with those from more advanced engineering codes, with other techniques of similar technical level of detail, and with experimental data show good agreement. These new capabilities make possible the rapid computation of three-dimensional heat transfer information for a wide range of geometric configurations and flight conditions. DTIC

N94-15645# Loughborough Univ. of Technology (England). Dept. of Transport Technology.
AN EXPERIMENTAL STUDY OF ASTOVL RELATED JET FLOWS TO PRODUCE CFD CODE VALIDATION DATA. PHASE 3: RESULTS OF EXPERIMENTS Final Report
P. BEHROUZI and J. J. MCGUIRK Oct. 1992 60 p
(TT-9203; ISBN-0-904947-38-6; ETN-93-94492) Copyright Avail: CASI HC A04/MF A01

A study aimed at the provision of experimental data for mean velocities and associated turbulence quantities in flow fields related to the ground effect phase of Advanced Short Takeoff and Vertical Landing (ASTOVL) aircraft operation is reported. These data are intended to serve as a benchmark validation data set for RANS based Computational Fluid Dynamics (CFD) codes which might in the future be used in design studies of ASTOVL aircraft. To aid the specification of boundary conditions in related CFD calculations, and to allow the isolation of several physical phenomena believed to be important in ground effect flows (in particular fountain formation), three idealized jet flow configurations were selected for study: (1) lateral pair (twin jets with line of centers perpendicular to crossflow direction) to study effect of velocity ratio (jet velocity/crossflow velocity), jet impingement height, jet splay angle, and jet spacing; (2) longitudinal pair (twin jets with line of centers aligned with crossflow direction) to study effect of velocity ratio and jet imbalance; (3) and three poster (a combination of lateral and longitudinal pair) to study effect of rear jets splay angle and jet imbalance. Low speed incompressible flows were concentrated upon. The use of laser Doppler velocimetry was selected as the measurement technique to be used, and optical access and seeding problems could be alleviated considerably by the use of a water flow rather than an air flow. Accordingly a small scale water tunnel was selected as the test facility to be used to gather the data. ESA

N94-15649# Mitre Corp., Bedford, MA.
JOHNSON-GIERHART PROGRAM PREDICTIONS OF EXCESS PROPAGATION LOSS FOR SUPER-HIGH FREQUENCY AIR-TO-GROUND PATHS. VOLUME 1: THEORY AND NUMERICAL RESULTS Final Report
M. M. WEINER and J. C. HERTHER Jun. 1993 141 p
(Contract F19628-89-C-0001)
(AD-A267105; MTR-92B0000027V1; ESC-TR-93-161-VOL-1)
Avail: CASI HC A07/MF A02

The Johnson-Gierhart tropospheric propagation program of the Institute for Telecommunications Sciences is used to obtain predictions of excess propagation loss over that of free space for super-high frequency (SHF) air-to-ground paths within or on the radio horizon. The principal loss (gain) mechanisms considered are atmospheric absorption and refraction, surface multipath interference, smooth spherical Earth diffraction, and single knife-edge diffraction caused by terrain roughness and/or a site-specified obstacle. The program uses a semi-empirical database to statistically weigh the losses from these mechanisms. The excess propagation loss increases with increasing range and can exceed 3 decibels-at distances as close as halfway to the radio horizon. DTIC

N94-15697 National Defence Headquarters, Ottawa (Ontario).
MONOPIECE STRAIN GAUGE STING MOUNTED WIND TUNNEL BALANCE Patent
GILLES FAUCHER, inventor (to Micromedia Ltd.), MARC-ANDRE PARADIS, inventor (to Micromedia Ltd.), and BERTRAND GIRARD, inventor (to Micromedia Ltd.) 22 Dec. 1992 25 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(CA-PATENT-1-311-626; INT-PATENT-CLASS-G01M-9/00; CTN-93-60777) Copyright Avail: Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC

A balance is disclosed for an apparatus for measuring the various aerodynamic coefficients of flight vehicles by testing scale models of these vehicles in a wind tunnel. The balance of the invention measures the following parameters: axial, normal, and side force; and pitching, yawing, and rolling moments. The balance is based on a monopiece center core where sensing components have a roll or primary frame as well as being reference supports to strain gauges. The dual function of the primary frame means that forces and moments, when applied to the balance, will generate interferences in several other components. Because of the center core configuration, it is possible to calibrate, calculate, and deduct with a very high precision the interferences of each component over the other. Except for the axial force sensing components, all forces and moments are sensed by two groups of crossed webs, one cross web at each end of the center core. The axial force sensing components are made of two tensioning rings, one at each end of the center core. The configuration of the balance is of the rigid-frame type, in order to make use of semiconductor strain gauges which are very precise. The resulting balance is more precise than any known balance of its size and can resist starting and stopping overloads which occur at the beginning and end of a test. Author (CISTI)

N94-15826 Wright Lab., Eglin AFB, FL. Armament Directorate.
AN ELECTRONIC IMAGING SYSTEM FOR THE AEROBALLISTIC RESEARCH FACILITY Final Report
G. L. WINCHENBACH, D. B. SNYDER, M. A. VALENTINO, H. C. MACKE, and W. J. ROWE Jul. 1993 11 p Limited

Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A267157; WL-TP-93-002) Avail: CASI HC A03

Until the present date, free-flight spark ranges used conventional film technology for recording the position-attitude histories of the projectiles as they traversed the instrumented ranges. The purpose is to describe the plans for converting the existing film based camera system in the Aeroballistic Research Facility to an electronic imaging system based on modern charge coupled device (CCD) technology. The primary concern associated with this conversion was always maintaining the facility's accuracy in measuring the projectile's position and attitude at each of the shadowgraph stations. This accuracy is directly related to the resolution of the CCD, i.e., number of pixels. Some other concerns were minimizing the facility down-time while the new imaging system is installed and maintaining a means of analyzing previous film exposures captured during the past 15 years of operation. The solution to these concerns is the development of a film reader system which also uses a CCD type camera to digitize the existing film. DTIC

N94-16078* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE VIBRO-ACOUSTIC MAPPING OF LOW GRAVITY TRAJECTORIES ON A LEARJET AIRCRAFT
C. M. GRODSINSKY and T. J. SUTLIFF *In* National Research Council Canada, Proceedings of the Second Workshop on Microgravity Experimentation 8 p 1990
Avail: Issuing Activity (National Research Council, Publication Sales and Distribution, Montreal Road, Ottawa, Ontario, K1A OR6 Canada)

The NASA LeRC Learjet aircraft is used to fly parabolic trajectories for carrying out in-flight microgravity experiments. To derive full benefit from data obtained in such experiments, it is not only required to understand the low- to moderate-frequency accelerations present but also necessary to characterize the broadband aircraft vibro-acoustic environment. A vibro-acoustic measurement program was conducted during a series of low-gravity trajectories flown on the Learjet. The fuselage and an experiment rack were instrumented with 13 channels of accelerometers and three channels of pressure transducers. The locations of these sensors were determined in order to build a time history of the dynamics involved in the flight of such a parabolic trajectory and thus determine the typical rigid-body and vibro-acoustic loading a payload would experience. The instrumentation, data acquisition sequence, and experimental results showing residual accelerations and high-frequency dynamics are presented. As suspected, the measurements revealed that the aircraft environment cannot simply be described in terms of the static level low-gravity g-vector obtained, but that it also must account for both rigid-body and high-frequency vibro-acoustic dynamics. Author (CISTI)

N94-16080 MPB Technologies, Inc., Pointe Claire (Quebec).
DEVELOPMENT OF THE LASER-BASED R/D TEST-BED SYSTEM (LTS)
M. OLIVIER, S. SIMARD, L. AUDET, A. LAFERRIERE, and W. JAMROZ *In* National Research Council Canada, Proceedings of the Second Workshop on Microgravity Experimentation 6 p 1990
Avail: Issuing Activity (National Research Council, Publication Sales and Distribution, Montreal Road, Ottawa, Ontario, K1A OR6 Canada)

The laser-based research and development testbed system (LTS), supported by Canadian Space Agency programs, is a modular multi-user research system based on commercially available components for use on the variable gravity environment provided by the NASA KC-135 aircraft. The LTS consists of seven basic units: the supporting structure, the integrated laser unit, the beam delivery unit, power supply, control and data acquisition unit, material processing unit, and the optical diagnostic unit. The units are described along with some planned experiments that will make use of LTS capabilities. The LTS is designed so that several types of laser systems can be used: CO2, He-Ne, argon, and excimer lasers.Some of the subjects to be studied using the LTS include the following: laser melting or quenching of metals and welding of thin metal sheets in near-zero gravity; laser interactions with water; laser welding of plastics and glasses; vacuum materials processing; laser chemical vapor processing; and mass spectroscopy analysis. Author (CISTI)

N94-16491*# California Univ., Los Angeles. Dept. of Mechanical, Aerospace and Nuclear Engineering.
FLUID FLOW AND HEAT CONVECTION STUDIES FOR ACTIVELY COOLED AIRFRAMES Report, Apr. - Nov. 1993
A. F. MILLS 1993 14 p
(Contract NCC2-374)
(NASA-CR-194624; NAS 1.26:194624) Avail: CASI HC A03/MF A01

This report details progress made on the jet impingement - liquid crystal - digital imaging experiment. With the design phase complete, the experiment is currently in the construction phase. In order to reach this phase two design related issues were resolved. The first issue was to determine NASP leading edge active cooling design parameters. Meetings were arranged with personnel at SAIC International, Torrance, CA in order to obtain recent publications that characterized expected leading edge heat fluxes as well as other details of NASP operating conditions. The information in these publications was used to estimate minimum and maximum jet Reynolds numbers needed to accomplish the required leading edge cooling, and to determine the parameters of the experiment. The details of this analysis are shown in Appendix A. One of the concerns for the NASP design is that of thermal stress due to large surface temperature gradients. Using a series of circular jets to cool the leading edge will cause a non-uniform temperature distribution and potentially large thermal stresses. Therefore it was decided to explore the feasibility of using a slot jet to cool the leading edge. The literature contains many investigations into circular jet heat transfer but few investigations of slot jet heat transfer. The first experiments will be done on circular jets impinging on a flat plate and results compared to previously published data to establish the accuracy of the method. Subsequent experiments will be slot jets impinging on full scale models of the NASP leading edge. Table 1 shows the range of parameters to be explored. Next a preliminary design of the experiment was done. Previous papers which used a similar experimental technique were studied and elements of those experiments adapted to the jet impingement study. Trade-off studies were conducted to determine which design was the least expensive, easy to construct, and easy to use. Once the final design was settled, vendors were contacted to verify that equipment could be obtained to meet our specifications. Much of the equipment required to complete the construction of the experiment has been ordered or received. The material status list is shown in Appendix B. Author

N94-16943# Naval Postgraduate School, Monterey, CA.
FATIGUE LIFE PROGRAM USING STRAIN-LIFE METHODS M.S. Thesis
MICHAEL V. SKELLY 25 Mar. 1993 91 p
(AD-A267310) Avail: CASI HC A05/MF A01

A user friendly program was developed to calculate fatigue life using Strain-Life equations, given either a stress history or a strain history. Additionally, the material parameters and associated stress concentration factors can be varied. Since certain material constants, such as cyclic strength coefficient (K') and cyclic strain hardening exponent (n') vary during a material's fatigue life, the program is capable of either keeping them constant or varying them as a function of elapsed cycles. The program was then utilized to examine the effects of varying K' and n' on the calculated fatigue life of aluminum 7075-T6 under a typical flight load history. DTIC

N94-16965# Federal Aviation Administration, Atlantic City, NJ.
SATELLITE COMMUNICATIONS INSTALLATION PLAN
HOWARD MEEKS May 1993 21 p

(AD-A266303; DOT/FAA/CT-TN93/1) Avail: CASI HC A03/MF A01

The installation plan describes the correct installation procedures for installing low rate Satellite Communications (SATCOM) equipment in a Federal Aviation Administration (FAA) Boeing 727 aircraft. The equipment includes an antenna, satellite communication avionics, a data collection computer, and a tape recorder. DTIC

N94-16966# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.

ADAPTIVE NAVIER-STOKES CALCULATIONS FOR VORTICAL FLOW Final Report, 1 Jun. 1989 - 31 Oct. 1992

EARLL M. MURMAN 12 Mar. 1993 15 p

(Contract AF-AFOSR-0395-89)

(AD-A266236; AFOSR-93-0439TR) Avail: CASI HC A03/MF A01

Brief summaries are given of research performed in the following areas: (1) adaptive Euler equation solvers; (2) adaptation parameters for vortical flow; (3) vortex breakdown calculations; (4) calculations for the F-117A; (5) normal force hysteresis; (6) visualization of vortical flows on unstructured grids; and (7) modeling of vortex breakdown. The reference list gives reports with detailed results. DTIC

N94-17215*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering.

STUDIES ON NONEQUILIBRIUM PHENOMENA IN SUPERSONIC CHEMICALLY REACTING FLOWS Progress Report for period ending 31 Aug. 1993

S. N. TIWARI and RAJNISH CHANDRASEKHAR Nov. 1993 139 p

(Contract NAG1-423)

(NASA-CR-194662; NAS 1.26:194662) Avail: CASI HC A07/MF A02

This study deals with a systematic investigation of nonequilibrium processes in supersonic combustion. The two-dimensional, elliptic Navier-Stokes equations are used to investigate supersonic flows with nonequilibrium chemistry and thermodynamics, coupled with radiation, for hydrogen-air systems. The explicit, unsplit MacCormack finite-difference scheme is used to advance the governing equations in time, until convergence is achieved. For a basic understanding of the flow physics, premixed flows undergoing finite rate chemical reactions are investigated. Results obtained for specific conditions indicate that the radiative interactions vary substantially, depending on reactions involving HO2 and NO species, and that this can have a noticeable influence on the flowfield. The second part of this study deals with premixed reacting flows under thermal nonequilibrium conditions. Here, the critical problem is coupling of the vibrational relaxation process with the radiative heat transfer. The specific problem considered is a premixed expanding flow in a supersonic nozzle. Results indicate the presence of nonequilibrium conditions in the expansion region of the nozzle. This results in reduction of the radiative interactions in the flowfield. Next, the present study focuses on investigation of non-premixed flows under chemical nonequilibrium conditions. In this case, the main problem is the coupled turbulence-chemistry interaction. The resulting formulation is validated by comparison with experimental data on reacting supersonic coflowing jets. Results indicate that the effect of heat release is to lower the turbulent shear stress and the mean density. The last part of this study proposes a new theoretical formulation for the coupled turbulence-radiation interactions. Results obtained for the coflowing jets experiment indicate that the effect of turbulence is to enhance the radiative interactions. Derived from text

N94-17286# Stanford Univ., CA. Thermosciences Div.

ACTIVE TURBULENCE CONTROL IN WALL BOUNDED FLOWS USING DIRECT NUMERICAL SIMULATION Final Technical Report, 1 Jul. 1989 - 30 Sep. 1992

PARVIZ MOIN 6 Nov. 1992 292 p

(Contract AF-AFOSR-0411-89)

(AD-A267261; AFOSR-93-0467TR) Avail: CASI HC A13/MF A03

The objective of the study is to explore concepts for control of turbulent boundary layers leading to skin-friction reduction using the direct numerical simulation technique. This report is divided into three parts where different control methods are investigated: an active control by sensing and perturbing structures near the wall, a feedback control procedure guided by control theory, and a passive control by longitudinal riblets. Part 1: significant drag reduction is achieved when the surface boundary condition is modified to suppress the dynamically significant coherent structures present in the wall region. Part 2: mathematical methods of control theory are applied to the problem of control of fluid flow. Part 3: direct numerical simulation is performed to analyze turbulent flow over longitudinal riblets, and to reduce the mechanism of drag reduction by riblets. DTIC

N94-17476*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SINGLE BLOCK THREE-DIMENSIONAL VOLUME GRIDS ABOUT COMPLEX AERODYNAMIC VEHICLES

STEPHEN J. ALTER (Lockheed Engineering and Sciences Co., Hampton, VA.) and K. JAMES WEILMUENSTER Nov. 1993 50 p

(Contract RTOP 506-40-91-02)

(NASA-TM-108986; NAS 1.15:108986) Avail: CASI HC A03/MF A01

This paper presents an alternate approach for the generation of volumetric grids for supersonic and hypersonic flows about complex configurations. The method uses parametric two dimensional block face grid definition within the framework of GRIDGEN2D. The incorporation of face decomposition reduces complex surfaces to simple shapes. These simple shapes are combined to obtain the final face definition. The advantages of this method include the reduction of overall grid generation time through the use of vectorized computer code, the elimination of the need to generate matching block faces, and the implementation of simplified boundary conditions. A simple axisymmetric grid is used to illustrate this method. In addition, volume grids for two complex configurations, the Langley Lifting Body (HL-20) and the Space Shuttle Orbiter, are shown. Author

N94-17479*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

STRUCTURAL MECHANICS DIVISION RESEARCH AND TECHNOLOGY ACCOMPLISHMENTS FOR CY 1992 AND PLANS FOR CY 1993

JOHN B. MALONE Nov. 1993 118 p

(Contract RTOP 505-63-50-07)

(NASA-TM-107752; NAS 1.15:107752) Avail: CASI HC A06/MF A02

The purpose of this report is to present the Structural Mechanics Division's research accomplishments for C.Y. 1992 and plans for C.Y. 1993. The technical mission and goals of the division and its constituent research branches are described. The work under each branch is described in terms of highlights of accomplishments during the past year and plans for the current year as they relate to branch long range goals. This information is useful in program coordination with other government organizations, universities, and industry in areas of mutual interest. Author

N94-17481*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

FLUTTER ANALYSIS USING TRANSVERSALITY THEORY

D. AFOLABI Nov. 1993 24 p

(Contract NCC3-233; RTOP 505-90-5K)

(NASA-TM-106382; ICOMP-93-43; E-8200; NAS 1.15:106382)

Avail: CASI HC A03/MF A01

A new method of calculating flutter boundaries of undamped aeronautical structures is presented. The method is an application of the weak transversality theorem used in catastrophe theory. In the first instance, the flutter problem is cast in matrix form using a frequency domain method, leading to an eigenvalue matrix. The characteristic polynomial resulting from this matrix usually has a smooth dependence on the system's parameters. As these parameters change with operating conditions, certain critical values are reached at which flutter sets in. Our approach is to use the transversality theorem in locating such flutter boundaries using this criterion: at a flutter boundary, the characteristic polynomial does not intersect the axis of the abscissa transversally. Formulas for computing the flutter boundaries and flutter frequencies of structures with two degrees of freedom are presented, and extension to multi-degree of freedom systems is indicated. The formulas have obvious applications in, for instance, problems of panel flutter at supersonic Mach numbers. Author

N94-17583*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MECHANICAL SYSTEMS TECHNOLOGY BRANCH RESEARCH SUMMARY, 1985 - 1992
TIMOTHY L. KRANTZ, ed. Sep. 1993 85 p
(Contract DA PROJ. 1L1-62211-A-47-A; RTOP 505-62-10)
(NASA-TM-106329; E-6886; NAS 1.15:106329; ARL-TR-237)
Avail: CASI HC A05/MF A01

A collection of significant accomplishments from the research of the Mechanical Systems Technology Branch at the NASA Lewis Research Center completed during the years 1985-1992 is included. The publication highlights and accomplishments made in bearing and gearing technology through in-house research, university grants, and industry contracted projects. The publication also includes a complete listing of branch publications for these years. Author (revised)

N94-17627 National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics/Informatics Div.
STUDY INTO THE LIMITS OF AN EULER EQUATION METHOD APPLIED TO LEADING-EDGE VORTEX FLOW
J. I. VANDENBERG, H. W. M. HOEIJMAKERS, and H. A. SYTSMA 9 Sep. 1991 12 p Presented at 9th GAMM Conference on Numerical Methods in Fluid Mechanics, Lausanne, Switzerland, 25-27 Sep. 1991 Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract NIVR-07701N)
(NLR-TP-91350-U; ETN-93-94781) Avail: CASI HC A03

A steady fow Euler method is applied to the subsonic leading edge vortex flow about a 65 deg sharp-edged cropped delta wing at high incidence. Above a critical value of the incidence the numerical procedure fails to fully converge, the solution at successive iterations exhibiting a behavior similar to the one observed during vortex breakdown. The occurrence of this 'solution breakdown' indicates the limits of the domain of applicability of the steady flow Euler method for the case of subsonic leading edge vortex flow. Analysis of the solution at incidences just below the critical value reveals that a bubble type of flow feature develops within the vortex core. ESA

N94-17763*# Colorado Univ., Boulder. Dept. of Chemical Engineering.
MODELING AND NEW EQUIPMENT DEFINITION FOR THE VIBRATION ISOLATION BOX EQUIPMENT SYSTEM Progress Report
ROBERT L. SANI 1993 11 p
(Contract NAG3-1410)
(NASA-CR-193185; NAS 1.26:193185; CU-153-6505) Avail: CASI HC A03/MF A01

Our MSAD-funded research project is to provide numerical modeling support for the VIBES (Vibration Isolation Box Experiment System) which is an IML2 flight experiment being built by the Japanese research team of Dr. H. Azuma of the Japanese National Aerospace Laboratory. During this reporting period, the following have been accomplished: A semi-consistent mass finite element projection algorithm for 2D and 3D Boussinesq flows has been implemented on Sun, HP And Cray Platforms. The algorithm has better phase speed accuracy than similar finite difference or lumped mass finite element algorithms, an attribute which is essential for addressing realistic g-jitter effects as well as convectively-dominated transient systems. The projection algorithm has been benchmarked against solutions generated via the commercial code FIDAP. The algorithm appears to be accurate as well as computationally efficient. Optimization and potential parallelization studies are underway. Our implementation to date has focused on execution of the basic algorithm with at most a concern for vectorization. The initial time-varying gravity Boussinesq flow simulation is being set up. The mesh is being designed and the input file is being generated. Some preliminary 'small mesh' cases will be attempted on our HP9000/735 while our request to MSAD for supercomputing resources is being addressed. The Japanese research team for VIBES was visited, the current set up and status of the physical experiment was obtained and ongoing E-Mail communication link was established. Derived from text

N94-17970# Aeronautical Research Inst. of Sweden, Stockholm.
SPECTRUM FATIGUE TESTING OF T-SHAPED TENSION CLIPS
BJOERN PALMBERG and BENGT WALLSTENIUS Dec. 1992 37 p
(Contract FMV/FFL-82250-90-276-16-001)
(FFA-TN-1992-22; ETN-93-94858) Avail: CASI HC A03/MF A01

An investigation of strain distributions during static loading and crack propagation and fatigue lives under spectrum loading of T-shaped tension clips was carried out. Three slightly different, with respect to geometry, T shaped tension clips made of aluminum alloy 7010-T73651 were studied. The type 1 and 4 test specimens were different only with respect to the web thickness of the clamping end. The type 1 and 2 test specimens were different with repect to milled flat circular countersink around the holes in the type 2 specimens and with respect to the radius between the web and foot. The spectrum fatigue loading consisted of a load sequence representative for the wing root, lower side, of a fighter aircraft. Tests were made at two different load levels for each specimen type. The strain measurements show that the countersink in the type 2 specimens increases the stresses in the fatigue critical region. This is also manifested in the spectrum fatigue life results, where type 2 specimens show the shortest fatigue lives. The strain measurements show that the torque used for the bolts in joining two test specimens or one test specimen and a dummy has a rather large impact on the strain in the fatigue region. The strains decrease with increasing torque. The spectrum fatigue loading resulted in approximately an equal number of flights to obtain a 10.0 mm crack for specimens of type 1 and 4. This suggests that the type 1 configuration is superior since the web thickness is smaller for this type as compared to the type 4 specimens. In other words, the type 4 specimens have an unnecessary oversize of the clamping end web thickness. ESA

N94-18124 Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany). Inst. fuer Experimentelle Stroemungsmechanik.
ON MEMORY EFFECTS IN TURBULENCE Thesis - Goettingen Univ. [UEBER GEDAECHTNISEFFEKTE IN DER TURBULENZ]
STEFAN WOPPOWA Feb. 1993 48 p In GERMAN Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(ISSN 0171-1342)
(DLR-FB-93-03; ETN-93-94873) Avail: CASI HC A03

A Reynolds stress closure scheme which takes into account memory effects in turbulent shear flows is tested against data for fully developed turbulent rotating channel flow. In the rotating cases the zone where memory effects are essential contains the region of negative turbulence production and overshoots the edge of the latter to the stable side of the channel. In this region the relationship between local Reynolds stress and mean velocity field is not of local nature. The comparison between calculated and experimental mean velocity profiles leads to satisfactory agreement. The field equations for highly accelerated two-dimensional turbulent boundary layers were substantiated by the method of matched asymptotic expansions. ESA

N94-18159 Japan Atomic Energy Research Inst., Tokyo.
A SURVEY ON TECHNICAL PROBLEMS IN DESIGNING HIGH-SPEED ROTORS WITH DEVELOPING MATERIALS
TETSUYA ABE (Japan Atomic Energy Research Inst., Naka.), YOSHIO MURAKAMI (Japan Atomic Energy Research Inst., Naka.), TAKEO HIRABAYASHI, HARUSHIGE OHSAWA, KAZUO HIKIDA, SHIGEYUKI SHIRAISHI, and SATOSHI HATA Jun. 1992 60 p In JAPANESE Limited Reproducibility: More than 20% of this document may be affected by poor print
(DE93-788519; JAERI-M-92-092) Avail: Issuing Activity (Department of Energy (DOE))

A survey was made on technical problems and limitations in designing high-speed rotors of turbo vacuum pumps using developing materials (fine ceramics, new composite materials, etc.) as well as conventional metals. Based on the surveyed results, the applicability of the developing materials to rotors has been evaluated assuming their use in large-size pumps for fusion reactors. DOE

N94-18225 Vanderbilt Univ., Nashville, TN. Dept. of Physics and Astronomy.
HIGH RESOLUTION SQUID MAGNETOMETRY FOR NON-DESTRUCTIVE EVALUATION Final Report, 1 Sep. 1987 - 30 Apr. 1993
JOHN P. WIKSWO 30 Apr. 1993 30 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract AF-AFOSR-0337-87)
(AD-A268884; AFOSR-93-0659TR) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Superconducting QUantum Interference Device (SQUID) magnetometers offer promise as multi-mode instruments capable of obtaining high resolution images of extremely low frequency injected currents or eddy currents, and they can be configured to image the magnetic susceptibility of titanium, aluminum, and nonmetallic composites. While high resolution SQUID magnetometers will generally be noisier than conventional SQUID's, the small coils and reduced coil-to-source spacing more than compensate to provide low-noise, high-resolution images. The high spatial resolution which can be obtained with SQUID magnetometers, the unparalleled sensitivity of SQUID's at low frequencies, the ability to measure weak perturbations in strong applied magnetic fields, and the ability to discriminate against external sources of noise should make SQUID magnetometers well suited for NDE of deep flaws in aluminum and titanium aerostructures. To explore SQUID NDE, we have developed research facilities that include the high-resolution MicroSQUID magnetometer, a magnetic shield, a scanning stage, and a computer-based control and data acquisition system. Using this instrumentation, we have imaged magnetic fields produced by sources as varied as intrinsic currents due to corrosion or Johnson noise, remanent magnetization from ferromagnetic contamination, flaw-induced perturbations in either injected current or eddy currents induced by an AC field, Johnson noise currents in a copper ring, persistent currents in high transition-temperature superconductors, distributions of dia- or paramagnetism in an AC or DC magnetic field, and surface flaws decorated with a paramagnetic tracer. DTIC

N94-18266 Wright Lab., Wright-Patterson AFB, OH.
A FINITE STRAIN RING DYNAMICAL MODEL FOR PNEUMATIC TIRES Final Report, May 1992 - May 1993
NED J. LINDSLEY Aug. 1993 104 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A269286; WL-TR-93-3089) Avail: CASI HC A06

In this report, using the most general 'plane sections remain plane' rod theory and the continuum mechanics approach, the exact strain expressions for a shearable, extensible ring are derived. These expressions are nonlinear in terms of both the displacements and the geometry of the ring and are Taylor series approximated after their derivation. A linear viscoelastic stress-strain relationship is assumed. The radial stress is considered negligible. The model includes extension of the neutral axis, transverse shear deformation, and the full complement of inertial forces created by rotation of the ring. A pretensioning force due to pressurizing the tire is included. The tire sidewall (viscoelastic foundation) is considered to act in a completely radial direction. The equations of motion are developed from the free body and inertial force diagrams of a differential element. The membrane forces and bending moment are then substituted to yield three nonlinear equations of motion. The equations of motion are then put into matrix form with the linear and nonlinear portions separated. Chapters 3 and 4 study linear wave propagation, while Chapter 5 provides verifying comparison examples with existing finite element codes, as well as a numerical example for the KC-135 transport aircraft tire. DTIC

N94-18391 Army Research Lab., Aberdeen Proving Ground, MD.
PARABOLIZED NAVIER-STOKES COMPUTATION OF SURFACE HEAT TRANSFER CHARACTERISTICS FOR SUPERSONIC AND HYPERSONIC KE PROJECTILES Final Report, Sep. 1991 - Apr. 1993
BERNARD J. GUIDOS and PAUL WEINACHT Aug. 1993 52 p See also BRL-IMR-970, Apr. 1992 Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A268858; ARL-TR-191; BRL-IMR-970) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Perfect gas heat transfer characteristics are presented for two existing supersonic finned kinetic energy (KE) projectiles (M735 and M829) and for a conceptual hypersonic KE projectile configuration. The hypersonic configuration is obtained by replacing the fins of the M829 with a conical flare of varying sweep angle. A three-dimensional, viscous, parabolized Navier-Stokes (PNS) computational technique is used to compute the perfect gas adiabatic wall temperatures and heat transfer rates in the velocity range 1.3 km/sec to 4 km/sec (Mach number range about 4 to 12). The heat transfer characteristics provide a necessary boundary condition for subsequent heat conduction computations, which simulate the transient in-flight thermal response of projectile configurations. DTIC

N94-18495# Mitre Corp., Bedford, MA.
VHF AIR/GROUND COMMUNICATIONS FOR AIR TRAFFIC CONTROL: A DECISION TREE APPROACH TO SYSTEM INNOVATIONS, VOLUME 2
CHENG-HONG CHEN, JAMES W. HOWLAND, ROBERT I. MILLAR, BRIAN E. WHITE, and WARREN J. WILSON Jul. 1993 275 p
(Contract DTFA01-93-C-0001)
(AD-A268632; MTR-M-93B0000096-VOL-2) Avail: CASI HC A12/MF A03

Improvements to VHF air/ground communications for civil aviation in the 188-137 MHz aeronautical mobile frequency band are systematically explored by means of a decision tree approach. Seven individual papers analyze in detail the operational anitechnical factors involved in making these improvements. Basic tradeoffs between analog and digital modulation are discussed to frame the problem. Near-term improvements utilizing various analog modulations with closer channel spacing are first reviewed. Then far-term improvements employing a wide range of digital modulation and coding techniques are considered. Multiplexing methods - frequency, time, and code division - are discussed in detail. Methods for random access to a shared communications channel are compared, with emphasis upon real-time operation for air traffic control. Volume 1 provides an executive summary of this work, while Volume 2 presents the technical details. DTIC

N94-18555*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TURBULENCE MODELING IN AIRCRAFT ICING
MARK G. POTAPCZUK *In its* Workshop on Computational Turbulence Modeling 11 p 1993
Avail: CASI HC A03/MF A04

The Icing and Cryogenic Technology Branch develops computational tools which predict ice growth on aircraft surfaces and uses existing CFD technology to evaluate the aerodynamic changes associated with such accretions. Surface roughness, transition location, and laminar, transition, or turbulent convective heat transfer all influence the ice growth process on aircraft surfaces. Turbulence modeling is a critical element within the computational tools used for both ice shape prediction and for performance degradation evaluation. Author

N94-18644# Oxford Univ. (England). Dept. of Engineering Science.
DATA ACQUISITION IN AERODYNAMIC RESEARCH
R. W. AINSWORTH *In* VKI, Measurement Techniques 78 p 1993
Copyright Avail: CASI HC A05/MF A04
Data acquisition, related to aerodynamic flows is discussed. Typical transducers used in aerodynamic research, how they are constructed, their excitation and response through any conditioning electronics to the equipment used to record their output are discussed. Those discussed include response transducers for pressure measurement, hot wire anemometers and thin film sensors. With the rapid and continuing reduction in the cost of computing power, there is a continuing emphasis on the digital manipulation of output signals (digital signal processing) involving much use of frequency time transformations, Fourier analysis and correlation functions. The basics of all the technology encompassed in data acquisition are introduced and examples of how the technology is used at the forefront of current research in aerodynamics are given. Examples are in general confined to the field of turbomachinery. ESA

N94-18645# Oxford Univ. (England). Dept. of Engineering Science.
RECENT DEVELOPMENTS IN FAST RESPONSE AERODYNAMIC PROBE TECHNOLOGY
R. W. AINSWORTH *In* VKI, Measurement Techniques 23 p 1993
Copyright Avail: CASI HC A03/MF A04
The design and construction of fast response probes pertinent to use in aerodynamic research is discussed. The recent progress in the area of fast response aerodynamic probes, increasingly being used as an alternative to hot wire anemometers, is reviewed. Focus is on semiconductor pressure sensing. Data which helps to assess and optimize the geometry of these probes is given. Future research directions are described. ESA

N94-18647# McDonnell-Douglas Astronautics Co., Saint Louis, MO.
PRESSURE SENSITIVE PAINT TECHNIQUE
R. C. CRITES *In* VKI, Measurement Techniques 70 p 1993
Original contains color illustrations
Copyright Avail: CASI HC A04/MF A04
The basic concepts and some of the more important engineering details of an optical pressure measurement, which is based on the fact that some compounds emit light when excited by a suitable light source (photoluminescence) are discussed. The intensity of the emitted light is inversely related to the partial pressure of oxygen and is of longer wavelength than the excitation light. This phenomena can be incorporated into a pressure measurement system. An oxygen quenched photoluminescent compound is mixed with an oxygen permeable binder to form a Pressure Sensitive Paint (PSP). This paint is applied to an aircraft model and excited with a proper light source. The light source must be filtered so that it emits no light in the luminescence band. A high resolution video camera views the model through a filter that removes all light except that emitted by the paint. The distribution of pressure over the model is computed from the measured distribution of light intensity; that is, the brighter a point in the image, the lower the pressure. The specification of a typical PSP system, current research in the area, and the future potential of the technique are discussed. ESA

N94-18651# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
PERSPECTIVE AND FUTURE POSSIBILITIES
A.-M. BOUCHARDY and D. L. BALAGEAS *In* VKI, Measurement Techniques 24 p 1993
Copyright Avail: CASI HC A03/MF A04
Future possibilities of infrared thermography are considered: staring array cameras for high thermal, temporal and spatial resolution imagery; infrared thermography for cryogenic wind tunnel; and photothermal cameras. The infrared array detectors are faster and faster and use a greater number of elements: HgCdTe, PtSi and InSb. Noise and sensitivity, the principle parameters characterizing the infrared camera, are discussed. ESA

N94-18739# Wright Lab., Wright-Patterson AFB, OH.
COMPUTATIONAL FLUID DYNAMICS (CFD) RESEARCH BRANCH TECHNICAL BRIEFS Final Report, May 1992 - 1993
DON W. KINSEY 9 Jun. 1993 31 p
(Contract AF PROJ. 2404)
(AD-A269698; WL-TR-93-3047) Avail: CASI HC A03/MF A01
This report consists of brief technical descriptions and one or more pictures of charts depicting research conducted in-house during the past year. The briefs are designed to provide enough information to clearly define the task, but are short enough to hold the reader's interest. Where applicable, a reference for more detailed information is provided. The research covers a wide spectrum of work; from grid generation to flow solvers, to post-processors; and from incompressible to hypersonic speeds. DTIC

N94-18796# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
CORRELATION OF INCOMING BOUNDARY LAYER PITOT PRESSURE FLUCTUATIONS WITH THE UNSTEADINESS OF FIN-INDUCED SHOCK WAVE TURBULENT BOUNDARY LAYER INTERACTIONS M.S. Thesis
SCOTT R. NOWLIN Dec. 1993 155 p
(AD-A270059; AFIT/CI/CIA-93-143) Avail: CASI HC A08/MF A02
This study focuses on the effects of boundary layer pitot pressure fluctuations on fin-induced separation shock unsteadiness. Experiments performed in two phases under adiabatic wall conditions in a Mach 5 wind tunnel used high frequency-response transducers to measure fluctuating pressures in a turbulent boundary layer and a separated flow induced by a hemi-cylindrical unswept fin. Phase 1 results indicate that the turbulent boundary layer/freestream interface pitot pressure fluctuation frequency levels do not correlate with the sharp fin-induced shock wave turbulent boundary layer interaction aperiodic separation shock motion frequencies. In Phase 2, correlations between fluctuations in incoming boundary layer pitot pressures, intermittent region wall pressures, separation shock dynamics, and fin leading edge pressures show contributions from fluctuations at both low frequencies (approximately 500 Hz)--their source is not well understood--and high frequencies, driven by incoming turbulence. DTIC

N94-18906# Naval Undersea Warfare Center, Newport, RI.
RELATION BETWEEN THE FLUCTUATING WALL PRESSURE AND THE TURBULENT STRUCTURE OF A BOUNDARY LAYER ON A CYLINDER IN AXIAL FLOW Ph.D. Thesis - Northwestern Univ., 1992
STEPHEN R. SNARSKI 12 Aug. 1993 245 p
(Contract N00014-89-J-1439)
(AD-A270242; NUWC-NPT-TR-10223) Avail: CASI HC A11/MF A03
The turbulent flow structures responsible for the fluctuating wall pressure in the turbulent boundary layer on a cylinder in axial flow (delta/a = 5.04, Re(sub theta) = 2870) have been investigated. Simultaneous measurements of the fluctuating wall pressure and turbulent streamwise velocities have been performed throughout a large volume of the boundary layer (y(sup +) = 14 to y/delta = 1.91, 0 less than or equal to x/delta less than or

equal to 1.52, azimuthal angle phi = 0 deg, 20 deg, 40 deg) with a subminiature electret microphone (d(sup +) = 25.9) and hotwire velocity probe (1(sup +) = 18.5). Pressure-velocity cross-spectra and cross-correlation measurements indicate that two primary groups of pressure fluctuations exist in the cylindrical boundary layer: (1) small-scale, high-frequency disturbances concentrated close to the wall associated with the burst-sweep cycle; and (2) large-scale, low-frequency disturbances extending from the wall to the turbulent/potential-flow interface that are consistent with a large spanwise-oriented 'vortex' in close contact with and inclined to the wall. DTIC

N94-19252# Lawrence Livermore National Lab., CA.

THREE DIMENSIONAL ULTRASONIC IMAGING: AN AGING AIRCRAFT NONDESTRUCTIVE INSPECTION TOOL

G. H. THOMAS, S. BENSON, and S. CRAWFORD Jul. 1993 10 p Presented at the Annual Meeting of the Society of Photo-Optical Instrumentation Engineers, San Diego, CA, 11-16 Jul. 1993

(Contract W-7405-ENG-48)

(DE93-018088; UCRL-JC-112604; CONF-930722-14) Avail: CASI HC A02/MF A01

Ultrasonic nondestructive evaluation is a valuable technique for finding defects in aircraft structures. It can detect unbonds, corrosion damage, and cracks in various aircraft components. Ultrasonic nondestructive evaluation techniques interrogate materials with high frequency acoustic energy. A piezoelectric transducer generates acoustic energy and converts returned acoustic energy into electrical signals which can be processed to identify the reflector. The acoustic energy propagates through the component and is reflected by abrupt changes in modulus and/or density that can be caused by a defect. Ultrasonic nondestructive evaluation typically provides a two dimensional image of internal defects. These images are either a planar view (C-scan) or a cross-sectional view (B-scan) of the component. The planar view is generated by raster scanning an ultrasonic transducer over the area of interest and capturing the peak amplitude of internal reflections. Depth information is generally ignored. The cross-sectional view is generated by scanning the transducer along a line and capturing the amplitude and time of flight for each internal reflection. The amplitude and time of flight information is converted into an image of the cross section of the component. By fusing the C-scan information with the B-scan information a three dimensional image of the internal structure of the component can be produced. The three dimensional image can be manipulated by rotating and slicing to produce the optimal view of the internal structure. Visualizing defects in three dimensions aids the interpretation of the severity of defects and helps confirm the need to repair or replace components. DOE

N94-19351*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

DESIGN FOR CYCLIC LOADING ENDURANCE OF COMPOSITES

MICHAEL C. SHIAO (Sverdrup Technology, Inc., Brook Park, OH.), PAPPU L. N. MURTHY, CHRISTOS C. CHAMIS, and LESLIE D. G. LIAW (Sverdrup Technology, Inc., Brook Park, OH.) Dec. 1993 22 p Presented at the 24th International SAMPE Technical Conference, Toronto, Ontario, 20-22 Oct. 1992; sponsored by the Society for the Advancement of Material and Process Engineering See also A93-53395

(Contract RTOP 510-02-12)

(NASA-TM-106407; E-8244; NAS 1.15:106407) Avail: CASI HC A03/MF A01

The application of the computer code IPACS (Integrated Probabilistic Assessment of Composite Structures) to aircraft wing type structures is described. The code performs a complete probabilistic analysis for composites taking into account the uncertainties in geometry, boundary conditions, material properties, laminate lay-ups, and loads. Results of the analysis are presented in terms of cumulative distribution functions (CDF) and probability density function (PDF) of the fatigue life of a wing type composite structure under different hygrothermal environments subjected to the random pressure. The sensitivity of the fatigue life to a number of critical structural/material variables is also computed from the analysis. Author (revised)

N94-19358# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.

A REVIEW OF AERONAUTICAL FATIGUE INVESTIGATIONS IN SWEDEN DURING THE PERIOD MAY 1991 TO APRIL 1993

ANDERS F. BLOM, ed. May 1993 84 p Presented at the 23rd International Committee on Aeronautical Fatigue Conference, Stockholm, Sweden, 7-8 Jun. 1993 Sponsored by Foersvarets Materialverk, Stockholm, Sweden

(FFA-TN-1993-22; ETN-93-94911) Avail: CASI HC A05/MF A01

The work carried out in Sweden in the area of aeronautical fatigue during the period from May 1991 to Apr. 1993 is reviewed. The review includes basic studies of fatigue development in metals and composites, stress analysis and fracture mechanics, studies of crack propagation and residual strength, testing of joints and full scale structures, and fatigue life predictions. A reference list of relevant papers issued during the period covered by the review is included. ESA

N94-19467*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

COMPOSITE IMPACT DYNAMICS RESEARCH AT NASA LARC: A REVIEW

HUEY D. CARDEN *In its* Computational Methods for Crashworthiness p 37-64 Aug. 1993

Avail: CASI HC A03/MF A03

The Landing and Impact Dynamics Branch of NASA Langley Research Center has been involved in impact dynamics research since the early 1970's. For the first ten years, the emphasis of the research was on metal aircraft structures in both the General Aviation Crash Dynamics Program and the Controlled Impact Demonstration (CID) Program, a transport aircraft program culminating in the controlled crash test of a Boeing 720 aircraft in 1984. Subsequent to the transport work, the emphasis has been on composite structures with efforts directed at understanding the behavior, responses, failure mechanisms, and general loads associated with the composite material systems under crash type loadings. Considerable work has been conducted to address the energy absorption characteristics and it indicates that composites can absorb as much if not considerably more energy than comparable aluminum structures. However, due to their brittle nature, attention must be given to proper geometry and designs to take advantage of the good energy absorbing properties while providing desired structural integrity. Achieving the desired new designs often requires an understanding of how more conventional designs behave under crash type loadings. The purpose is to present a review of the composite impact dynamics research being conducted at NASA Langley Research Center. Examples are presented of experimental and analytical data to illustrate the activities in the four program elements of the composite research. Author (revised)

N94-19468*# Grumman Aerospace Corp., Bethpage, NY. Research Dept.

IMPACT ANALYSIS OF COMPOSITE AIRCRAFT STRUCTURES

ALLAN B. PIFKO and ALAN S. KUSHNER (State Univ. of New York, Stony Brook.) *In* NASA. Langley Research Center, Computational Methods for Crashworthiness p 65-94 Aug. 1993

Avail: CASI HC A03/MF A03

The impact analysis of composite aircraft structures is discussed. Topics discussed include: background remarks on aircraft crashworthiness; comments on modeling strategies for crashworthiness simulation; initial study of simulation of progressive failure of an aircraft component constructed of composite material; and research direction in composite characterization for impact analysis. CASI

N94-19469*# Army Aviation Systems Command, Fort Eustis, VA. Aviation Applied Technology Directorate.
DEVELOPMENT AND USE OF COMPUTATIONAL TECHNIQUES IN ARMY AVIATION RESEARCH AND DEVELOPMENT PROGRAMS FOR CRASH RESISTANT HELICOPTER TECHNOLOGY
LEROY T. BURROWS *In* NASA. Langley Research Center, Computational Methods for Crashworthiness p 95-104 Aug. 1993
Avail: CASI HC A02/MF A03

During the 1960's over 30 full-scale aircraft crash tests were conducted by the Flight Safety Foundation under contract to the Aviation Applied Technology Directorate (AATD) of the U.S. Army Aviation Systems Command (AVSCOM). The purpose of these tests were to conduct crash injury investigations that would provide a basis for the formulation of sound crash resistance design criteria for light fixed-wing and rotary wing aircraft. This resulted in the Crash Survival Design Criteria Designer's Guide which was first published in 1967 and has been revised numerous times, the last being in 1989. Full-scale aircraft crash testing is an expensive way to investigate structural deformations of occupied spaces and to determine the decelerative loadings experienced by occupants in a crash. This gave initial impetus to the U.S. Army to develop analytical methods to predict the dynamic response of aircraft structures in a crash. It was believed that such analytical tools could be very useful in the preliminary design stage of a new helicopter system which is required to demonstrate a level of crash resistance and had to be more cost effective than full-scale crash tests or numerous component design support tests. From an economic point of view, it is more efficient to optimize for the incorporation of crash resistance features early in the design stage. However, during preliminary design it is doubtful if sufficient design details, which influence the exact plastic deformation shape of structural elements, will be available. The availability of simple procedures to predict energy absorption and load-deformation characteristics will allow the designer to initiate valuable cost, weight, and geometry tradeoff studies. The development of these procedures will require some testing of typical specimens. This testing should, as a minimum, verify the validity of proposed procedures for providing pertinent nonlinear load-deformation data. It was hoped that through the use of these analytical models, the designer could optimize aircraft design for crash resistance from both a weight and cost increment standpoint, thus enhancing the acceptance of the design criteria for crash resistance.
Author (revised)

N94-19470*# Wright Lab., Wright-Patterson AFB, OH. Aircrew Enclosures Group.
EXPLICIT SOLUTION TECHNIQUES FOR IMPACT WITH CONTACT CONSTRAINTS
ROBERT E. MCCARTY *In* NASA. Langley Research Center, Computational Methods for Crashworthiness p 105-123 Aug. 1993
Avail: CASI HC A03/MF A03

Modern military aircraft transparency systems, windshields and canopies, are complex systems which must meet a large and rapidly growing number of requirements. Many of these transparency system requirements are conflicting, presenting difficult balances which must be achieved. One example of a challenging requirements balance or trade is shaping for stealth versus aircrew vision. The large number of requirements involved may be grouped in a variety of areas including man-machine interface; structural integration with the airframe; combat hazards; environmental exposures; and supportability. Some individual requirements by themselves pose very difficult, severely nonlinear analysis problems. One such complex problem is that associated with the dynamic structural response resulting from high energy bird impact. An improved analytical capability for soft-body impact simulation was developed.
Author (revised)

N94-19493*# Stanford Univ., CA. Dept. of Aeronautics and Astronautics.
RESEARCH AND TRAINING ACTIVITIES OF THE JOINT INSTITUTE FOR AERONAUTICS AND ACOUSTICS Progress Report, Oct. 1992 - Sep. 1993
L. ROBERTS Dec. 1993 26 p
(Contract NCC2-55)
(NASA-CR-194742; NAS 1.26:194742) Avail: CASI HC A03/MF A01

During the period October 1992 to September 1993 progress was made on each of the following tasks: (1) experimental studies of free shear flows; (2) analysis of conical flow; (3) experimental and theoretical studies of vortex flows; and (4) aircraft attitude control using active flow control devices. The details of this work was discussed with the technical and management staff at Ames Research Center.
Author (revised)

N94-19539# Lawrence Livermore National Lab., CA.
TEMPERATURE OF AIRCRAFT CARGO FLAME EXPOSURE DURING ACCIDENTS INVOLVING FUEL SPILLS
J. A. MANSFIELD Jan. 1993 299 p
(Contract W-7405-ENG-48)
(DE93-019633; UCRL-CR-114509; DDV-93-0004) Avail: CASI HC A13/MF A03

This report describes an evaluation of flame exposure temperatures of weapons contained in alert (parked) bombers due to accidents that involve aircraft fuel fires. The evaluation includes two types of accident: collisions into an alert aircraft by an aircraft that is on landing or take-off; and engine start accidents. Both the B-1B and B-52 alert aircraft are included in the evaluation.
DOE

N94-19669 Technische Univ., Delft (Netherlands). Structures and Materials Lab.
FATIGUE CRACK INITIATION IN RIVETED LAP JOINTS AND IN PRESSURIZED FUSELAGES
RICHARD P. G. MUELLER Jun. 1993 27 p Presented at the SAMPE European Conference, Birmingham, England, 19-21 Oct. 1993 Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(LR-725; ETN-93-95029) Avail: CASI HC A03

Riveted joints in pressurized fuselages are exposed to severe fatigue loading. The study was carried out to increase fundamental understanding of the behavior of riveted fuselage joints. Areas of interest include rivet flexibility, load transfer, residual stress distribution, fatigue crack location, secondary bending and inter-sheet friction. These aspects depend on the squeezing force used to drive the rivet. Flat uniaxially loaded riveted lap joint specimens show longer fatigue lives than curved riveted panels loaded by internal pressure in a barrel test setup. Strain gauge measurements on a barrel test setup show more severe loading of the non-countersunk inner sheet compared to the countersunk outer sheet. Finite element calculations gave insight to the improved fatigue crack initiation performance for increased sqeezing force and to the crack initiation location. The early crack initiation at the edges of flat riveted lap joint panels is explained.
ESA

N94-20171*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
QUANTIFICATION OF UNCERTAINTIES IN THE PERFORMANCE OF SMART COMPOSITE STRUCTURES
MICHAEL C. SHIAO (Sverdrup Technology, Inc., Brook Park, OH.) and CHRISTOS C. CHAMIS Oct. 1993 21 p Presented at the 34th Structures, Structural Dynamics, and Materials Conference, La Jolla, CA, 19-21 Apr. 1993; cosponsored by AIAA, ASME, AHS, and ASC
(Contract RTOP 210-02-12)
(NASA-TM-106335; E-8102; NAS 1.15:106335) Avail: CASI HC A03/MF A01

A composite wing with spars, bulkheads, and built-in control devices is evaluated using a method for the probabilistic assessment of smart composite structures. Structural responses (such as change in angle of attack, vertical displacements, and stresses in regular plies with traditional materials and in control plies with mixed traditional and actuation materials) are probabilistically assessed to quantify their respective scatter. Probabilistic sensitivity factors are computed to identify those parameters that have a significant influence on a specific structural response. Results show that the uncertainties in the responses of smart composite structures can be quantified. Responses such as structural deformation, ply stresses, frequencies, and buckling loads in the presence of defects can be reliably controlled to satisfy specified design requirements. Author

N94-20203# Naval Air Warfare Center, Patuxent River, MD. Aircraft Div.

ROTORWASH WIND SENSOR EVALUATION Final Report

CURTIS L. MEYERHOFF, ROBERT E. LAKE, and DENNIS N. GORDGE Aug. 1993 30 p Original contains color illustrations
(Contract DTFA01-92-Y-02017)
(AD-A268987; DOT/FAA/RD-93/10) Avail: CASI HC A03/MF A01

This project's purpose was to assess and document the ability of the Qualimetrics, Inc. model 2132 wind sensor (a cup and vane type sensor) to measure a rotor wash flow field as compared to the TSI, Inc. model 204D ion beam deflection sensor. The tests concentrated on the sensor's ability to capture dynamic characteristics of a helicopter rotor wash flow field. The project was conducted from April to November 1992 and consisted of quantitative laboratory and field testing. The laboratory testing included 9.5 hours of wind tunnel test time, subjecting each sensor to three step input tests at velocities of 20 knots, 50 knots, and 80 knots. Field test data were collected during one hour of SH-60B helicopter hover time at heights of 15 and 25 feet above ground level at distances of 35 and 70 feet from the wind sensors. Aircraft gross weights ranged between 19,600 and 20,500 pounds. All field test data were obtained in ambient wind conditions of approximately 8 knots at 40 degrees relative to the aircraft nose, -40 feet pressure altitude in an ambient temperature of 85 F. Laboratory data analysis indicates the model 2132 cup and vane sensor's time constant values were significantly higher than those of the model 204D ion beam sensor and varied relative to wind tunnel velocity settings. This indicates the model 2132 sensor's ability to accurately capture oscillations in a dynamic flow field is significantly less than the model 204D sensor. The model 2132 sensor did detect periodic or pulsating velocity magnitudes, but failed to capture significant oscillations as compared to the model 204D sensor. Comparative analysis of all field test event data indicate the model 2132 sensor only detected frequencies below 1.5 Hz and only captured an average of 46 percent of the model 204D sensor's maximum amplitude pulse values that were below 1.5 Hz. The model 2132 sensor's inability to capture many of the maximum pulse amplitudes is evidence of the sensor's limited capability to capture velocity magnitude variations in a dynamic flow field. The model 2132 cup and vane sensor's average and minimum velocities for each test event were significantly higher than the model 204D ion beam sensor's values. This is additional evidence that the model 2132 sensor is slower to respond to rapid changes in a dynamic flow field. Compared to the TSI, Inc. model 204D ion beam sensor, the Qualimetrics, Inc. model 2132 cup and vane sensor failed to measure accurately a rotorwash flow field in terms of frequency, amplitude, frequency content, and velocity magnitude and thus is not recommended for helicopter rotorwash velocity data collection. Author

13
GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A94-10123

AIRBORNE WINDSHEAR SYSTEM ALERT PRINCIPLE STUDY

HONG ZHANG and CHANGJIANG JIN (Beijing Univ. of Aeronautics and Astronautics, China) Beijing University of Aeronautics and Astronautics, Journal (ISSN 1001-5965) no. 2 April 1993 p. 75-81. In CHINESE refs

A simplified windshear hazard criterion is developed based on the mechanism of the effects of windshear on aircraft flight and the CAT I worst landing limits specified by FAA. The effects of longitudinal and vertical windshear components on the flight performance are analyzed with the aim of investigating the hazard of windshear components. After a careful study of the correlations between the hazard criterion and the performance deteriorating parameter J2, the alert principle and the threshold of a predictive airborne windshear detection and warning system are discussed in detail. Author (revised)

A94-10875* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

CASE STUDY OF A LOW-REFLECTIVITY PULSATING MICROBURST - NUMERICAL SIMULATION OF THE DENVER, 8 JULY 1989, STORM

FRED H. PROCTOR (NASA, Langley Research Center, Hampton, VA) Oct. 1993 5 p. AMS, Conference on Severe Local Storms, 17th, Saint Louis, MO, Oct. 4-8, 1993, Paper refs

Results from a 3D simulation of a very strong microburst, detected by the Low-Level Windshear Alert System, are presented. The simulation was performed using the Terminal Area Simulation System (TASS) model (Proctor, 1987) which is a 3D nonhydrostatic cloud model that includes parameterizations for both liquid and ice-phase microphysics. Emphasis is placed om the pulsating characteristic and the very-low radar reflectivity of the event. The simulation revealed that the dissipating cloud induces a type-1 pulsating microburst event, with at least three distinct microburst pulses over a period of 20 min. AIAA

A94-10882* National Aeronautics and Space Administration, Washington, DC.

TERRESTRIAL VOLCANISM IN SPACE AND TIME

TOM SIMKIN (Smithsonian Institution, Washington) *In* Annual review of earth and planetary sciences. Vol. 21 Palo Alto, CA Annual Reviews, Inc. 1993 p. 427-452. Research supported by Smithsonian Institution and NASA refs
Copyright

A survey is presented of current volcanic activity around the world and of dated volcanism over the past 10,000 yrs. The patterns in the data are described. The hazard presented by volcanism is briefly examined. AIAA

A94-12286* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

THE GUST-FRONT DETECTION AND WIND-SHIFT ALGORITHMS FOR THE TERMINAL DOPPLER WEATHER RADAR SYSTEM

LAURIE G. HERMES (NOAA, National Severe Storms Lab., Norman, OK; NASA, Johnson Space Center, Houston, TX), ARTHUR WITT (NOAA, National Severe Storms Lab., Norman, OK), STEVEN D. SMITH (NOAA, National Weather Service, Norman, OK), DIANA KLINGLE-WILSON (MIT, Lexington, MA), DALE MORRIS (NOAA, National Severe Storms Lab., Norman, OK), GREGORY J. STUMPF (NOAA, National Severe Storms Lab.; Cooperative Inst. for Mesoscale Meteorological Studies, Norman, OK), and MICHAEL D. EILTS (NOAA, National Severe Storms Lab., Norman, OK) Journal of Atmospheric and Oceanic

Technology (ISSN 0739-0572) vol. 10, no. 5 Oct. 1993 p. 693-709. Research supported by FAA refs
Copyright
The Federal Aviation Administration's (FAA) Terminal Doppler Weather Radar (TDWR) system was primarily designed to address the operational needs of pilots in the avoidance of low-altitude wind shears upon takeoff and landing at airports. One of the primary methods of wind-shear detection for the TDWR system is the gust-front detection algorithm. The algorithm is designed to detect gust fronts that produce a wind-shear hazard and/or sustained wind shifts. It serves the hazard warning function by providing an estimate of the wind-speed gain for aircraft penetrating the gust front. The gust-front detection and wind-shift algorithms together serve a planning function by providing forecasted gust-front locations and estimates of the horizontal wind vector behind the front, respectively. This information is used by air traffic managers to determine arrival and departure runway configurations and aircraft movements to minimize the impact of wind shifts on airport capacity. This paper describes the gust-front detection and wind-shift algorithms to be fielded in the initial TDWR systems. Results of a quantitative performance evaluation using Doppler radar data collected during TDWR operational demonstrations at the Denver, Kansas City, and Orlando airports are presented. The algorithms were found to be operationally useful by the FAA airport controllers and supervisors.

A94-12361* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SIGNAL PROCESSING ASPECTS OF WINDSHEAR DETECTION
DAVID D. AALFS, ERNEST G. BAXA, JR. (Clemson Univ., SC), and EMEDIO M. BRACALENTE (NASA, Langley Research Center, Hampton, VA) Microwave Journal (ISSN 0192-6225) vol. 36, no. 9 Sept. 1993 p. 76, 79, 82-84 (7 ff.). refs
(Contract NAG1-928)
Copyright
Low-altitude windshear (LAWS) has been identified as a major hazard to aircraft, particularly during takeoff and landing. The Federal Aviation Administration (FAA) has been involved with developing technology to detect LAWS. A key element in this technology is high resolution pulse Doppler weather radar equipped with signal and data processing to provide timely information about possible hazardous conditions.

N94-10725*# California Univ., Los Angeles. Dept. of Atmospheric Sciences.
LEE WAVES: BENIGN AND MALIGNANT
M. G. WURTELE, A. DATTA, and R. D. SHARMAN Jun. 1993 30 p Sponsored by NASA. Dryden Flight Research Facility
(Contract NCC2-0374; RTOP 505-68-50)
(NASA-CR-186024; H-1890; NAS 1.26:186024) Avail: CASI HC A03/MF A01
The flow of an incompressible fluid over an obstacle will produce an oscillation in which buoyancy is the restoring force, called a gravity wave. For disturbances of this scale, the atmosphere may be treated as dynamically incompressible, even though there exists a mean static upward density gradient. Even in the linear approximation - i.e., for small disturbances - this model explains a great many of the flow phenomena observed in the lee of mountains. However, nonlinearities do arise importantly, in three ways: (1) through amplification due to the decrease of mean density with height; (2) through the large (scaled) size of the obstacle, such as a mountain range; and (3) from dynamically singular levels in the fluid field. These effects produce a complicated array of phenomena - large departure of the streamlines from their equilibrium levels, high winds, generation of small scales, turbulence, etc. - that present hazards to aircraft and to lee surface areas. The nonlinear disturbances also interact with the larger-scale flow in such a manner as to impact global weather forecasts and the climatological momentum balance. If there is no dynamic barrier, these waves can penetrate vertically into the middle atmosphere (30-100 km), where recent observations show them to be of a length scale that must involve the coriolis force in any modeling. At these altitudes, the amplitude of the waves is very large, and the phenomena associated with these wave dynamics are being studied with a view to their potential impact on high performance aircraft, including the projected National Aerospace Plane (NASP). The presentation shows the results of analysis and of state-of-the-art numerical simulations, validated where possible by observational data, and illustrated with photographs from nature. Author (revised)

N94-11173# Sandia National Labs., Albuquerque, NM.
FATIGUE LIFE PREDICTION FOR WIND TURBINES: A CASE STUDY ON LOADING SPECTRA AND PARAMETER SENSITIVITY
H. J. SUTHERLAND, P. S. VEERS, and T. D. ASHWILL 1992 39 p Presented at the 5th ASTM Symposium on Composite Materials: Fatigue and Fracture, Atlanta, GA, 4-6 May 1993
(Contract DE-AC04-76DP-00789)
(DE93-011597; SAND-92-0501C; CONF-930532-2) Avail: CASI HC A03/MF A01
Wind turbines are fatigue-critical machines used to produce electrical energy from the wind. These rotating machines are subjected to environmental loadings that are highly irregular in nature. Historical examples of fatigue problems in both research and commercial wind turbine development are presented. Some example data on wind turbine environments, loadings and material properties are also shown. Before a description of how the authors have chosen to attack the cumulative damage assessment, questions are presented for the reader's reflection. The solution technique used by the authors is then presented, followed by a case study applying the procedures to an actual wind turbine blade joint. The wind turbine is the 34-meter diameter vertical axis wind turbine (VAWT) erected by Sandia National Laboratories near Bushland, Texas. The case study examines parameter sensitivities for realistic uncertainties in inputs defining the turbine environment, stress response and material properties. The fatigue lifetimes are calculated using a fatigue analysis program, called LIFE2, which was developed at Sandia. The LIFE2 code, described in some detail in an appendix, is a PC-based, menu-driven package that leads the user through the steps required to characterize the loading and material properties, then uses Miner's rule or a linear crack propagation rule to numerically calculate the time to failure. Only S-n based cumulative damage applications are illustrated here. The LIFE2 code is available to educational institutions for use as a case study in describing complicated loading histories and for use by students in examining, hands on, parameter sensitivity of fatigue life analysis. DOE

N94-11500# Technische Univ., Brunswick (Germany). Inst. fuer Flugfuehrung.
STABILITY MODEL OF THE ATMOSPHERE
ANDREAS KNUEPPEL, DANIEL MARTENS, and ANDREAS SIEMER (Technische Univ., Hamburg, Germany.) *In* AGARD, Stability in Aerospace Systems 17 p Feb. 1993
Copyright Avail: CASI HC A03/MF A03
The atmosphere of the earth is a very complex system covering a wide range of interacting scales. The concept of stability is applied to subsystems thereof where the quantities involved in a stability analysis depend on the particular question to be answered. But all stability considerations share a common basic structure. After giving a short account to the nature of stability investigations, some examples of stability related atmospheric phenomena are presented which are relevant for flight operation. Finally, the impact of atmospheric instability on aircraft performance with special regard to flight safety is illustrated. Author

N94-11711# Hamburg Univ. (Germany). Inst. fuer Meereskunde.
A C-BAND WIND SCATTEROMETER MODEL DERIVED FROM THE DATA OBTAINED DURING THE ERS-1 CALIBRATION/VALIDATION CAMPAIGN
VOLKMAR WISMANN *In* ESA, Proceedings of First ERS-1 Symposium on Space at the Service of Our Environment, Volume 1 p 55-59 Mar. 1993

(Contract BMFT-01-QS-90144)
Copyright Avail: CASI HC A01/MF A04; EPD, ESA, ESTEC, Noordwijk, Netherlands, HC

The geophysical calibration and validation campaign for the first European Remote Sensing Satellite (ERS-1) took place in the Norwegian Sea between 15 Sep. - 10 Dec. 1991. Ocean surface wind measurements were carried out with the airborne C band scatterometer RACS of the University of Hamburg during 46 underflights of the satellite. The wind was measured by the navigational system of the Do-228 aircraft during low level (6 to 150 m) flights. A high quality subset of these data was used to tune the proposed wind scatterometer model function which differs from the ERS-1 prelaunch CMOD-2 formulation by an azimuth dependance of the wind speed exponent. A wind retrieval test demonstrates that the proposed model satisfies the ESA specifications for the ERS-1 wind scatterometer model. ESA

N94-11716# Aston Univ., Birmingham (England). Dept. of Computer Science and Applied Mathematics.
CALIBRATION OF ERS-1 ALTIMETRY OVER THE NORTH SEA
C. W. LAM, P. MOORE, and P. L. WOODWORTH (Proudman Oceanographic Lab., Birkenhead, England.) *In* ESA, Proceedings of First ERS-1 Symposium on Space at the Service of Our Environment, Volume 1 p 85-90 Mar. 1993
Copyright Avail: CASI HC A02/MF A04; EPD, ESA, ESTEC, Noordwijk, Netherlands, HC

A calibration exercise utilizing seven ascending repeat passes over the English Channel in conjunction with precise orbits, GPS (Global Positioning System) measurement, local levelling, tide gauge data, and geoid/ocean tide/storm surge models was carried out for Jan. - Mar. 1992. Precise orbits of +/- 5 cm radial accuracy was achieved due to the satellite flying near overhead of the Herstmonceux laser ranger. From a total of 76 calibration points, a mean height residual of -46.0 cm with a standard deviation of 10.8 cm was observed. The derived electronic bias of -46.0 cm +/- 11 cm can be compared to -19.2 cm as estimated from the dedicated calibration validation based on the Venice Tower experiment and -60 cm to -70 cm from various long-arc studies. ESA

N94-12502# Meteorological Office, Bracknell (England).
USE OF ERS-1 WIND AND WAVE PRODUCTS IN OPERATIONAL METEOROLOGY
STUART BELL and MARTIN HOLT *In* ESA, Proceedings of 1st ERS-1 Symposium on Space at the Service of Our Environment, Volume 2 p 705-710 Mar. 1993
Copyright Avail: CASI HC A02/MF A03; EPD, ESA, ESTEC, Noordwijk, Netherlands, HC

Statistics from validations of altimeter and scatterometer data are presented. The scatterometer winds were processed from the sigma O's in house and dealiased with the help of U.K. Meteorological Office (UKMO) operational global model background winds. The altimeter data were obtained directly from the ESA fast delivery product. Winds derived from the scatterometer were assimilated into the UKMO atmospheric forecast model and preliminary results from these assimilations are presented. The derived wind fields from atmospheric assimilations were used to drive a global wave model to measure their impact on analyzed wave fields. Preliminary experiments to assimilate the altimeter wave data directly into the wave model are reported. Further work to optimize the use of these new data sources is anticipated. ESA

N94-12503# MeteorMer, Puget sur Argens (France).
USE OF SAR-WAVE, ALTIMETER, AND WIND-SCATTEROMETER DATA IN AN OPERATIONAL SWELL FORECASTING SYSTEM
P. LASNIER, P. CHARRIEZ, H. HAJJI, and F. CAUNEAU (Ecole Nationale Superieure des Mines, Sophia-Antipolis, France.) *In* ESA, Proceedings of 1st ERS-1 Symposium on Space at the Service of Our Environment, Volume 2 p 711-720 Mar. 1993
Copyright Avail: CASI HC A02/MF A03; EPD, ESA, ESTEC, Noordwijk, Netherlands, HC

The first phase of a pilot project whose aim was to evaluate the quality improvement of marine meteorological forecast and analysis, using the information provided on sea state by the three instruments of the ESA ERS-1 satellite (Synthetic Aperture Radar (SAR) in wave mode, wind scatterometer, and radar altimeter) is reported. The mastery in the domains of data acquisition (fast delivery), via a server installed at the French meteorological office, and in the domain of data management and archiving (applied to the site climatology study) was given. This implied the first handling of visualization softwares, and permitted a first visual evaluation of the data. The first analysis and controls for the data quality were achieved. ESA

N94-12572*# Aerodyne Research, Inc., Billerica, MA.
STRATOSPHERIC AIRCRAFT EXHAUST PLUME AND WAKE CHEMISTRY
R. C. MIAKE-LYE, M. MARTINEZ-SANCHEZ, R. C. BROWN, C. E. KOLB, D. R. WORSNOP, M. S. ZAHNISER, G. N. ROBINSON, J. M. RODRIGUEZ (Atmospheric and Environmental Research, Inc., Cambridge, MA.), M. K. W. KO (Atmospheric and Environmental Research, Inc., Cambridge, MA.), R-L. SHIA (Atmospheric and Environmental Research, Inc., Cambridge, MA.) et al. Jul. 1993 65 p
(Contract NAS1-19161; RTOP 537-01-20-01)
(NASA-CR-191495; NAS 1.26:191495; ARI-RR-1006) Avail: CASI HC A04/MF A01

Progress to date in an ongoing study to analyze and model emissions leaving a proposed High Speed Civil Transport (HSCT) from when the exhaust gases leave the engine until they are deposited at atmospheric scales in the stratosphere is documented. A kinetic condensation model was implemented to predict heterogeneous condensation in the plume regime behind an HSCT flying in the lower stratosphere. Simulations were performed to illustrate the parametric dependence of contrail droplet growth on the exhaust condensation nuclei number density and size distribution. Model results indicate that the condensation of water vapor is strongly dependent on the number density of activated CN. Incorporation of estimates for dilution factors into a Lagrangian box model of the far-wake regime with scale-dependent diffusion indicates negligible decrease in ozone and enhancement of water concentrations of 6-13 times background, which decrease rapidly over 1-3 days. Radiative calculations indicate a net differential cooling rate of the plume about 3K/day at the beginning of the wake regime, with a total subsidence ranging between 0.4 and 1 km. Results from the Lagrangian plume model were used to estimate the effect of repeated superposition of aircraft plumes on the concentrations of water and NO(y) along a flight corridor. Results of laboratory studies of heterogeneous chemistry are also described. Kinetics of HCl, N2O5 and ClONO2 uptake on liquid sulfuric acid were measured as a function of composition and temperature. Refined measurements of the thermodynamics of nitric acid hydrates indicate that metastable dihydrate may play a role in the nucleation of more stable trihydrates PSC's. Author (revised)

N94-15326* National Aeronautics and Space Administration, Washington, DC.
WIND SHEAR AND HEAVY RAIN (Videotape)
Jul. 1989 Videotape: 2 min. 56 sec. playing time, in color, with sound
(NASA-TM-109453; NONP-VT-93-190250) Avail: CASI VHS A01/BETA A22

This document looks at research on countering the effects of wind shear and heavy rain situations on flight stability. CASI

N94-15851 Army Engineer Waterways Experiment Station, Vicksburg, MS. Environmental Lab.
ENVIRONMENTAL CHARACTERIZATION FOR TARGET ACQUISITION. REPORT 1: SITE DESCRIPTIONS AND MEASUREMENTS
TOMMY BERRY, SALVADOR RIVERA, JR., and BRUCE SABOL Jun. 1993 198 p Limited Reproducibility: More than 20% of

this document may be affected by microfiche quality
(AD-A267192; WES/TR/EL-93-9-REPT-1) Avail: CASI HC A09

Automatic/Aided Target Recognition (ATR) systems are being developed for current and next generation attack and reconnaissance helicopters. Part of the development cycle consists of testing and evaluation of these systems at field test facilities within the United States. Preliminary tests of ATR systems have demonstrated a high sensitivity to terrain and environmental conditions. Testers and analysts must therefore have an understanding of the relationship between system performance and terrain/environmental conditions to plan tests and interpret data. To develop an understanding of this relationship, the Environmental Characterization for Target Acquisition (ECTA) Program was initiated. As part of this program, visible and thermal infrared imagery, meteorological data, and terrain characterization data were systematically collected from six different United States testing sites for different times of year and times of day. This report (Report 1) describes field and laboratory procedures used to obtain this data. Analysis of these data is described in Report 2. DTIC

N94-16589# Army Research Lab., White Sands Missle Range, NM.

COMPLEX TERRAIN WIND MODEL EVALUATION Final Report

MARTIN E. LEE Jun. 1993 169 p
(AD-A266467; ARL-TR-54) Avail: CASI HC A08/MF A02

The Winds on Critical Steamline Surfaces (WOCSS) complex terrain wind flow model is designed to simulate lateral, mechanical forcing effects on air flows along elevated, solid boundaries. These effects exert significant influence on observed flow field properties, such as transport and diffusion. The degree to which WOCSS model outputs are more reliable than a basic mass consistency model (that does not address lateral forcing dynamics in complex terrain) is discussed in terms of statistical and spatial results, and conclusions regarding this comparison are presented. Results indicate that the WOCSS model does not predict directional changes resulting from lateral forcing, which is a serious limiting factor in its potential application. The WOCSS model was also found to have an oversimplified mass consistency algorithm, averaging speed-up effects over the entire lateral free-flow surface, which restricts prediction of localized lateral speed-up effects in the vicinity of mechanical flow obstacles. Finally, the WOCSS model tends to over-predict the quantity of flow restricted space under both stable and unstable conditions in the transition from moderate to rugged complex terrain when wind speeds are generally less than or equal to 4.0 m/s. However, despite the observed WOCSS model limitations, the WOCSS model did demonstrate the potential to selectivity predict reasonable and significant dynamic lateral forcing spaces over a variety of terrain and stability conditions. DTIC

N94-16597*# Lockheed Engineering and Sciences Co., Bay Saint Louis, MS.

A QUANTITATIVE ANALYSIS OF TIMS DATA OBTAINED ON THE LEARJET 23 AT VARIOUS ALTITUDES

S. JAGGI *In* JPL, Summaries of the Third Annual JPL Airborne Geoscience Workshop. Volume 2: TIMS Workshop p 4-6 1 Jun. 1992
Avail: CASI HC A01/MF A01

A series of Thermal Infrared Multispectral Scanner (TIMS) data acquisition flights were conducted on the NASA Learjet 23 at different altitudes over a test site. The objective was to monitor the performance of the TIMS (its estimation of the brightness temperatures of the ground scene) with increasing altitude. The results do not show any significant correlation between the brightness temperatures and the altitude. The analysis indicates that the estimation of the temperatures is a function of the accuracy of the atmospheric correction used for each altitude. Author (revised)

N94-17245 Pennsylvania State Univ., University Park.

THE USE OF THE AIR FORCE ACADEMY HIGH WIND ALERT SYSTEM IN FORECASTING MODERATE INTENSITY WIND EVENTS FOR MILITARY BASES IN THE COLORADO SPRINGS AREA M.S. Thesis

DOUGLAS S. CLARK Aug. 1993 45 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A267648) Avail: CASI HC A03

A study of the problem of forecasting moderate intensity wind events in the Colorado Springs area, which are operationally significant to the military bases there, was conducted over a three year period. This study centered on the use of the United States Air Force Academy High Wind Alert System, a network of automatic observing stations in the foothills of the Air Force Academy. The usefulness of the High Wind Alert System as an aid to forecasting the onset of moderate intensity events at the other bases was investigated. The results of a statistical analysis of data taken from the High Wind Alert System on a number of days during which the synoptic conditions indicated the possibility of a moderate intensity wind event are presented, with emphasis on the correlation between the output from the High Wind Alert System and the time of onset of moderate intensity winds at the concerned bases. The results of this analysis, along with the possible empirical forecasting rules they suggest, are explained. DTIC

N94-17283*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

WINDSHEAR DATABASE FOR FORWARD-LOOKING SYSTEMS CERTIFICATION

G. F. SWITZER (Research Triangle Inst., Research Triangle Park, NC.), F. H. PROCTOR, D. A. HINTON, and J. V. AANSTOOS (Research Triangle Inst., Research Triangle Park, NC.) Nov. 1993 128 p
(Contract RTOP 505-64-12-01)
(NASA-TM-109012; NAS 1.15:109012) Avail: CASI HC A07/MF A02

This document contains a description of a comprehensive database that is to be used for certification testing of airborne forward-look windshear detection systems. The database was developed by NASA Langley Research Center, at the request of the Federal Aviation Administration (FAA), to support the industry initiative to certify and produce forward-look windshear detection equipment. The database contains high resolution, three dimensional fields for meteorological variables that may be sensed by forward-looking systems. The database is made up of seven case studies which have been generated by the Terminal Area Simulation System, a state-of-the-art numerical system for the realistic modeling of windshear phenomena. The selected cases represent a wide spectrum of windshear events. General descriptions and figures from each of the case studies are included, as well as equations for F-factor, radar-reflectivity factor, and rainfall rate. The document also describes scenarios and paths through the data sets, jointly developed by NASA and the FAA, to meet FAA certification testing objectives. Instructions for reading and verifying the data from tape are included. Author

N94-17853# Lawrence Livermore National Lab., CA.

REGENERATIVE FUEL CELLS FOR HIGH ALTITUDE LONG ENDURANCE SOLAR POWERED AIRCRAFT

F. MITLITSKY, N. J. COLELLA, B. MYERS, and C. J. ANDERSON (AeroVironment, Inc., Monrovia, CA.) 2 Jun. 1993 8 p Presented at the 28th Intersociety Energy Conversion Engineering Conference, Atlanta, GA, 8-13 Aug. 1993
(Contract W-7405-ENG-48)
(DE93-016991; UCRL-JC-113485; CONF-930804-12) Avail: CASI HC A02/MF A01

High Altitude Long Endurance (HALE) unmanned missions appear to be feasible using a lightweight, high efficiency, span-loaded, Solar Powered Aircraft (SPA) which includes a Regenerative Fuel Cell (RFC) system and novel tankage for energy storage. An existing flightworthy electric powered flying wing design was modified to incorporate present and near-term technologies in energy storage, power electronics, aerodynamics, and guidance and control in order to substantiate feasibility. The design philosophy was to work with vendors to identify affordable near-term technological opportunities that could be applied to existing designs in order to reduce weight, increase reliability, and maintain adequate efficiency of components for delivery within 18 months. The energy storage subsystem for a HALE SPA is a key driver for the entire vehicle because it can represent up to half of the vehicle weight and most missions of interest require the specific energy to be considerably higher than 200 W-hr/kg for many cycles. This stringent specific energy requirement precludes the use of rechargeable batteries or flywheels and suggests examination of various RFC designs. An RFC system using lightweight tankage, a single fuel cell (FC) stack, and a single electrolyzer (EC) stack separated by the length of a spar segment (up to 39 ft), has specific energy of approximately 300 W-hr/kg with 45% efficiency, which is adequate for HALE SPA requirements. However, this design has complexity and weight penalties associated with thermal management, electrical wiring, plumbing, and structural weight. A more elegant solution is to use unitized RFC stacks (reversible stacks that act as both FC's and EC's) because these systems have superior specific energy, scale to smaller systems more favorably, and have intrinsically simpler thermal management. DOE

N94-18573 Air Weather Service, Scott AFB, IL.
NEW TECHNIQUES FOR CONTRAIL FORECASTING Technical Report
JEFFREY L. PETERS Aug. 1993 37 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A269686; AWS/TR-93/001) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

This report documents the results of a study requested by the Strategic Air Command Deputy Chief of Staff for Operations (SAC/DO) to update previous contrail forecasting research done by Herbert Appleman for HQ Air Weather Service in 1953. Advancements in aircraft power plants, especially the development of bypass turbofan engines, made the new study necessary. This attempt to update and improve current contrail forecasting methods was performed by the SAC Directorate of Weather (SAC/DOW). It describes the development of new contrail forecast algorithms for several types of engines used in high-flying aircraft. It also provides contrail forecasting rules that correlate synoptic-scale upward vertical motion with contrail formation. The results indicate significant improvement in contrail forecasting accuracy over the Appleman technique now in use at the Air Force Global Weather Central. DTIC

N94-18684 Massachusetts Inst. of Tech., Lexington.
INTEGRATED TERMINAL WEATHER SYSTEM (ITWS) Annual Report, 1992
JAMES E. EVANS 7 Sep. 1993 104 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract F19628-90-C-0002)
(AD-A269884; ATC-203; DOT/FAA/RD-93/27) Avail: CASI HC A06

Hazardous weather in the terminal area is the major cause of aviation system delays as well as a principal cause of air carrier accidents. Several systems presently under development will provide significant increases in terminal safety. However, these systems will not make a major impact on weather-induced delays in the terminal area, meet a number of the safety needs (such as information to support ground deicing decisions), or reduce the workload of the terminal controller. The Integrated Terminal Weather System (ITWS) will provide improved aviation weather information in the allocated TRACON area (up to 50 nmi from the airport) by integrating data and products from various Federal Aviation Administration (FAA) and National Weather Service (NWS) sensors and weather information systems. The data from these sources will be combined to provide a unified set of safety and planning weather products for pilots, controllers, and terminal area traffic managers. By using data from multiple sensors, ITWS can generate important new products where no individual sensor alone could generate a single, reliable product. In other instances, use of data from several sources can compensate for erroneous data from one sensor and thus improve the overall integrity of existing products. Major objectives of the ITWS program are to increase the effective airport acceptance rate in adverse weather by providing information to support terminal automation systems, better terminal route planning, and wake vortex advisory services, and to reduce the need for controllers to communicate weather information to pilots via VHF voice. DTIC

N94-19702 Royal Netherlands Meteorological Inst., De Bilt.
ORGANIZED TRACK SYSTEM: AIR WAYS ABOVE THE OCEAN [ORGANIZED TRACK SYSTEM, LUCHTWEGEN OVER DE OCEAAN]
G. R. DAGRACA *In its* Reports of the 1992 Synoptic Symposium p 44-53 1993 In DUTCH
Copyright Avail: Issuing Activity (Royal Netherlands Meteorological Inst., Postbus 201, 3730 AE De Bilt, Wilhelminalaan 10, Netherlands)

The Organized Track System (OTS) for the optimization of airways above the Atlantic Ocean is presented. OTS determines an optimal set of air routes at both sides of the ocean by taking into account wind and temperature data and air traffic particularities. There is no radar escort, and aircraft have to fulfill the minimum navigation performance specifications. The interpretation of jet stream forecasting is discussed with a view to fuel consumption. ESA

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.

A94-10103
MONTE CARLO SIMULATION OF COMMERCIAL AIRCRAFT RELIABILITY
WEIMIN YANG, QINGCI TU, YIXING SHENG (Beijing Univ. of Aeronautics and Astronautics, China), and YUAN ZHU (Chinese Academy of Sciences, Academic Energetics Research and Development Center, China) Beijing University of Aeronautics and Astronautics, Journal (ISSN 1001-5965) no. 1 Jan. 1992 p. 16-23. In CHINESE refs

By applying Monte Carlo simulation methods, a simulation model is established in this paper, which considers factors such as R&M characteristics of the aircraft, weather conditions, management, flight dispatching, number of aircraft, route structure, maintenance level, personnel skills, spare parts supply, etc. The analysis results can provide the decision-making basis to improve product's R&M for manufacturers and to rationally adjust the flight, dispatch procedure, logistic supports, etc. for airlines. Author (revised)

A94-10112
DISCUSSIONS OF STANDARDIZATION SYSTEMS ENGINEERING AND ITS RESEARCH (WORKING) OBJECTS
XICHUN ZHANG (Beijing Univ. of Aeronautics and Astronautics, China) Beijing University of Aeronautics and Astronautics, Journal (ISSN 1001-5965) no. 1 Jan. 1992 p. 93-100. In CHINESE refs

The implications of standardization systems engineering are expounded, and its characters are described. A comparison of standardization systems engineering with complex standardization is given. The major types of standardization systems engineering of the aero-astronautical industry are discussed. It is argued that the direct research (working) objects of standardization systems

engineering are the standards system, and the standardization operating system (together they are called the standardization system), and the main body of the dependence is the usual service object of standardization. The characters of two subsystems of the standardization system are also discussed. It is concluded that defining the research (working) objects of standardization systems engineering has certain universal significance.
Author (revised)

A94-10119
THE RESEARCH AND ESTABLISHMENT OF GRAPHICS LIBRARY OF AERO-ENGINE ROTOR SYSTEM STRUCTURE SCHEME
SHUFEN GUO (Beijing Univ. of Aeronautics and Astronautics, China) Beijing University of Aeronautics and Astronautics, Journal (ISSN 1001-5965) no. 2 April 1993 p. 49-56. In CHINESE refs

This paper introduces an aero-engine rotor structure graphics base through utilizing the Auto CAD software and the Auto LISP language program. The typical part shape classification, the typical part shape and the typical structure program configuration are set up through collecting and analyzing the current compressor and turbine rotor parts of the internal and external aero-engines. The establishment of the structure program is displayed with multistage screen menus. An interactive method is provided for the users. After the program is set up, the specific value is given for the definite parameter through the interactive method so that the rotor structure program configuration can be drawn quickly and also can be modified and optimized in real time. Author (revised)

A94-10298 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TURBOMACHINERY CFD ON PARALLEL COMPUTERS
R. A. BLECH, E. J. MILNER (NASA, Lewis Research Center, Cleveland, OH), A. QUEALY, and S. E. TOWNSEND (Sverdrup Technology, Inc., Brook Park, OH) Computing Systems in Engineering (ISSN 0956-0521) vol. 3, no. 6 Dec. 1992 p. 613-623. Previously announced in STAR as N93-13154 refs
(Contract RTOP 505-62-52)
Copyright

The role of multistage turbomachinery simulation in the development of propulsion system models is discussed. Particularly, the need for simulations with higher fidelity and faster turnaround time is highlighted. It is shown how such fast simulations can be used in engineering-oriented environments. The use of parallel processing to achieve the required turnaround times is discussed. Current work by several researchers in this area is summarized. Parallel turbomachinery CFD research at the NASA Lewis Research Center is then highlighted. These efforts are focused on implementing the average-passage turbomachinery model on MIMD, distributed memory parallel computers. Performance results are given for inviscid, single blade row and viscous, multistage applications on several parallel computers, including networked workstations.

A94-10806* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLIGHT CONTROL APPLICATION OF NEW STABILITY ROBUSTNESS BOUNDS FOR LINEAR UNCERTAIN SYSTEMS
RAMA K. YEDAVALLI (Ohio State Univ., Columbus) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 6 Nov.-Dec. 1993 p. 1032-1037. refs
(Contract NAG1-1164)
Copyright

This paper addresses the issue of obtaining bounds on the real parameter perturbations of a linear state-space model for robust stability. Based on Kronecker algebra, new, easily computable sufficient bounds are derived that are much less conservative than the existing bounds since the technique is meant for only real parameter perturbations (in contrast to specializing complex variation case to real parameter case). The proposed theory is illustrated with application to several flight control examples.

A94-10819
H(INFINITY) ROBUST CONTROL DESIGN FOR LINEAR FEEDBACK SYSTEMS
JIANN-SHIOU YANG (Minnesota Univ., Duluth) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 6 Nov.-Dec. 1993 p. 1131-1137. Research supported by Univ. of Minnesota refs
Copyright

This paper deals with the problem of designing, for a linear time invariant multivariable plant, a feedback controller that minimizes the H(infinity) norm of a quadratic combination of the sensitivity and complementary sensitivity functions. With the parameterization of the controller and quadratic cost, a design procedure based on a gain equalization test for computing the optimal controller is described in detail. A design algorithm, which is implementable in computers, is presented. The pitch-axis controller design for a digitized version of the Grumman F-14 aircraft is given. The performance robustness under the external disturbances and large aircraft parameter variations are shown to demonstrate the effectiveness of this approach. Author (revised)

A94-10822
ORDER REDUCTION OF LINEAR-QUADRATIC-GAUSSIAN-DESIGNED CONTROLLERS
E. NISSIM (Technion - Israel Inst. of Technology, Haifa) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 6 Nov.-Dec. 1993 p. 1154-1161. AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2, p. 1000-1009. Previously cited in issue 13, p. 2390, Accession no. A93-33973 refs
Copyright

A94-11249
ENGINE'S PARAMETERS COMPLEX OPTIMIZATION IN AEROSPACE SYSTEMS
I. GARANIN, A. FEDOSEEVA, and V. SAMOKHIN (Moscow Aviation Inst., Russia) Oct. 1993 7 p. IAF, International Astronautical Congress, 44th, Graz, Austria, Oct. 16-22, 1993 refs
(IAF PAPER 93-462) Copyright

A rapid decision method is proposed for selecting the optimal version of an aerospace transport engine, using an intellectualized synthesis technique. The technique is realized in three stages: (1) the conceptual stage, at which the desired structures and engine schemes are selected using the expert system; (2) the imitational stage, at which the quantitative characteristics of the engine's subsystems are estimated; and (3) the global optimization stage. The technique allows the user to evaluate maximum payload by minimizing fuel consumption for a given purpose and to define optimal engine's parameters for this mission. A configurational-design scheme of aerospace transport systems is included. AIAA

A94-11357
COMPUTER GRAPHIC RECREATIONS OF AIRCRAFT ACCIDENTS
ALAN TREIBITZ (Z-Axis Corp., Englewood, CO) *In* The use of simulation in aircraft accident prevention and investigation; Proceedings of the Conference, London, United Kingdom, Nov. 11, 12, 1992 London Royal Aeronautical Society 1992 p. 2.1-2.5.
Copyright

The complexity of available data following an aircraft accident today can be overwhelming. If properly designed, computer graphic video simulations which visually summarize this data can provide valuable insights into the way in which different factors contributed to the cause of an accident. A variety of computer graphic and video techniques are available to the designer of these simulations which can improve the information content of this tool. There are, however, some inherent limitations in the use of this medium. This paper will describe several computer and video techniques which should be considered in order to maximize the effectiveness of the visual communication. In addition, it will discuss methods to overcome or minimize the limitations. Author (revised)

A94-11359
INTEGRATION OF SIMULATION AND VISUALIZATION AIDS IN AIRCRAFT ACCIDENT INVESTIGATION
J. GROENEWEG (National Aerospace Lab., Amsterdam, Netherlands) *In* The use of simulation in aircraft accident prevention and investigation; Proceedings of the Conference, London, United Kingdom, Nov. 11, 12, 1992 London Royal Aeronautical Society 1992 p. 4.1-4.6.
Copyright

This paper presents a new method for accident investigation and prevention. The method demonstrates how results from a simulated flight are visualized. This visualization can lead directly to a better insight of the cause and course of the accident and indirectly to an improvement of flight safety. The method is supported by new simulation and visualization tools which improve the way to reconstruct the last minutes of the flight.

A94-11360
THE END OF FLIGHT SIMULATION - THE USE OF SIMULATIONS TO TRAIN AIRCRAFT ACCIDENT INVESTIGATORS AND EMERGENCY SERVICES
J. M. ROLFE and A. F. TAYLOR (Cranfield Inst. of Technology, United Kingdom) *In* The use of simulation in aircraft accident prevention and investigation; Proceedings of the Conference, London, United Kingdom, Nov. 11, 12, 1992 London Royal Aeronautical Society 1992 p. 5.1-5.11. refs
Copyright

The present evaluation of the use of simulations to train accident-investigation and emergency-service personnel develops a systematic methodology for the creation of such training systems. Attention is given to the January, 1982 crash of an airliner into the Potomac river after taking off from Washington National Airport. The importance of debriefings after simulation/training sessions is discussed. AIAA

A94-11411#
PILOT - AN INTELLIGENT DISTRIBUTED SYSTEM MANAGER
ARTHUR N. RASMUSSEN (Mitre Corp., Houston, TX) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 77-82. refs
(AIAA PAPER 93-4474) Copyright

A number of efforts at NASA's Johnson Space Center are exploring ways of improving operational efficiency and effectiveness of the current and future manned space flight control centers. The Real-Time Data System (RTDS) project has been investigating several technologies and their application to the control center environment using an environment based on a heterogeneous network of engineering workstations in which live real-time data from simulated and actual Space Shuttle missions is distributed. The system is a complex set of interacting processes that must provide services with minimal downtime. This paper discusses the approaches used to ensure the system functions at high levels of reliability and availability. These include a process visibility facility, a local workstation environment monitor, a network level communication facility, and a global process incorporating artificial intelligence techniques.

A94-11422#
DEVELOPING A FRAMEWORK FOR CONCURRENCY BY CAPTURING SYSTEMS ENGINEERING RATIONAL USING A PROCESS MODELLING METHODOLOGY
JOHN T. BOARDMAN and ALISON J. COLE (Portsmouth Univ., United Kingdom) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 173-181. refs
(Contract SERC-GR/H/54317)
(AIAA PAPER 93-4489) Copyright

This paper describes a Process Modelling Methodology (PMM) which has been applied within particular avionics business. The methodology is able to add value and provide convenient representation for the processes that describe the evolution of the product system with the evolution of the product program, in a unified manner within a project lifecycle. The same methodology can be used to inform of concepts that are intuitively deployed by experienced managers and project engineers that ensure the healthy execution of the more tangible project lifecycle processes. A classical hierarchical approach assembles the higher level models down to specific tasks which become the subject of a concurrent engineering framework. The paper describes how this framework together with higher level process models have been deployed to describe the rationale of a Systems Engineering Business.

A94-11447*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE R-SHELL APPROACH - USING SCHEDULING AGENTS IN COMPLEX DISTRIBUTED REAL-TIME SYSTEMS
SWAMINATHAN NATARAJAN, WEI ZHAO (Texas A & M Univ., College Station), and ANDRE GOFORTH (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 383-389. refs
(AIAA PAPER 93-4523) Copyright

Large, complex real-time systems such as space and avionics systems are extremely demanding in their scheduling requirements. The current OS design approaches are quite limited in the capabilities they provide for task scheduling. Typically, they simply implement a particular uniprocessor scheduling strategy and do not provide any special support for network scheduling, overload handling, fault tolerance, distributed processing, etc. Our design of the R-Shell real-time environment fcilitates the implementation of a variety of sophisticated but efficient scheduling strategies, including incorporation of all these capabilities. This is accomplished by the use of scheduling agents which reside in the application run-time environment and are responsible for coordinating the scheduling of the application.

A94-11452#
PARALLEL TURBINE ENGINE INSTRUMENTATION SYSTEM
TED BAPTY, BEN ABBOTT, CSABA BIEGL, AKOS LEDECZI, and JANOS SZTIPANOVITS (Vanderbilt Univ., Nashville, TN) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 423-433. refs
(Contract F49620-88-C-0053)
(AIAA PAPER 93-4529) Copyright

The hardware and software architecture are described of an instrumentation system with more than 100 parallel processors for turbine engine aeromechanic stress analysis. The hardware consists of a mixture of heterogeneous processing nodes arranged in a configuration closely matching the analysis algorithms. Specialized processors are used for numerical, input/output, graphics, user interface, and storage. The software uses model-based program synthesis techniques to reconfigure signal analysis algorithms dynamically to meet changing requirements. AIAA

A94-11453#
AUTOMATIC TEST INSTRUMENTATION PROGRAM GENERATION
AKOS LEDECZI, CSABA BIEGL, BEN ABBOTT, JANOS SZTIPANOVITS, and TED BAPTY (Vanderbilt Univ., Nashville, TN) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 434-440. refs
(AIAA PAPER 93-4530) Copyright

Aerospace system testing is a highly complex and dynamic process. Requirements are constantly changing, even as a test progresses. Handling the data from aerospace tests must adapt to these changes. The algorithms to process data are typically complex, due to the variety of algorithms and the large number of channels which must be managed. Furthermore, the processing throughput and response times require a parallel processing approach. At Vanderbilt University we have developed a software system to address these issues. The Transient Data Analysis System automatically generates test data processing systems for parallel processors from high level specifications. The process is dynamic in that the processing algorithms executed by the system can be changed at any time during execution.

A94-11454#

MODEL-BASED SOFTWARE SYNTHESIS FOR LARGE SYSTEMS

BEN ABBOTT, TED BAPTY, CSABA BIEGL, AKOS LEDECZI, and JANOS SZTIPANOVITS (Vanderbilt Univ., Nashville, TN) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 441-451. refs

(AIAA PAPER 93-4531) Copyright

In this paper, we describe techniques for knowledge representation and compilation of large software systems in a model-based, automatic program synthesis environment. Domain specific declarative models are used to represent specifications and implementation strategies for reactive systems. Dynamic re-synthesis of an executing system is supported, allowing the system structure to adapt to the external or internal environment. We describe an application of these techniques to a large, high performance parallel instrumentation system used for analysis of turbine engine strain gauge signals produced during altitude testing. The unique features of this approach include: explicit domain-specific declarative models; graphical representation of models; multiple aspect models; automatic specification of the necessary hardware architecture; and on-line re-synthesis of dynamic systems.

A94-11462*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SOFTWARE TESTABILITY AND ITS APPLICATION TO AVIONIC SOFTWARE

JEFFREY M. VOAS (RST Corp., Reston, VA), KEITH W. MILLER (Sangamon State Univ., Springfield, IL), and JEFFERY E. PAYNE (RST Corp., Reston, VA) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 507-515. refs

(Contract NAG1-884)

(AIAA PAPER 93-4542) Copyright

Randomly generated black-box testing is an established yet controversial method of estimating software reliability. Unfortunately, as software applications have required higher reliabilities, practical difficulties with black-box testing have become increasingly problematic. These practical problems are particularly acute in life-critical avionics software, where requirements of 10 exp -7 failures per hour of system reliability can translate into a probability of failure (POF) of perhaps 10 exp -9 or less for each individual execution of the software. This paper describes the application of one type of testability analysis called 'sensitivity analysis' to B-737 avionics software; one application of sensitivity analysis is to quantify whether software testing is capable of detecting faults in a particular program and thus whether we can be confident that a tested program is not hiding faults. We so 80 by finding the testabilities of the individual statements of the program, and then use those statement testabilities to find the testabilities of the functions and modules. For the B-737 system we analyzed, we were able to isolate those functions that are more prone to hide errors during system/reliability testing.

Author (revised)

A94-11477#

BUILDING FAULT-TOLERANT DISTRIBUTED COMPUTING SYSTEMS USING STANDARD COMPONENTS

PETER A. BARRETT, SANTOSH K. SHRIVASTAVA, NEIL A. SPEIRS, and ADRIAN WATERWORTH (British Aerospace, Dependable Computing Systems Centre; Newcastle-upon-Tyne Univ., United Kingdom) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 640-648. Research supported by SERC and British Aerospace refs

(AIAA PAPER 93-4571) Copyright

The aerospace industry is making increasing use of computers in the implementation of safety-critical systems. New generations of airliners (Airbus A320/330/340, Boeing 777), for example, are using digital computers in their primary flight control systems - systems upon whose integrity and availability depends the safety of the aircraft and its passengers. Such systems are required to be fault-tolerant so that they can continue to function correctly in the presence of a finite number of component failures. Current generations of fault-tolerant computers for safety-critical applications tend to make extensive use of special-purpose hardware, and are thus expensive and inflexible. This paper investigates the possibility of constructing fault-tolerant computer systems using standard hardware components replicated to an appropriate degree and communicating via special-purpose software protocols. The Voltan family of fail-controlled nodes are introduced and described, and ways of incorporating Voltan nodes into Integrated Modular Avionics (IMA) architectures are presented. Means of overcoming the potential drawbacks of such nodes arc discussed. In particular, possible extensions to IMA galeway modules in order to provide communications and data validation services in support of Voltan nodes are described.

A94-11481#

ON ANALYZING THE EFFECT OF NEAR-COINCIDENT FAULTS ON FLIGHT CONTROL COMPUTERS

CRISTIAN CONSTANTINESCU (Duke Univ., Durham, NC) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 676-681. refs

(AIAA PAPER 93-4575) Copyright

The impact of near-coincident faults has to be taken into account for designing highly reliable flight control computers. The Markov version of the CARE III coverage model is employed for assessing that impact. Closed form solutions for permanent and transient near-coincident fault factors are derived, assuming that parameters of the coverage model are exponentially distributed. The influence of fault detection rate, fault detectability, error production and propagation rates, error detectability and transient fault/error transition rate, on the near-coincident fault factors, is discussed. Eventually, the near-coincident fault factors are employed for analyzing the effect of the interfering faults on the reliability of a triple modular redundant (TMR) computer. A homogeneous, continuous-time Markov chain is used for describing the behavior of the TMR system in presence of faults. System reliability and near-coincident fault unreliability are derived as functions of mission time, fault detectability and the weight of permanent and transient faults/errors. We conclude that the impact of near-coincident faults is higher when the percentage of transients is lower. That impact can be curbed by increasing fault detectability.

A94-11496#

UPGRADING THE ALENIA FLIGHT TEST COMPUTING SYSTEM

S. SARNICO (Alenia S.p.A., Turin, Italy) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 806-816.

(AIAA PAPER 93-4606) Copyright

The approach and success achieved by Alenia in replacing an obsolete flight test computing system with a new system employing modern technology and an open architecture are discussed. The new computing system employs the VME bus as the system bus and a widely used version of Unix as the operating system. The replacement was made as a controlled set of changes implemented over a period of five years. The effort has significantly improved the reliability of the existing computer. The new disk subsystem has also increased the amount of postflight processing that could be done by 30 percent. Modern I/O equipment with new and expanded features has replaced the old I/O equipment. A LAN has been installed to enable modern hardware and application software to be used in postflight data analysis. Alenia has all the source codes required to maintain and modify the real-time application programs and the postflight analysis program. AIAA

A94-11499#
NEURAL NETWORKS AS OPTIMAL NONLINEAR CONTROLLERS - CONCEPTS AND FLIGHT CONTROL APPLICATIONS
TARIQ SAMAD and THOMAS TING (Honeywell Systems and Research Center, Minneapolis, MN) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 833-840. refs
(AIAA PAPER 93-4615) Copyright

Current neural network controllers are designed relative to specific plant models and performance criteria with the intent of completely replacing conventional control designs. While some progress is being made towards this goal, we believe that a meaningful, and perhaps more achievable, intermediate goal is to augment conventional linear control designs with the nonlinear capabilities of neural networks to improve overall system performance. To this end we introduce the concept of parametrized neurocontrollers (PNCs), neurocontrollers with inputs that are used to adjust control system performance and to provide information about the plant dynamics. PNCs are optimized in simulation over spaces of plant models and performance criteria; no application-specific training is needed. This structure circumvents one of the main drawbacks of traditional neurocontrollers: the need for individual training for different plants and retraining for any plant variations or changes in control objectives. A particular instance of the PNC concept, the NeuroPID controller where the external parameters are the well-known PID control gains, is presented. An application of the PNC concept to flight control design is described. Author (revised)

A94-11505*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
COOPERATIVE GN&C DEVELOPMENT IN A RAPID PROTOTYPING ENVIRONMENT
ALDO BORDANO, JO UHDE-LACOVARA (NASA, Johnson Space Center, Houston, TX), RAY DEVALL, CHARLES PARTIN, JEFF SUGANO (Lockheed Engineering and Sciences Co., Houston, TX), KENT DOANE, and JIM COMPTON (McDonnell Douglas Aerospace, Houston, TX) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 883-890.
(AIAA PAPER 93-4622)

The Navigation, Control and Aeronautics Division (NCAD) at NASA-JSC is exploring ways of producing Guidance, Navigation and Control (GN&C) flight software faster, better, and cheaper. To achieve these goals NCAD established two hardware/software facilities that take an avionics design project from initial inception through high fidelity real-time hardware-in-the-loop testing. Commercially available software products are used to develop the GN&C algorithms in block diagram form and then automatically generate source code from these diagrams. A high fidelity real-time hardware-in-the-loop laboratory provides users with the capability to analyze mass memory usage within the targeted flight computer, verify hardware interfaces, conduct system level verification, performance, acceptance testing, as well as mission verification using reconfigurable and mission unique data. To evaluate these concepts and tools, NCAD embarked on a project to build a real-time 6 DOF simulation of the Soyuz Assured Crew Return Vehicle flight software. To date, a productivity increase of 185 percent has been seen over traditional NASA methods for developing flight software. Author (revised)

A94-11532#
ENHANCING FUNCTIONALITY OF REAL TIME SYSTEMS THROUGH MACHINE LEARNING
Z. CHEN (Nebraska Univ., Omaha) *In* AIAA Computing in Aerospace Conference, 9th, San Diego, CA, Oct. 19-21, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1093-1101. refs
(AIAA PAPER 93-4662) Copyright

Ways to enhance the functionality of real-time systems through flexible inference control are investigated. The motivations for developing a computer model which is used to enhance the functionality of knowledge-based real-time systems are discussed. The model features flexible control of knowledge-based searching strategies based on user modeling; flexible control is achieved through inductive learning of user behavior. Some related work in which AI techniques have been used for real-time systems is summarized. The notion of real-time flexible inference control is proposed, and the rationale behind this approach is discussed. It is suggested that meta-rules be used to achieve flexible inference control, and a computer model which incorporates this consideration is described. Ways to apply machine learning techniques to obtain user models are also discussed. AIAA

A94-11770
NPSNET - FLIGHT SIMULATION DYNAMIC MODELING USING QUATERNIONS
JOSEPH M. COOKE, MICHAEL J. ZYDA, DAVID R. PRATT, and ROBERT B. MCGHEE (U.S. Naval Postgraduate School, Monterey, CA) Presence: Teleoperators and Virtual Environments (ISSN 1054-7460) vol. 1, no. 4 Fall 1992 p. 404-420. Research supported by DARPA and U.S. Navy refs
(Contract NSF BCS-91-09989)
Copyright

The Naval Postgraduate School (NPS) has actively explored the design and implementation of networked, real time, three-dimensional battlefield simulations on low-cost, commercially available graphics workstations. The most recent system, NPSNET, has improved in functionality to such an extent that it is considered a low-cost version of the Defense Advanced Research Project Agency's (DARPA) SIMNET system. To reach that level, it was necessary to economize in certain areas of the code so that real time performance occurred at an acceptable level. One of those areas was in aircraft dynamics. However, with 'off-the-shelf' computers becoming faster and cheaper, real-time and realistic dynamics are no longer an expensive option. Realistic behavior can now be enhanced through the incorporation of an aerodynamic model. To accomplish this task, a prototype flight simulator was built that is capable of simulating numerous types of aircraft simultaneously within a virtual world. Besides being easily incorporated into NPSNET, such a simulator also provides the base functionality for the creation of a general purpose aerodynamic simulator that is particularly useful to aerodynamics students for graphically analyzing differing aircraft's stability and control characteristics. This system is designed for use on a Silicon Graphics workstation and uses the GL libraries. A key feature of the simulator is the use of quaternions for aircraft orientation representation to avoid singularities and high data rates associated with the more common Euler angle representation of orientation.

A94-12010
SUBSYSTEM INTEGRATION TECHNOLOGY ASSESSMENT METHODOLOGY
DAVID E. BLANDING, JOSE F. ALDANA, and DONALD W. SCHLUNDT (Rockwell International Corp., Los Angeles, CA) Oct. 1992 12 p. SAE, Aerotech '92 Conference, Anaheim, CA, Oct. 5-8, 1992 Research supported by USAF refs
(SAE PAPER 922006) Copyright

A systematic integration method for the evaluation of subsystem design processes and the identification of integration technologies across different aircraft utility subsystems is presented. The objective of this methodology is to assess the integration possibilities in the design of aircraft utility subsystems, explore the technology that is available for performing that integration, and define a path for the development and demonstration of technologies. Preliminary results are presented. AIAA

A94-12679
TIME DOMAIN COMPUTATIONAL TECHNIQUES
K. C. PARK (Colorado Univ., Boulder) *In* Flight-vehicle materials, structures, and dynamics - Assessment and future directions. Vol. 5 - Structural dynamics and aeroelasticity New York American Society of Mechanical Engineers 1993 p. 29-43. refs
Copyright

Major issues in direct time integration procedures are reviewed. Recent advances in methods for coupled problems, for real-time multibody dynamics, and in parallel computation are addressed. Directions for future research are suggested. AIAA

A94-12764
SYSTEM OBSERVER TECHNIQUES IN ROBUST CONTROL SYSTEMS DESIGN SYNTHESIS
TSUYOSHI OKADA, MASAHIKO KIHARA, MASAKAZU IKEDA, and TOSHIHIRO HONMA (National Defense Academy, Yokosuka, Japan) *In* Control and dynamic systems. Vol. 50 - Robust control system techniques and applications. Pt. 1 San Diego, CA Academic Press, Inc. 1992 p. 79-118. refs
Copyright

Methods of recovering the robustness in a control system observer are presented: the output feedback method (OFM), the model matching method (MMM), and the pole placement method (PPM). In OFM, the robustness is recovered by selection of the adequate output feedback gain. This method can obtain good characteristics with relative ease, but it has the drawback that the system dimension increases. In MMM, a loop is used which makes feedback of the difference between the output of the plant and the output of the observer, and the robustness is recovered by the selection of the element included there. In PPM, the same output feedback loop as in OFM is used, but the robustness is recovered by the placement of the poles in the observer channel, and the response characteristics of the closed-loop system between input and output are improved by the output feedback channel. All three methods are effective in recovering the robustness of the system including observer. AIAA

N94-10267# Lawrence Livermore National Lab., CA.
SURVEY TO DETERMINE THE VALUE OF DYNA
J. W. WALTER and D. BELLSHAW Jan. 1993 36 p
(Contract W-7405-ENG-48)
(DE93-012390; UCRL-ID-112607) Avail: CASI HC A03/MF A01

This report presents the value of the DYNA software program to US Industry. The software conducts dynamic finite element analysis tailored specifically to simulating high energy impacts, such as car crashes or aircraft collisions with birds. DYNA is available at nearly zero cost to the public in two-dimensional (DYNA2D) and three-dimensional versions (DYNA3D). DYNA has had a major impact on US industry. Measuring this impact using conventional approaches, such as profitability or revenue size, does not apply to DYNA. A new approach is needed to estimate DYNA's value to US industry. Our challenge was two fold: (1) to develop a methodology for valuing technology transferred to the public domain; and (2) to apply this methodology to DYNA. We accomplished the evaluation task by using indirect measurements of value. These indicators encompassed three broad categories, answering three key questions: (1) Use of DYNA and 'DYNA-like' codes--Are companies, academic institutions, government agencies actually using DYNA and codes like it? (2) Savings generated from using these codes--Is the use of DYNA and codes like it creating a positive economic impact? and (3) Market size of all 'DYNA-like' codes--Has a commercial market developed for 'DYNA-like' codes? This study represents the results of interviews with people identified by Lawrence Livermore National Laboratory (LLNL) as users of DYNA. Some of the people surveyed for this study do not use DYNA. They rely upon other dynamic finite element analysis codes. We refer to these individuals as users of 'DYNA-like' codes or 'codes like DYNA.' Several of the 'DYNA-like' codes used DYNA as their core. These codes are descendants of DYNA. DOE

N94-10724*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DISTRIBUTED SIMULATION USING A REAL-TIME SHARED MEMORY NETWORK
DONALD L. SIMON, DUANE L. MATTERN (Sverdrup Technology, Inc., Bay Saint Louis, MS.), EDMOND WONG, and JEFFREY L. MUSGRAVE Jul. 1993 20 p
(Contract DA PROJ. 1L1-61102-AH-45; RTOP 505-62-50)
(NASA-TM-106239; E-7969; NAS 1.15:106239; AVSCOM-TR-92-C-020) Avail: CASI HC A03/MF A01

The Advanced Control Technology Branch of the NASA Lewis Research Center performs research in the area of advanced digital controls for aeronautic and space propulsion systems. This work requires the real-time implementation of both control software and complex dynamical models of the propulsion system. We are implementing these systems in a distributed, multi-vendor computer environment. Therefore, a need exists for real-time communication and synchronization between the distributed multi-vendor computers. A shared memory network is a potential solution which offers several advantages over other real-time communication approaches. A candidate shared memory network was tested for basic performance. The shared memory network was then used to implement a distributed simulation of a ramjet engine. The accuracy and execution time of the distributed simulation was measured and compared to the performance of the non-partitioned simulation. The ease of partitioning the simulation, the minimal time required to develop for communication between the processors and the resulting execution time all indicate that the shared memory network is a real-time communication technique worthy of serious consideration. Author (revised)

N94-10814*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PROGRESS IN MULTIDISCIPLINARY DESIGN OPTIMIZATION AT NASA LANGLEY
SHARON L. PADULA Jul. 1993 22 p Presented at the SIAM Annual Meeting, Philadelphia, PA, 12-16 Jul. 1993
(Contract RTOP 505-63-36-06)
(NASA-TM-107754; NAS 1.15:107754) Avail: CASI HC A03/MF A01

Multidisciplinary Design Optimization refers to some combination of disciplinary analyses, sensitivity analysis, and optimization techniques used to design complex engineering systems. The ultimate objective of this research at NASA Langley Research Center is to help the US industry reduce the costs associated with development, manufacturing, and maintenance of aerospace vehicles while improving system performance. This report reviews progress towards this objective and highlights topics for future research. Aerospace design problems selected from the author's research illustrate strengths and weaknesses in existing multidisciplinary optimization techniques. The techniques discussed include multiobjective optimization, global sensitivity equations and sequential linear programming. Author

N94-10893# Aircraft Research Association Ltd., Bedford (England).
GENERATION AND ANALYSIS OF HYBRID STRUCTURED/UNSTRUCTURED GRIDS
P. N. CHILDS and J. A. SHAW Apr. 1992 10 p Presented at the ICFD Conference on Numerical Methods for Fluid Dynamics, Reading, England, 7-10 Apr. 1992
(Contract SLS41B/2437)
(ARA-MEMO-365) Avail: CASI HC A02/MF A01

The development of a hybrid structured/unstructured grid generation strategy is pursued. Automatic and flexible techniques are introduced for the generation of such meshes whereby local regions of unstructured grid are embedded within a global block-structured environment. Author

N94-11104 SRI International Corp., Menlo Park, CA.
A REAL-TIME SPOKEN-LANGUAGE SYSTEM FOR INTERACTIVE PROBLEM SOLVING Final Report
PATTI J. PRICE and ROBERT C. MOORE May 1993 177 p
Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract N00014-90-C-0085)
(AD-A266046) Avail: CASI HC A09

SRI International (SRI) has carried out a three-year project to develop spoken-language understanding technology for interactive problem solving. The technology should have the following features: real-time performance, large vocabulary, high semantic accuracy, habitability, and robustness. This technology has been developed using an Air Travel Information System (ATIS) as a prototype application. We have developed technology that enables a user to retrieve airline schedules, fares, and related information by means of spoken natural-language queries. We have evaluated this technology in four ATIS benchmark evaluations, and we have incorporated it into a demonstration system, which we have also used for data collection. This final report consists of a summary of the research and other activities carried out under the project, followed by an Appendix containing 26 technical papers describing work performed on the project. The report covers work on speech recognition, natural-language understanding, speech and natural-language integration, data collection and analysis, performance evaluation, demonstration systems, and related activities. DTIC

N94-11198*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
SUMMARY OF RESEARCH IN PROGRESS AT ICASE Semiannual Report, 1 Oct. 1992 - 31 Mar. 1993
Jun. 1993 71 p
(Contract NAS1-19480; RTOP 505-90-52-01)
(NASA-CR-191481; NAS 1.26:191481) Avail: CASI HC A04/MF A01

This report summarizes research conducted at the Institute for Computer Applications in Science and Engineering in applied mathematics, fluid mechanics, and computer science during the period October 1, 1992 through March 31, 1993. Author

N94-11423*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
EXPERIMENTAL SOFTWARE ENGINEERING: SEVENTEEN YEARS OF LESSONS IN THE SEL
FRANK E. MCGARRY *In its* Proceedings of the Seventeenth Annual Software Engineering Workshop 14 p Dec. 1992
Avail: CASI HC A03/MF A04

Seven key principles developed by the Software Engineering Laboratory (SEL) at the Goddard Space Flight Center (GSFC) of the National Aeronautics and Space Administration (NASA) are described. For the past 17 years, the SEL has been experimentally analyzing the development of production software as varying techniques and methodologies are applied in this one environment. The SEL has collected, archived, and studied detailed measures from more than 100 flight dynamics projects, thereby gaining significant insight into the effectiveness of numerous software techniques, as well as extensive experience in the overall effectiveness of 'Experimental Software Engineering'. This experience has helped formulate follow-on studies in the SEL, and it has helped other software organizations better understand just what can be accomplished and what cannot be accomplished through experimentation. Author (revised)

N94-11425*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
IMPACTS OF OBJECT-ORIENTED TECHNOLOGIES: SEVEN YEARS OF SEL STUDIES
MICHAEL STARK *In its* Proceedings of the Seventeenth Annual Software Engineering Workshop 17 p Dec. 1992
Avail: CASI HC A03/MF A04

The premise that object-oriented technology (OOT) is the most significant technology ever examined by the Software Engineering Laboratory is examined. The evolution of the use of OOT in the Software Engineering Laboratory (SEL) 'experience factory' is described in terms of the SEL's original expectations, focusing on how successive generations of projects have used OOT. General conclusions are drawn on how the usage of the technology has evolved in this environment. Author (revised)

N94-11434*# Naval Postgraduate School, Monterey, CA. Information Sciences and Labs.
APPLYING RELIABILITY MODELS TO THE MAINTENANCE OF SPACE SHUTTLE SOFTWARE
NORMAN F. SCHNEIDEWIND *In* NASA. Goddard Space Flight Center, Proceedings of the Seventeenth Annual Software Engineering Workshop 18 p Dec. 1992
Avail: CASI HC A03/MF A04

Software reliability models provide the software manager with a powerful tool for predicting, controlling, and assessing the reliability of software during maintenance. We show how a reliability model can be effectively employed for reliability prediction and the development of maintenance strategies using the Space Shuttle Primary Avionics Software Subsystem as an example. Author (revised)

N94-11680# Arkansas Univ., Fayetteville.
COMPUTATIONAL ALGORITHMS OR IDENTIFICATION OF DISTRIBUTED PARAMETER SYSTEMS Final Technical Report, 1 Sep. 1989 - 28 Feb. 1993
DENNIS W. BREWER and ROBERT K. POWERS 24 Apr. 1993 78 p
(Contract AF-AFOSR-0472-89)
(AD-A265252; AFOSR-93-0361TR) Avail: CASI HC A05/MF A01

This research established a general framework for the convergence of a parameter estimation algorithm based on quasi-linearization which applies to a class of distributed parameter systems described by linear dynamical systems. Conditions were established which guarantee local convergence of the identification algorithm. The algorithm was applied to delay and coefficient identification in systems of delay-differential equations. Such systems have been proposed as hereditary models of aeroelastic systems. A numerical identification algorithm was developed and tested for estimating parameters in a Volterra integral equation arising from a viscoelastic model of a flexible structure with Boltzmann damping. In particular, one of the parameters identified was the order of the derivative in Volterra integro-differential equations containing fractional derivatives, a form of viscoelastic damping. A Galerkin approximation in the space variable was used to approximate the partial differential equation with memory by a system of integro-differential equations. Numerical experiments were performed to test the ability of the algorithm to estimate unknown damping parameters in these systems. DTIC

N94-12886*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPROACHES TO HIGH ASPECT RATIO TRIANGULATIONS
M.-A. POSENAU Aug. 1993 21 p Presented at the 5th Canadian Conference on Computational Geometry, Waterloo, Ontario, 5-9 Aug. 1993
(Contract RTOP 505-90-53-02)
(NASA-TM-107684; NAS 1.15:107684) Avail: CASI HC A03/MF A01

In aerospace computational fluid dynamics calculations, high aspect ratio, or stretched, triangulations are necessary to adequately resolve the features of a viscous flow around bodies. In this paper, we explore alternatives to the Delaunay triangulation which can be used to generate high aspect ratio triangulations of point sets. The method is based on a variation of the lifting map concept which derives Delaunay triangulations from convex hull calculations. Author (revised)

N94-13077# National Aeronautical Lab., Bangalore (India). Aerospace Electronics Div.

PC BASED A320 QUICK ACCESS RECORDER READOUT FACILITY

B. S. ADIGA, S. J. MURALIDHAR, C. RAMESH, and ARAVIND (Indian Inst. of Tech., Madras.) Sep. 1991 21 p
(PD-AL-9109) Avail: CASI HC A03/MF A01

A Readout Facility was established at NAL for Indian Airlines for Decoding of A320 Quick Access Recorder Data which is presently in operation in India. This PC based system reads the data recorded on QAR, transfers the data to PC, converts the raw data into its appropriate engineering units and displays it on the screen. It also has the provision of graphical representation of various parameters with reference to altitude coarse. This system can be used to investigate any incident/day-to-day maintenance of A320 Aircraft. Author (revised)

N94-13204*# MCAT Inst., San Jose, CA.

IMPLEMENTATION OF ADI: SCHEMES ON MIMD PARALLEL COMPUTERS

ROB F. VANDERWIJNGAART Jul. 1993 23 p Proposed for presentation at the Supercomputing 1993 Conference, Portland, OR, 15-19 Nov. 1993 Original contains color illustrations
(Contract NCC2-752)
(NASA-CR-193720; NAS 1.26:193720; MCAT-93-13) Avail: CASI HC A03/MF A01; 1 functional color page

In order to simulate the effects of the impingement of hot exhaust jets of High Performance Aircraft on landing surfaces a multi-disciplinary computation coupling flow dynamics to heat conduction in the runway needs to be carried out. Such simulations, which are essentially unsteady, require very large computational power in order to be completed within a reasonable time frame of the order of an hour. Such power can be furnished by the latest generation of massively parallel computers. These remove the bottleneck of ever more congested data paths to one or a few highly specialized central processing units (CPU's) by having many off-the-shelf CPU's work independently on their own data, and exchange information only when needed. During the past year the first phase of this project was completed, in which the optimal strategy for mapping an ADI-algorithm for the three dimensional unsteady heat equation to a MIMD parallel computer was identified. This was done by implementing and comparing three different domain decomposition techniques that define the tasks for the CPU's in the parallel machine. These implementations were done for a Cartesian grid and Dirichlet boundary conditions. The most promising technique was then used to implement the heat equation solver on a general curvilinear grid with a suite of nontrivial boundary conditions. Finally, this technique was also used to implement the Scalar Penta-diagonal (SP) benchmark, which was taken from the NAS Parallel Benchmarks report. All implementations were done in the programming language C on the Intel iPSC/860 computer. Derived from text

N94-13549# Operational Research and Analysis Establishment, Ottawa (Ontario). Directorate of Logistics Analysis.

SPARE PARTS ANALYSIS OF THE MK.32B-751 AAR POD

MICHAEL K. ORMROD Jan. 1993 15 p
(DSIS-93-00737; ORAE-PR-614; CTN-93-60839) Avail: CASI HC A03/MF A01

To provide air refuelling support, maintain airlift capability, and contribute to the modernization of the air reserves, Canada's Department of National Defence purchased five C130H tankers and outfitted them with Mk32B-751 air-to-air refuelling (AAR) pods. A study was undertaken to determine if the quantity of spares initially procured for the AAR pods is adequate to maintain a 75 percent operational availability. The initial spares were analyzed using the ROSAM program which predicted the operational availability of the pod to be 98 percent. In addition, a sensitivity analysis of the estimated mean time before failure (MTBF), operating hours, and contractor repair time was also performed. By halving the MBTF of the parts or doubling the operating hours of the pod, availability fell to 90 percent. By doubling the time required for the contractor to repair any part, availability dropped to 92 percent. In all cases, the operational availability of the pod was well above the 75 percent target. CISTI

N94-13717*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PRECONDITIONING AND THE LIMIT TO THE INCOMPRESSIBLE FLOW EQUATIONS

E. TURKEL, A. FITERMAN, and B. VANLEER Washington Jul. 1993 23 p Submitted for publication
(Contract NAS1-18605; NAS1-19480; RTOP 505-90-52-01)
(NASA-CR-191500; ICASE-93-42; NAS 1.26:191500) Avail: CASI HC A03/MF A01

The use of preconditioning methods to accelerate the convergence to a steady state for both the incompressible and compressible fluid dynamic equations are considered. The relation between them for both the continuous problem and the finite difference approximation is also considered. The analysis relies on the inviscid equations. The preconditioning consists of a matrix multiplying the time derivatives. Hence, the steady state of the preconditioned system is the same as the steady state of the original system. For finite difference methods the preconditioning can change and improve the steady state solutions. An application to flow around an airfoil is presented. Author

N94-13860# National Research Council of Canada, Ottawa (Ontario). Machinery and Engine Technology.

A DISTRIBUTED, VISUAL OBJECT SYSTEM USING AGGREGATION OBJECTS WITH A LOCAL NAMESPACE

DAVID M. MORTON Oct. 1992 38 p
(IME-MET-TR-007; NRCC-35853; CTN-93-60834) Avail: CASI HC A03/MF A01

A design for a distributed object system is described. Active objects are used to group other objects. Objects in the group may share specialized behavior and may reference each other by name. The distributed system is implemented in Audition, an object oriented language that extends the theatrical paradigm of performers and stages introduced in Rehearsal World. In Audition, Stages aggregate other objects and manage local namespaces; in Distributed Audition they are also active objects. Stages can themselves be named and can be members of a group of objects defined on another stage. Stages can be moved to any workstation on a network, thus, providing a global partitioned namespace. Stages maintain multiple threads and a queue of incoming messages. A potential intelligent simulation application is an air traffic control system. Author (CISTI)

N94-13987# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.

GATE ASSIGNMENT USING LINEAR PROGRAMMING M.S. Thesis

C. G. VANRHEE Jul. 1992 254 p
(LR-698; ETN-93-94010) Avail: CASI HC A12/MF A03

A method for optimizing the aircraft to gate assignment with the use of linear programming is presented. The Automatic Optimal Resource and Tarmac Allocation (AORTA) program is able to handle many real life assignment criteria. The purpose of the development of a program using linear programming was to investigate whether this method could be effectively used to provide a practical solution to the problem. This means that all kinds of practical constraints must be incorporated and all kinds of assignment rules must be taken into account. The effectiveness of the program is tested with data from Schiphol Airport. The results show that the AORTA program can be used to solve assignment problems. ESA

N94-14006# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Military Aircraft Div.

MATHEMATICAL OPTIMIZATION: A TOOL FOR AIRCRAFT DESIGN

J. KRAMMER and O. SENSBURG 24 Jul. 1992 14 p Presented at DGLR-Jahrestagung 1992, Bremen, Germany, 29 Sep. - 2 Oct.

1992
(MBB-LME-251-S-PUB-0492; ETN-93-94198) Copyright Avail: CASI HC A03/MF A01

Formal mathematical optimization methods developed for the structural design of aircraft are introduced. Together with reliable analysis programs like finite element methods they provide powerful tools for the structural design. They are efficient in at least two ways: producing designs that meet all specified requirements at minimum weight in one step; relieving the engineer from a time consuming search for modifications that give better results, they allow more creative design modifications. The practical architecture of multidisciplinary design optimization software is discussed. In the case of structural design this is based on three concepts: a structural model, an optimzation algorithm and an optimization model. A powerful optimization code called MBB-LAGRANGE which uses mathematical programming methods to fulfill different constraints simultaneously was developed. Some examples depicting the successful application of the MBB-LAGRANGE code are presented. Results of other optimization codes are also shown. ESA

N94-14207 Operational Research and Analysis Establishment, Ottawa (Ontario). Directorate of Land Operational Research.
GROUND ATTACK PROFILE SELECTOR PROGRAM, VERSION 3.0
TOM WHITEFORD Jan. 1993 93 p
(DSIS-93-00702; ORAE-DLOR-RN-92-4; CTN-93-60840) Avail: CASI HC A05

The Ground Attack Profile Selector version 3.0 is an interactive program written in C language which allows the user to construct a three dimensional flight profile of an aircraft. Perspective views of 100-m resolution digital terrain data from the Carmonette database were produced on a Silicon Graphics workstation to increase the realism of the flight profile. This new version expands on the overall graphics presentation of the terrain and translates the program to the lower level C programming code. The theory and the algorithms developed in the previous versions of the program are documented, and the new graphics routines are explained. A listing of the main program and subroutines is included. Author (CISTI)

N94-14611# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
DEVELOPMENT OF PC-BASED AERONAUTICAL SOFTWARE (AEROWARE)
PREMALATHA RAMAMOORTHY and P. RAMAMOORTHY *In its* Proceedings of the Fluid Dynamics Symposium in Honour of Professor R. Narasimha on his 60th Birthday p 153-158 Jul. 1993
Avail: CASI HC A02/MF A03

The development of a software package called 'AEROWARE' (AEROnautical softWARE) is described. The organization of the first version of the package, including user interface utilities, is explained. The hardware and software resources needed for the development, are briefly discussed. Recommendations are made for future versions of the package. Author

N94-15919*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRSAR SOUTH AMERICAN DEPLOYMENT: OPERATION PLAN, VERSION 3.0
M. KOBRICK *In its* Proceedings of the Third Spaceborne Imaging Radar Symposium p 441-465 28 May 1993
Avail: CASI HC A03/MF A04

The United States National Aeronautics and Space Administration (NASA) and the Brazilian Commission for Space Activities (COBAE) are undertaking a joint experiment involving NASA's DC-8 research aircraft and the Airborne Synthetic Aperture Radar (AIRSAR) system during late May and June 1993. The research areas motivating these activities are: (1) fundamental research in the role of soils, vegetation, and hydrology in the global carbon cycle; and (2) in cooperation with South American scientists, airborne remote sensing research for the upcoming NASA Spaceborne Imaging Radar (SIR)-C/X-SAR flights on the Space Shuttle. A flight schedule and plans for the deployment that were developed are included. Maps of the site locations and schematic indications of flight routes and dates, plots showing swath locations derived from the flight requests and generated by flight planning software, and, most importantly, a calendar showing which sites will be imaged each day are included. Author (revised)

N94-16768# Universal Analytics, Inc., Torrance, CA.
ASTROS ENHANCEMENTS. VOLUME 1: ASTRO USER'S MANUAL Interim Report, 15 Jan. 1987 - 30 Oct. 1992
D. J. NEILL and D. L. HERENDEEN Mar. 1993 439 p
(Contract F33615-87-C-3216)
(AD-A266818; WL-TR-93-3025-VOL-1) Avail: CASI HC A19/MF A04

ASTROS (Automated STRuctural Optimization System) is a computer program for the multidisciplinary design and analysis of aerospace structures. ASTROS combines mathematical optimization algorithms with traditional structural analysis disciplines such as static forces, normal modes, static aeroelasticity, and dynamic aeroelasticity (flutter), all in a finite element context, to perform automated preliminary design of an aircraft structure. This report is a complete user's manual that documents the many features of ASTROS through version 10 of the software package. It also provides information on system architecture and other topics of interest. This report is Volume 1 of a set; Volume 2 (WL-TR-93-3038) is the programmer's manual. DTIC

N94-16769 Universal Analytics, Inc., Torrance, CA.
ASTROS ENHANCEMENTS. VOLUME 2: ASTRO PROGRAMMER'S MANUAL Interim Report, 15 Jan. 1987 - 30 Oct. 1992
D. J. NEILL, D. L. HERENDEEN, and R. L. HOESLY Mar. 1993 711 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract F33615-87-C-3216)
(AD-A266819; WL-TR-93-3025-VOL-2) Avail: CASI HC A99

ASTROS (Automated STRuctural Optimization System) is a computer program for the multidisciplinary design and analysis of aerospace structures. ASTROS combines mathematical optimization algorithms with traditional structural analysis disciplines such as static forces, normal modes, static aeroelasticity, and dynamic aeroelasticity (flutter), all in a finite element context, to perform automated preliminary design of an aircraft structure. This report is a complete user's manual that documents the many features of ASTROS through version 10 of the software package. It also provides information on system architecture and other topics of interest. This report is Volume 2 of a set; Volume 1 (WL-TR-93-3025) is the user's manual. DTIC

N94-16993# General Accounting Office, Washington, DC. Information Management and Technology Div.
EMBEDDED COMPUTER SYSTEMS: STATUS OF C-17 SOFTWARE
18 Mar. 1993 6 p
(AD-A267307; GAO/T-IMTEC-93-2) Avail: CASI HC A02/MF A01

The C-17 will be the most computerized, software-intensive, transport aircraft ever built. Embedded computers are essential for the C-17 to accomplish its mission; the aircraft depends on these computers to control basic avionics functions such as flight control, communication, and instrument displays. The C-17 relies on 19 different types of embedded computers incorporating over 80 microprocessors and about 1.3 million lines of code. This statement provides information on the current status of embedded computer and software development for the C-17. In summary, we have observed a pattern of the Air Force continuing to permit its prime contractor, McDonnell Douglas Corporation, to defer software development to future aircraft. Originally, the first aircraft (T-1), delivered in September 1991, was supposed to include all the software. But, McDonnell was unable to develop and deliver the software on time. Rather than slowing aircraft production until the software could be completed, McDonnell deferred software development, initially to the P-2 aircraft, then to the P-5 aircraft, and now to the P-6 and future aircraft. Each software development deferral further delays the Air Force's ability to fully test the software and demonstrate that the C-17 can meet all of its requirements. DTIC

N94-17429 Carnegie-Mellon Univ., Pittsburgh, PA. Software Engineering Inst.
AN INTRODUCTION TO STRUCTURAL MODELS Final Report, Jun. 1986 - Aug. 1992
JOE BATMAN, LARRY HOWARD, and BILL SCHELKER Aug. 1992 30 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract F19628-90-C-0003)
(AD-A268151; ASC-TR-93-5008) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

This paper introduces structural models for flight simulators to technical managers. It gives the rationale for using structural models, defines structural models, and discusses practices associated with their use. The paper provides an example of a structural model based on the model used on a number of recent simulator acquisitions. The paper also discusses what ASC/YT expects in proposals for the use of structural models in the development of training simulators. DTIC

N94-17590# Boeing Defense and Space Group, Seattle, WA.
X RAY COMPUTED TOMOGRAPHY FOR GEOMETRY ACQUISITION Interim Report, May 1991 - Feb. 1992
ALAN R. CREWS, RICHARD H. BOSSI, and GARY E. GEORGESON 1 Mar. 1993 22 p
(Contract F33615-88-C-5404)
(AD-A268085; WL-TR-93-4036) Avail: CASI HC A03/MF A01

X-ray computed tomography (CT) provides quantitative measures of component feature dimensions and density as related to the linear X-ray attenuation of the material under study. The data are available in digital format to be input not only to NDE workstations but also design workstations. By converting the CT data to computer aided design/engineering (CAD/E) workstations, the designer/engineer can access the as-built component geometry. Productivity gains are realized in generating computer drawings for as-built components. In the case of components that do not have adequate drawing documentation, particularly ergonomically, aesthetically or aerodynamically shaped parts, the CT data provide a highly cost effective approach for generating digital format documentation. Multiple slice CT data may be used to completely define the object, or CT data at selected orientations may be used to define specific features. Once data are transferred to a workstation, the designer can manipulate the data to create a part drawing. The process of obtaining digital definition of an existing component is referred to as geometry acquisition. DTIC

N94-18241# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
INTRODUCTION TO QUANTITATIVE FEEDBACK THEORY (QFT) TECHNIQUE
CONSTANTINE H. HOUPIS *In* AGARD, Non Linear Dynamics and Chaos *20 p Jun. 1993*
Copyright Avail: CASI HC A03/MF A02

Quantitative Feedback Theory (QFT) has achieved the status as a powerful design technique for the achievement of assigned performance tolerances over specified ranges of plant parameter uncertainties without and with control effector failures. It is a frequency domain design technique utilizing the Nichols chart (NC) to achieve a desired robust design over the specified region of plant parameter uncertainty. An introduction to QFT analog and discrete design techniques is presented for both multiple-input single-output (MISO) and multiple-input multiple-output (MIMO) control systems. QFT computer aided design (CAD) packages are readily available to expedite the design process. The purposes of these lectures are: (1) to provide a basic understanding of QFT, (2) to provide the minimum amount of mathematics necessary to achieve this understanding, (3) to discuss the basic design steps, and (4) to present two practical examples. Author (revised)

N94-19969 Air Force Inst. of Tech., Wright-Patterson AFB, OH. *School of Engineering.*
COMPARISON OF A DISTRIBUTED KALMAN FILTER VERSUS A CENTRALIZED KALMAN FILTER WITH FAULT DETECTION CONSIDERATIONS M.S. Thesis
PAUL J. LAWRENCE, JR. 30 Jul. 1993 280 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A270713; AFIT/GE/ENG/93S-06) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

This project examined the results obtained by simulating an aircraft navigation system with a partial complement of a typical avionics sensor array. Two different techniques of estimation processes were utilized and compared: the conventional Kalman and the federated filter architectures. Areas of interest include error state estimation accuracy and overall performance, residual behavior under normal and induced sensor failure conditions, and potential for failure detection and isolation. Several simulations were accomplished for each filter design and the results were compared in order to verify the validity of the newly developed federated filter architecture. Comparison of the error state estimation accuracies of the two filter designs revealed excellent overall performances for both. The identification of failures showed a definite advantage in the federated filter design. Having sensor-dedicated local filters allowed for easy sensor failure identification for the federated filter, while the centralized filter design suffered from navigation solution corruption under the same circumstances. Once established as a valuable estimation technique, the federated filter will add significantly to the viable alternatives when choosing a particular filter architecture for current avionics modifications or future avionics implementations. DTIC

N94-20316 Lawrence Livermore National Lab., CA.
THREE-DIMENSIONAL DYNAMIC THERMAL IMAGING OF STRUCTURAL FLAWS BY DUAL-BAND INFRARED COMPUTED TOMOGRAPHY
N. K. DELGRANDE, K. W. DOLAN, P. F. DURBIN, M. R. GORVAD, B. T. KORNBLUM, D. E. PERKINS, D. J. SCHNEBERK, and A. B. SHAPIRO Apr. 1993 12 p Presented at the Society of Photo-Optical Instrumentation Engineers (SPIE) OE/Aerospace Science and Sensing Meeting, Orlando, FL, 11-16 Apr. 1993 Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract W-7405-ENG-48)
(DE93-019575; UCRL-JC-113744; CONF-930445-23) Avail: CASI HC A03

This paper discusses three-dimensional (3D) dynamic thermal imaging of structural flaws using dual-band infrared (DBIR) computed tomography. Conventional thermography provides single-band infrared images which are difficult to interpret. Standard procedures yield imprecise (or qualitative) information about sub-surface flaw sites which are typically masked by surface clutter. The authors use a DBIR imaging technique pioneered at LLNL to capture the time history of surface temperature difference for flash-heated targets. They relate these patterns to the location, size, shape, and depth of subsurface flaws. The authors demonstrate temperature accuracies of 0.2 C, timing synchronizations of 3 ms (after onset of heat flash), and intervals of 42 ms, between images, during an 8 s cooling (and heating) interval characterizing the front (and back) surface temperature-time history of an epoxy-glue disbond site in a flash-heated aluminum lap joint. This type of disbond played a significant role in causing damage to the Aloha Aircraft fuselage on the aged Boeing 737 jetliner. By ratioing DBIR images (near 5 and 10 micron), the authors located surface temperature patterns (generated by weak heat flow anomalies at subsurface flaw sites) and removed the emissivity mask (from surface roughness variations). They compared measurements with calculations from the three-dimensional, finite element computer code TOPAZ3D. They combined infrared, ultrasound, and x-ray imaging methods to characterize the lap joint disbond site spatial, bond quality, and material differences. DOE

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.

A94-11029
DEPENDENCE OF THE ANGULAR VELOCITY OF AN ELECTROSTATIC GYROSCOPE ON THE AMBIENT TEMPERATURE [ZAVISIMOST' UGLOVOJ SKOROSTI EHLEKTROSTATICHESKOGO GIROSKOPA OT TEMPERATURY OKRUZHAYUSHCHEJ SREDY]
S. ZH. KARIPBAEV, B. E. LANDAU, YU. G. MARTYNENKO, and V. V. PODALKOV Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Tverdogo Tela (ISSN 0572-3299) no. 3 May-June 1993 p. 42-49. In RUSSIAN refs
Copyright
A solution is presented for a nonstationary heat conductivity equation describing the temperature field inside a spherical gyroscope rotor. Rotor deformations resulting from nonuniform heating are determined. It is shown that periodic changes of the ambient temperature with time produce fluctuations in the angular velocity of an electrostatic gyroscope. AIAA

A94-11351*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SIMULATED HIGH SPEED FLIGHT EFFECTS ON SUPERSONIC JET NOISE
THOMAS D. NORUM and MARTHA C. BROWN (NASA, Langley Research Center, Hampton, VA) Oct. 1993 11 p. AIAA, Aeroacoustics Conference, 15th, Long Beach, CA, Oct. 25-27, 1993 refs
(AIAA PAPER 93-4388) Copyright
A free jet is utilized to investigate the changes in the noise received from supersonic jets in high speed subsonic flight. Flight Mach numbers to 0.9 are simulated for supersonic jets with fully expanded Mach numbers between 1 and 2. Plume pressure measurements show only minor changes in the shock structure of off-design jets up to a Mach number of 0.6. Correspondingly, far-field noise measurements indicate little change to the broadband shock noise emitted at right angles to the jet. However, measurements within the free jet show that convection effects on the noise are substantial, and that the point source convective amplification that is proportional to the fourth power of the Doppler factor may apply for broadband shock noise in flight. Measurements of jet mixing noise for an on-design supersonic jet show that the current predictions of mixing noise in flight can be extended to flight Mach numbers of at least 0.5.

A94-11353*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE EFFECT OF VELOCITY PROFILES ON SUPERSONIC JET NOISE
T. R. S. BHAT (Old Dominion Univ., Norfolk, VA) and J. M. SEINER (NASA, Langley Research Center, Hampton, VA) Oct. 1993 11 p. AIAA, Aeroacoustics Conference, 15th, Long Beach, CA, Oct. 25-27, 1993 refs
(Contract NAG1-1518)
(AIAA PAPER 93-4410) Copyright
This paper presents stability calculations made for a shock-free coannular jet, with both the inner and outer flows supersonic, using the instability wave model. The Mach wave emission process is modeled as the noise generated by the large scale turbulent structures or the instability waves in the mixing region. Both the vortex-sheet and the realistic finite thickness shear layer models are considered. The stability calculations have been performed for both inverted and normal velocity profiles. Comparisons are made with the results for an equivalent single jet, based on equal thrust, mass flow rate and exit area to that of the coannular jet. The advantages and disadvantages of these velocity profiles as far as noise radiation is concerned are discussed.

A94-11354*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC GASDISPERSIONAL JETS AND JET NOISE
M. M. GILINSKY, J. M. SEINER (NASA, Langley Research Center, Hampton, VA), B. J. JANSEN (Lockheed Engineering & Sciences Co., Hampton, VA), and T. R. S. BHAT (Old Dominion Univ., Norfolk, VA) Oct. 1993 18 p. AIAA, Aeroacoustics Conference, 15th, Long Beach, CA, Oct. 25-27, 1993 refs
(AIAA PAPER 93-4389) Copyright
This paper examines the potential for controlling jet noise radiation using methods developed for modifying jet infra-red thermal radiation. The control of jet noise may be possible by properly adding different solid and liquid particles into the jet flow and by using special nozzle shapes to change the jet exhaust flow structure. The numerical methods used to achieve these objectives are outlined in this paper. A combined Lagrangian-Eulerian approach is used to numerically simulate a Jet flow with particle addition. The unsteady behavior of jet impingement is examined. The techniques for grid and boundary condition definition are discussed as related to the accuracy of the calculations. Preliminary comparisons to experimental data are presented.

A94-12043
HELICOPTER NOISE CERTIFICATION - PAST-PRESENT-FUTURE
JOHN W. LEVERTON (E. H. Industries, Inc., Arlington, VA) Sep. 1992 30 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs
A development history and a development trends evaluation are presented for helicopter noise-certification rules. It is noted that the Committee for Aircraft Noise 7 limits effectively constitute a cap on helicopter noise levels; a 9 dB total reduction in noise limits appears to be a desirable goal for variants of current helicopter designs. The certification scheme should allow noise-abatement (and other, similar) procedures to be exploited; this could result in the public's experience of lower noise levels, and establish a better groundwork for future noise reductions. AIAA

A94-12049
VALIDATION OF THE ROTAC CODE FOR THE ROTOR NOISE PREDICTION
P. GNEMMI, J. HAERTIG, and CH. JOHE (Saint-Louis, French-German Research Inst., France) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs
A prediction code has been developed for the thickness and loading noises radiated by helicopter rotors. The code computes in the time domain and is suitable for subsonic speeds and noncompact sources. The code is validated here by a comparison of calculated results with experimental noise findings. AIAA

A94-12052
MODEL TAIL ROTOR NOISE STUDY IN THE DNW - MEASURED ACOUSTICS, BLADE PRESSURES, NOISE PREDICTIONS
KLAUS-J. SCHULTZ and WOLF R. SPLETTSTOESSER (DLR, Braunschweig, Germany) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by BMVg and Ministry of Transportation of Germany refs
The acoustic characteristics of the BO 105 model rotor have been measured in a wind tunnel experiment, and the results are reported. Emphasis is given to the main rotor/tail rotor interference

noise. Simultaneously measured tail rotor blade surface pressures are presented and used to interpret the test results and as input for tail rotor noise predictions. AIAA

A94-12053

INFLUENCE OF DIFFERENT FLIGHT CONDITIONS ON HELICOPTER NOISE CONTOURS ON GROUND

G. NIESL (Eurocopter Deutschland GmbH, Munich, Germany) and R. PONGRATZ (MBB GmbH, Munich, Germany) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper refs

Helicopter exterior noise measurements are presented which were performed for the verification of a noise prediction method in the vicinity of heliports. The test campaign has been supported by the German Federal Environmental Agency (FEA). The measurement program covered landing, takeoff, and flyover conditions for the Eurocopter BO 105 and the Sikorsky CH 53. In addition, BO 105 hover and turn flight conditions were measured. The noise on ground was measured with nine microphones arranged in an array of 600 x 500 m. By varying the starting/landing point, 17 measurement positions were achieved for each flight condition covering a field of 600 x 1000 m. The measurements are evaluated in form of noise contour footprints for maximum noise levels during flyover and time integrated noise levels like SEL. Special view is given to the noise reduction effect of steep approach flight conditions with glide path angles between 9 and 15 deg and steep takeoff procedures. It can be shown that the prediction methodology of the German Air Traffic Noise Control Act calculates too high noise levels for helicopters. By modification of the noise data base and the flyover time calculation, the accuracy can be considerably increased. Author (revised)

A94-12054

THEORETICAL AND EXPERIMENTAL COMPARISONS FOR HIGH-SPEED AND BLADE-VORTEX INTERACTION NOISE

S. IANNIELO (Italian Aerospace Research Centre, Capua, Italy), P. DI FRANCESCANTONIO (Agusta S.p.A., Cascina Costa di Samarate, Italy), D. TARICA, and E. DE BERNARDIS (Italian Aerospace Research Centre, Capua, Italy) Sep. 1992 13 p. AAAF, European Rotorcraft Forum, 18th, Avignon, France, Sept. 15-18, 1992, Paper Research supported by EES refs

Helicopter rotor noise calculations to validate two numerical codes currently being developed are presented. BENP code results for high-speed impulse noise are illustrated for helicopters in forward flight up to very high advancing blade tip Mach number. The HERNOP and WOPWOP codes are compared for high-speed flight. AIAA

A94-12140

STRUCTURAL AND ACOUSTIC NOISE PRODUCED BY TURBULENT FLOW OVER AN ELASTIC TRAILING EDGE

M. S. HOWE (Boston Univ., MA) Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0962-8444) vol. 442, no. 1916 Sept. 8, 1993 p. 533-554. refs

(Contract N00014-89-C-0254)

Copyright

An analysis is made of the sound and vibration produced by turbulent flow at low Mach number over the trailing edge of an elastic plate. General formulas are developed for the structural and acoustic edge-noise when the control surface is modeled by a semiinfinite thin elastic plate which can support bending waves. Numerical results are given for steel plates in air and in water. In the latter case it is shown that, when the frequency is smaller than the coincidence frequency, the bending wave power exceeds the total sound power generated at the edge by 20-40 dB, independently of the mean flow velocity, so that sound generated by secondary scattering may then be the dominant source of acoustic radiation. Author (revised)

A94-12394* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

FLUID DYNAMICS AND NOISE EMISSION ASSOCIATED WITH SUPERSONIC JETS

JOHN M. SEINER (NASA, Langley Research Center, Hampton, VA) *In* Studies in turbulence New York Springer-Verlag 1992 p. 297-323. refs

Copyright

Methods have long been sought to find an efficient means for reduction of jet noise using either active or passive turbulence control measures. Progress in this area is limited by unclear understanding of the physical supersonic jet noise source mechanisms as they relate to the jet plume turbulence structure. These mechanisms have been extensively studied using round jets. This paper shows that jets with nonround jet exit geometry can provide beneficial noise reduction relative to round jets. Both the fluid dynamic structure and noise of several nonround jets are examined in the paper.

A94-12483

AN IMPEDANCE APPROACH TO VIBRO-ACOUSTIC MODELING

DIRK OTTE, HERMAN VAN DER AUWERAER, and JAN LEURIDAN (LMS, International, Louvain, Belgium) *In* International Modal Analysis Conference, 10th, San Diego, CA, Feb. 3-7, 1992, Proceedings. Vol. 1 Bethel, CT Society for Experimental Mechanics, Inc. 1992 p. 104-109. refs

Copyright

Noise and vibration control measures in large structures such as aircraft need the development of a representative model of the complex vibro-acoustic system, built up by the fuselage, the trim panels, and the cabin cavity. The complexity of such systems often results in a failure of the classical multiple degree-of-freedom parameter estimation techniques to obtain a consistent modal model. This paper discusses some alternative experimental, modeling techniques for such complex vibro-acoustic systems, based on singular value decomposition of a measured FRF-matrix. The physical significance of this orthogonal decomposition on the FRF-matrix is explored. Two related modeling concepts, Principal Field Shape Analysis and the U-vector Expansion Method (Impedance Modeling) are introduced. A case study on a twin propeller aircraft, featuring Principal Field Shape Analysis is presented and commented. Finally, issues to be investigated more thoroughly are mentioned and current research topics are outlined.

N94-10752*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.

PERPENDICULAR BLADE VORTEX INTERACTION AND ITS IMPLICATIONS FOR HELICOPTER NOISE PREDICTION: WAVE-NUMBER FREQUENCY SPECTRA IN A TRAILING VORTEX FOR BWI NOISE PREDICTION Final Technical Report, period ending 15 Aug. 1993

WILLIAM J. DEVENPORT and STEWART A. L. GLEGG (Florida Atlantic Univ., Boca Raton.) Aug. 1993 367 p Original contains color illustrations

(Contract NAG1-1119)

(NASA-CR-193623; NAS 1.26:193623) Avail: CASI HC A16/MF A03; 3 functional color pages

Perpendicular blade vortex interactions are a common occurrence in helicopter rotor flows. Under certain conditions they produce a substantial proportion of the acoustic noise. However, the mechanism of noise generation is not well understood. Specifically, turbulence associated with the trailing vortices shed from the blade tips appears insufficient to account for the noise generated. The hypothesis that the first perpendicular interaction experienced by a trailing vortex alters its turbulence structure in such a way as to increase the acoustic noise generated by subsequent interactions is examined. To investigate this hypothesis a two-part investigation was carried out. In the first part, experiments were performed to examine the behavior of a streamwise vortex as it passed over and downstream of a spanwise blade in incompressible flow. Blade vortex separations between

+/- one eighth chord were studied for at a chord Reynolds number of 200,000. Three-component velocity and turbulence measurements were made in the flow from 4 chord lengths upstream to 15 chordlengths downstream of the blade using miniature 4-sensor hot wire probes. These measurements show that the interaction of the vortex with the blade and its wake causes the vortex core to loose circulation and diffuse much more rapidly than it otherwise would. Core radius increases and peak tangential velocity decreases with distance downstream of the blade. True turbulence levels within the core are much larger downstream than upstream of the blade. The net result is a much larger and more intense region of turbulent flow than that presented by the original vortex and thus, by implication, a greater potential for generating acoustic noise. In the second part, the turbulence measurements described above were used to derive the necessary inputs to a Blade Wake Interaction (BWI) noise prediction scheme. This resulted in significantly improved agreement between measurements and calculations of the BWI noise spectrum especially for the spectral peak at low frequencies, which previously was poorly predicted. Author (revised)

N94-10853# National Inst. of Standards and Technology, Gaithersburg, MD.

THEORETICAL EVALUATION OF R22 AND R502 ALTERNATIVES

P. A. DOMANSKI and D. A. DIDION Jan. 1993 26 p Prepared for Air-Conditioning and Refrigeration Technology Inst., Inc., Arlington, VA

(Contract DE-FG02-91CE-23810)

(DE93-014767; DOE/CE-23810/7) Avail: CASI HC A03/MF A01

The study was conducted using a semi-theoretical model, CYCLE-11, with a pure cross-flow representation of heat transfer in the evaporator and condenser. The Carnahan-Starling-DeSantis equation of state was used for calculating thermodynamic properties. Transport properties were not involved in the simulations. Simulations were conducted for 'drop-in' performance, for performance in a modified system to assess the fluids' potentials, and for performance in a modified system equipped with a liquid-line/suction-line heat exchanger. The results--presented on a relative basis to R22 and R502 performance--include the volumetric capacity, coefficient of performance, pressure increase across the compressor, and compressor discharge pressure and temperature. DOE

N94-11057 Notre Dame Univ., IN.

AN EXPERIMENTAL INVESTIGATION OF THE SOURCES OF PROPELLER NOISE DUE TO TURBULENCE INGESTION Ph.D. Thesis

DANIEL FRANCIS SCHARPF 1993 287 p

Avail: Univ. Microfilms Order No. DA9311108

Experimental measurements were performed on a four-bladed, 10-inch diameter marine propeller operating in a new open-jet, anechoic wind tunnel. A significant portion of the work consisted of the design, construction, and calibration of the wind tunnel facility. The wind tunnel could be operated from 5-100 ft/s with open-jet lengths from 2-7 feet. When the wind tunnel was installed the majority of the chamber had a low-frequency cut-off of 150 Hz. The freestream velocity and propeller rotational speed were 33 ft/s and 3000 RPM, respectively. Turbulence was generated at the exit plane of the wind tunnel inlet by square-mesh grids composed of cylindrical rods which resulted in turbulence levels at the propeller location from 0.2-5.5 percent. Measurements included steady thrust and torque, detailed hot wire surveys of the incoming flow and propeller wake, and sound pressure levels detailing the acoustic spectra and directivity. Bicoherence measurements in the propeller wake showed high coherence between the blade passage harmonics and the broadband frequencies near the hub and tip regions of the blades which indicated that the wake interactions were primarily non-linear. Inflow turbulence reduced this coherence. The integrated broad-band sound pressure level increased by approximately 2 dB for every 1 percent increase in the turbulence. These increases were decomposed into smaller frequency bandwidths and related to the inflow turbulence spectrum. Dissert. Abstr.

N94-11176*# University of Southern California, Los Angeles. Dept. of Aerospace Engineering.

CONTROL OF JET NOISE Final Report, 1 Feb. 1992 - 30 Jun. 1993

STEFAN SCHRECK 1993 45 p Submitted for publication

(Contract NAG1-1096)

(NASA-CR-193612; NAS 1.26:193612) Avail: CASI HC A03/MF A01

This reports describes experiments conducted at the High-Speed Jet Facility at the University of Southern California on supersonic jets. The goal of the study was to develop methods for controlling the noise emitted from supersonic jets by passive and/or active means. Work by Seiner et al (1991) indicates that eddy Mach wave radiation is the dominant noise source in a heated high speed jet. Eddy Mach radiation is caused by turbulent eddies traveling at supersonic speed in the shear layer of the jet. The convection velocity of the eddies decays with increasing distance from the nozzle exit due to the mixing of the jet stream with the ambient fluid. Once the convection speed reaches subsonic velocities, eddy Mach wave radiation ceases. To control noise, a rapid decay of the convection velocity is desired. This may be accomplished by enhanced mixing in the jet. In this study, small aspect ratio rectangular jet nozzles were tested. A flapping mode was noticed in the jets. By amplifying screech components of the jets and destabilizing the jet columns with a collar device, the flapping mode was excited. The result was a rapid decay of the jet velocity. A reduction in eddy Mach radiation in rectangular supersonic jets may be achieved with this device. Author

N94-11887# Aircraft Research Association Ltd., Bedford (England).

THE EVOLUTION OF WHOLE FIELD OPTICAL DIAGNOSTICS FOR EXTERNAL TRANSONIC TESTING

K. A. FRY and P. BRYANSTON-CROSS (Warwick Univ., Coventry, England.) Sep. 1992 15 p Presented at the European Forum on Wind Tunnels and Wind Tunnel Testing Techniques, Southampton, England, 14-17 Sep. 1992

(ARA-MEMO-379) Avail: CASI HC A03/MF A01

The diagnostic use of quantitative laser flow visualization techniques has increased rapidly over recent years. The limitations imposed by conventional single point techniques such as laser Doppler anemometry are addressed and how they have been overcome by the development of a new family of whole field measurement techniques is demonstrated. In particular near instantaneous whole field velocity data was obtained in a relatively hostile, industrial 2.74 m x 2.44 m transonic wind tunnel (TWT) at the Aircraft Research Association (ARA). The techniques were evaluated for their suitability for making quantitative measurements in the wing/pylon region of a model wing and engine combination. Three optical diagnostic techniques were successfully developed within the context of the ARA facility. The first technique, laser light sheet (LLS), combines the operation of a pulse laser and video capture system to provide a 'real time' visualization of the flow, whereas a second pulse laser technique, Particle Image Velocimetry (PIV) can be used to make specific quantitative whole field instantaneous velocity measurements. The third method, holography, was used to produce a stored three dimensional visualization of the unsteady and shock wave features of the transonic flow in the gully region. A description is made of their installation and operation, and examples are presented of current test results. Author (revised)

N94-12615# Hiroshima Univ. (Japan). School of Engineering.

AERODYNAMIC SOUND DUE TO INTERACTION BETWEEN A TWO-DIMENSIONAL FREE SHEAR LAYER AND THE LEADING EDGE OF A PARALLEL FLAT PLATE [NIJIGEN SENDANSOU TO HEIBAN NO KANSHOU NIYORU HASSHIN TO KUURIKION]

FUJIHIKO SAKAO *In* NAL, Proceedings of the 9th and 10th

NAL Workshop on Investigation and Control of Boundary-Layer Transition p 15-22 Nov. 1992 In JAPANESE
Avail: CASI HC A02/MF A02

Sound is generated aerodynamically when the leading edge of a flat plate is set in the middle of a free shear layer. The mechanism for it is a self-maintaining oscillation based on a feedback loop including perturbation of the shear layer by sound at the nozzle lip, developments of the perturbation downstream, and sound generation at the edge by passing of the perturbed vorticity. Due to absence of acoustic resonance in the present set up, any change in parameters results in smooth, continuous, and wide-ranged changes in the outcome, unlike in previous experiments, where changes are often sticky, discontinuous, and with hysteresis. It seems that there are more than two different mechanisms, and either of them appears according to the conditions. Among the conditions is whether the shear layer from the nozzle to the edge is laminar or turbulent is very important. Author (NASDA)

N94-13291*# MCAT Inst., San Jose, CA.
COLORIMETRIC QUALIFICATION OF SHEAR SENSITIVE LIQUID CRYSTAL COATINGS
JOSEPH J. MURATORE, JR. Aug. 1993 26 p Original contains color illustrations
(Contract NCC2-704)
(NASA-CR-194126; NAS 1.26:194126; MCAT-93-17) Avail: CASI HC A03/MF A01; 6 functional color pages

The work that has been done to date on the Shear Sensitive Liquid Crystal Project demonstrated that cholesteric liquid crystal coatings respond to both the direction and magnitude of a shearing force. The response of the coating is to selectively scatter incident white light into a spectrum of colors. Discernible color changes at a fixed angle of observation and illumination are the result of an applied shear stress. The intention was to be able to convert these observable color patterns from a flow visualization technique into a quantitative tool. One of the earlier intentions was to be able to use liquid crystals in dynamic flow fields. This was assumed possible because liquid crystals had made it possible to visualize transients in surface shear forces. Although the transients were visualized by color changes to an order one micro second, the time response of a coating to align to a shearing force is dependent on the magnitude of the change between its initial and final states. Unfortunately, the response is not instantaneous. It is for this reason any future attempt at quantifying the magnitude and directions of a shearing force are limited to surface shear stress vector fields in three dimensional steady state flows. This limitation does not significantly detract from the utility of liquid crystal coatings. The measurement of skin friction in the study of transition on wings, prediction of drag forces, performance assessment, and the investigation of boundary layer behavior is of great importance in aerodynamics. There exist numerous examples of techniques for the measurement of surface shear stress. Most techniques require arduous calibrations and necessitate extensive preparation of the receiving surfaces. However, the main draw back of instruments such as Preston tubes, hot films, buried wire gages, and floating element balances is that they only provide a point measurement. The advantages of capturing global shear data would be appreciable when compared with conventional point measurement sensors. It has yet to be determined if a repeatable correlation exists between the measured color of a liquid crystal coating and the magnitude/directional components of a shear vector imposed onto it. Author (revised)

N94-13692# European Space Agency, Paris (France).
THE PROBLEM OF THE SONIC BOOM FOR FUTURE HIGH-SPEED TRANSPORT AIRCRAFT
ANDRE AURIOL (Office National d'Etudes et de Recherches Aerospatiales, Paris, France.), CLAUDE LECOMTE (Office National d'Etudes et de Recherches Aerospatiales, Paris, France.), and CHRISTIAN THERY (Office National d'Etudes et de Recherches Aerospatiales, Paris, France.) Apr. 1993 70 p Transl. into ENGLISH of Le probleme du bang sonique pour de futurs avions de transport a haute vitesse (Paris, France, ONERA) 1990 p 1-52
Original language document announced as N93-30020
(ESA-TT-1286; ONERA-NT-1990-3; ETN-93-94584) Avail: CASI HC A04/MF A01

The sonic boom origin and propagation in the atmosphere are reviewed. The main effects on structures and living creatures are described. The only appreciable nuisance resulting from the boom is due to the startle reaction. No acceptability threshold was defined up until now. However, the startle reactions appear to become rare for boom intensities less than 50 pascals or for booms having a low intensity forward shock front followed by progressive compression. The following studies are recommended to be carried out: on the startle reactions so as to define tolerable booms of unconventional shapes; and on the aerodynamics of the shapes of aircraft liable to generate such booms. ESA

N94-13719*# Daedalus Enterprises, Inc., Ann Arbor, MI.
MODIS-N AIRBORNE SIMULATOR Final Report, 1 Feb. - 1 May 1992
STEVEN D. CECH 22 May 1992 36 p
(Contract NAS5-31334)
(NASA-CR-194364; NAS 1.26:194364) Avail: CASI HC A03/MF A01

All required work associated with the above referenced contract has been successfully completed at this time. The Modis-N Airborne Simulator has been developed from existing AB184 Wildfire spectrometer parts as well as new detector arrays, optical components, and associated mechanical and electrical hardware. The various instrument components have been integrated into an operational system which has undergone extensive laboratory calibration and testing. The instrument has been delivered to NASA Ames where it will be installed on the NASA ER-2. The following paragraphs detail the specific tasks performed during the contract effort, the results obtained during the integration and testing of the instrument, and the conclusions which can be drawn from this effort. Derived from text

N94-13885 National Physical Lab., Teddington (England). Radiation Science and Acoustics Div.
AN EXPERIMENTAL ASSESSMENT OF THE USE OF GROUND-LEVEL MICROPHONES TO MEASURE THE FLY-OVER NOISE OF JET-ENGINED AIRCRAFT
R. C. PAYNE Jan. 1993 38 p Sponsored by Dept. of Transport, London, United Kingdom
(ISSN 0955-9655)
(NPL-RSA(EXT)-0039; ETN-93-94466) Copyright Avail: National Physical Laboratory, Teddington, Middlesex TW11 0LW, United Kingdom HC

During aircraft flight trials to measure the noise levels of six different military jet aircraft types in low altitude high speed operations, noise measurements were performed using microphones at ground level and at a height of 1.2 m. The program provided reliable data on the difference between sound pressure levels from the two microphone arrangements, for sound incident over a range of angles, from 0 deg (aircraft overhead) to approximately 80 deg. Substantial differences from ground level to 1.2 m were observed in measurements of maximum perceived noise level, effective perceived noise level and maximum A-weighted sound pressure level. For sound waves incident to the ground at angles less than approximately 60 deg from vertical, these differences were found to be independent of angle of incidence for all the six aircraft and all flight procedures. Within this range of sound incidence angles the ground plane arrangement produced data that closely approximated pressure doubled values. The conventional 1.2 m high microphone gave rise to noise levels approximately 4 dB lower. For sound incident at angles greater than 60 deg from vertical, the difference between noise levels measured using the two microphone configurations was found to depend on angle of incidence, reducing to zero at approximately 75 deg. When noise measurements are made using the ground plane arrangement, the effects of meteorological conditions must be considered in relation to sound incident at angles greater than approximately 60 deg. ESA

N94-13897*# APD Cryogenics, Inc., Allentown, PA.
THREE-STAGE LINEAR, SPLIT-STIRLING CRYOCOOLER FOR 1 TO 2K MAGNETIC COLD STAGE
R. C. LONGSWORTH Aug. 1993 101 p Original contains color illustrations
(Contract NAS2-13180)
(NASA-CR-4538; A-93105; NAS 1.26:4538) Avail: CASI HC A06/MF A02; 3 functional color pages

A long-life, linear, high efficiency 8K split Stirling cycle cryocooler was designed, built, and tested. The refrigerator is designed for cooling a 50 mW, 1.5K magnetic cold stage. Dual opposed piston compressors are driven by moving-coil linear motors. The three stage expander, although not completed, is also driven by a linear motor and is designed to produce 1 SW at 60K, 4W at 16K, and 1.2W at 8K. The cold regenerator employs a parallel gap construction for high efficiency. The key technology areas addressed include warm and cold flexible suspension bearings and a new cold regenerator geometry for high efficiency at 8K.
Author (revised)

N94-14481*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACTIVE CONTROL OF FAN-GENERATED PLANE WAVE NOISE
CARL H. GERHOLD, WILLIAM E. NUCKOLLS (Analytical Services and Materials, Inc., Hampton, VA.), ODILLYN L. SANTAMARIA, and SCOTT D. MARTINSON Aug. 1993 28 p Sponsored by NASA. Washington
(Contract RTOP 535-03-11-02)
(NASA-TM-109008; NAS 1.15:109008) Avail: CASI HC A03/MF A01

Subsonic propulsion systems for future aircraft may incorporate ultra-high bypass ratio ducted fan engines whose dominant noise source is the fan with blade passage frequency less than 1000 Hz. This low frequency combines with the requirement of a short nacelle to diminish the effectiveness of passive duct liners. Active noise control is seen as a viable method to augment the conventional passive treatments. An experiment to control ducted fan noise using a time domain active adaptive system is reported. The control sound source consists of loudspeakers arrayed around the fan duct. The error sensor location is in the fan duct. The purpose of this experiment is to demonstrate that the in-duct error sensor reduces the mode spillover in the far field, thereby increasing the efficiency of the control system. In this first series of tests, the fan is configured so that predominantly zero order circumferential waves are generated. The control system is found to reduce the blade passage frequency tone significantly in the acoustic far field when the mode orders of the noise source and of the control source are the same. The noise reduction is not as great when the mode orders are not the same even though the noise source modes are evanescent, but the control system converges stably and global noise reduction is demonstrated in the far field. Further experimentation is planned in which the performance of the system will be evaluated when higher order radial and spinning modes are generated. Author (revised)

N94-15115*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CRUISE NOISE MEASUREMENTS OF A SCALE MODEL ADVANCED DUCTED PROPULSOR
JAMES H. DITTMAR, CHRISTOPHER E. HUGHES, LAWRENCE A. BOCK (Pratt and Whitney Aircraft, East Hartford, CT.), and DAVID G. HALL (Sverdrup Technology, Inc., Brook Park, OH.) Oct. 1993 12 p Proposed for presentation at the 15th AIAA Aeroacoustics Conference, Long Beach, CA, 25-27 Oct. 1993; sponsored by AIAA
(Contract RTOP 535-03-10)
(NASA-TM-105808; E-8042; NAS 1.15:105808; AIAA PAPER 93-4400) Avail: CASI HC A03/MF A01

A scale model Advanced Ducted Propulsor (ADP) was tested in NASA Lewis Research Center's 8- by 6-Foot Wind Tunnel to obtain acoustic data at cruise conditions. The model, designed and manufactured by Pratt & Whitney Division of United Technologies, was tested with three inlet lengths. The model has 16 rotor blades and 22 stator vanes, which results in a cut-on condition with respect to rotor-stator interaction noise. Comparisons of the noise directivity of the ADP with that of a previously tested high-speed, unducted propeller showed that the ADP peak blade passing tone was about 30 dB below that of the propeller, and therefore, should not present a cabin or enroute noise problem. The maximum blade passing tone first increased with increasing helical tip Mach number, peaked, and then decreased at a higher Mach number. The ADP tests with the shortest inlet showed more noise in the inlet arc than did tests with either of the other two inlet lengths. Author

N94-15487*# Lockheed Engineering and Sciences Co., Hampton, VA.
ON THE USE OF THE NONCENTRAL CHI-SQUARE DENSITY FUNCTION FOR THE DISTRIBUTION OF HELICOPTER SPECTRAL ESTIMATES
DONALD P. GARBER Oct. 1993 41 p
(Contract NAS1-19000; RTOP 505-63-70-02)
(NASA-CR-191546; NAS 1.26:191546) Avail: CASI HC A03/MF A01

A probability density function for the variability of ensemble averaged spectral estimates from helicopter acoustic signals in Gaussian background noise was evaluated. Numerical methods for calculating the density function and for determining confidence limits were explored. Density functions were predicted for both synthesized and experimental data and compared with observed spectral estimate variability. Author

N94-15506 National Aerospace Lab., Amsterdam (Netherlands). Aerodynamics Div.
TECHNICAL EVALUATION REPORT ON THE AGARD-PEP SPECIALISTS MEETING ON COMBAT AIRCRAFT NOISE
W. B. DEWOLF 14 Nov. 1991 8 p Meeting held in Bonn, Germany, 23-25 Oct. 1991 Limited Reproducibility: More than 20% of this document may be affected by poor print and microfiche quality
(NLR-TP-91445-U; ETN-93-94342; AD-B169653L) Avail: Issuing Activity (European Space Agency (ESA))

A technical evaluation of the AGARD-PEP specialists' meeting on combat aircraft noise at Bonn (Germany), Oct. 1991 which concentrated on the noise from combat aircraft in low altitude high speed training missions, is presented. Considerable improvement on the understanding and prediction of various noise components was reported. One of the main conclusions was that the overall effectiveness of reduction of engine based noise critically depends on the airframe noise level at high flight speeds, and more work is required in this area to clarify the situation.
ESA

N94-17278*# Georgia Inst. of Tech., Atlanta.
STRATEGIC PLANNING FOR AIRCRAFT NOISE ROUTE IMPACT ANALYSIS: A THREE DIMENSIONAL APPROACH Final Report, 12 Jul. 1991 - 15 Jan. 1993
C. R. BRAGDON, M. J. ROWAN, and K. K. AHUJA Sep. 1993 259 p
(Contract NAS1-19061; RTOP 537-03-21-03)
(NASA-CR-191484; A8612-009/1; NAS 1.26:191484) Avail: CASI HC A12/MF A03

The strategic routing of aircraft through navigable and controlled airspace to minimize adverse noise impact over sensitive areas is critical in the proper management and planning of the U.S. based airport system. A major objective of this phase of research is to identify, inventory, characterize, and analyze the various environmental, land planning, and regulatory data bases, along with potential three dimensional software and hardware systems that can be potentially applied for an impact assessment of any existing or planned air route. There are eight data bases that have to be assembled and developed in order to develop three dimensional aircraft route impact methodology. These data bases which cover geographical information systems, sound metrics, land use, airspace operational control measures, federal regulations and advisories, census data, and environmental attributes have been examined and aggregated. A three dimensional format is necessary for planning, analyzing space and possible noise impact, and formulating potential resolutions. The need to develop this three dimensional approach is essential due to the finite capacity of airspace for managing and planning a route system, including airport facilities. It appears that these data bases can be integrated effectively into a strategic aircraft noise routing system which should be developed as soon as possible, as part of a proactive plan applied to our FAA controlled navigable airspace for the United States. Author (revised)

N94-17599 Federal Aviation Administration, Cambridge, MA. National Transportation Systems Center.
NOISE MEASUREMENT FLIGHT TEST OF FIVE LIGHT HELICOPTERS Final Report, Jul. 1991 - May 1993
EDWARD J. RICKLEY, KENNETH E. JONES, AMANDA S. KELLER, and GREGG G. FLEMING Jul. 1993 400 p
(AD-A268566; DOTVNTSC-FAA-93-5; DOT/FAA/EE-93-01)
Avail: CASI HC A17

The U.S. Department of Transportation, Federal Aviation Administration, (U.S.DOT/FAA), along with the U.S.DOT, Research and Special Programs Administration, Volpe National Transportation Systems Center (RSPA/Volpe Center) conducted a helicopter noise measurement flight test in Champaign, Illinois, during the period 22-26 July 1991. The primary objective of the study was to obtain the field data necessary to examine the feasibility of a simplified helicopter-noise-certification procedure (screening test). Acoustic data were measured by and stored on a hand-held sound-level meter (on-line processing) and recorded on digital tape for later off-line processing. A comparison of the measured on-line acoustic data with the acoustic data processed off-line provided the foundation necessary to evaluate the feasibility of the proposed screening test. In addition to acoustic measurements, meteorological data and helicopter tracking and performance data were also obtained. DTIC

N94-18238# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
STABILITY ANALYSIS THROUGH BIFURCATION THEORY, 1
P. GUICHETEAU *In* AGARD, Non Linear Dynamics and Chaos 10 p Jun. 1993
Copyright Avail: CASI HC A02/MF A02

This communication is the first part of the three papers which are presented by the author in the same AGARD Lecture Series (LS 191). It aims at the study of asymptotic solutions of non-linear differential equations depending on parameters. The first part is devoted to a brief presentation of the basis of Bifurcation Theory which is limited to the non-linear phenomena observed by the author when he analyzed high performance aircraft behavior. In particular, complex bifurcations and chaotic motions are not treated. Numerical procedures developed to use results from Bifurcation Theory are presented. Then, some remarks are stated to establish a connection between asymptotic and quasi-stationary behavior. Finally, a methodology dedicated to the analysis of non-linear systems is proposed. Author (revised)

N94-18664# Pennsylvania State Univ., University Park. Applied Research Lab.
ACOUSTIC INTENSITY MEASUREMENTS IN THE PRESENCE OF LOW MACH NUMBER FLOW
TOBY MCNEAL and G. C. LAUCHLE Sep. 1993 110 p
(AD-A269995; ARL/PSU/TR-93-11) Avail: CASI HC A06/MF A02

Acoustic intensity is an important analysis tool since it provides wave propagation directionality along with absolute magnitude, and it can be measured in the near or far field of a source. Acoustic intensity measurements acquired in the presence of a mean flow are susceptible to errors due to the effects of the flow noise on the sensor. To determine if this error could be accurately quantified, intensity measurements were acquired, with the standard two microphone cross spectral technique, in a sound field that contained both mean flow and an independent random broadband noise source. The microphones were flush mounted, at several different separation distances, in the test section of a wind tunnel that provided the desired flow conditions, while a large speaker provided the independent random noise source. The error calculations were based on a technique that had already been derived theoretically and published, but had not been proven experimentally. The experiments performed validate that the error is indeed a bias error and that it can be accurately quantified. In addition, accurate quantification of the error is not limited to one-dimensional sound fields that contain only plane waves, and the method can be easily extended to two or three directions with complex wave propagation. DTIC

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.

A94-10111
PURSUE INTEGRATED LOGISTIC SUPPORT AND ENHANCE THE COST-EFFECTIVENESS OF MILITARY AIRCRAFT
GUODONG ZHANG (Beijing Univ. of Aeronautics and Astronautics, China) Beijing University of Aeronautics and Astronautics, Journal (ISSN 1001-5965) no. 1 Jan. 1992 p. 76-84. In CHINESE refs

All military aircraft are required to achieve higher cost-effectiveness. So significant efforts must be devoted to pursuring integrated logistic support (ILS) to increase the effectiveness of their logistic support and decrease their operation and support cost during their life cycle. To accomplish ILS, the ILS plan should be taken as a management approach throughout the life cycle of a military aircraft. Through the ILS plan, the supportability design and other design activities are coordinated, and the implementation of all needed support resources are ensured. During implementation of the integrated logistic support, the logistic support analysis is the essential engineering effort. Author (revised)

A94-10333
STRUCTURE AND UTILIZATION OF DATABASES FOR NAVIGATION [CONSTITUTION ET UTILISATION DES BASES DE DONNEES POUR LA NAVIGATION]
MARINUS M. GROOTENBOER (Datavia BV, Zoetermeer, Netherlands) Navigation (Paris) (ISSN 0028-1530) vol. 41, no. 163 July 1993 p. 364-375. In FRENCH EURNAV, London, United Kingdom, Nov. 17-19, 1992
Copyright

The importance of navigation databases for aviation and possibly other means of transportation is emphasized. The need for integrating the various databases that may be in operation in the same organization and in similar organizations is discussed. Issues of coordination, implementation, and utilization are examined. AIAA

A94-13147
FINANCIAL CRISIS IN THE AVIATION INDUSTRY - UNITED KINGDOM
PATRICK FARRELL (Norton Rose, London, United Kingdom) Air & Space Law (ISSN 0927-3379) vol. 18, no. 4-5 Sept. 1993 p. 153-167.
Copyright

While the aviation industry is international, the insolvency laws that are brought to bear during financial crises such as the current European recession are of merely national scope. It is presently noted that insolvency proceedings were expressly excluded from the Brussels Convention; a draft European Bankruptcy Convention has yet to be implemented despite the creation of the 'single market' in January 1993. Cross-border insolvency issues have nevertheless not yet resulted in serious difficulties for airlines and their financiers. AIAA

A94-13148

FINANCIAL CRISIS IN THE AVIATION INDUSTRY - UNITED STATES

MARTIN D. JACOBSON and MARK J. THOMPSON (Simpson Thatcher & Bartlett, New York) Air & Space Law (ISSN 0927-3379) vol. 18, no. 4-5 Sept. 1993 p. 168-182. refs

Copyright

A detailed outline of the laws governing airline bankruptcy in the U.S. is presented. Attention is given to such major aspects of bankruptcies as the choice between liquidation and restructuring, remedies available to lessors and mortgagers, and multinational issues involving the enforceability of U.S. bankruptcy court decisions overseas. The U.S. courts must rely primarily on the willingness of foreign courts to furnish comity to U.S. bankruptcy proceedings and enforce its orders. AIAA

A94-13149

FINANCIAL CRISIS IN THE AVIATION INDUSTRY - FRANCE

JEAN-PIERRE LE GALL and SONIA REEB (Jeantet & Associes, Paris, France) Air & Space Law (ISSN 0927-3379) vol. 18, no. 4-5 Sept. 1993 p. 183-191.

Copyright

The main feature of France's 1985 Bankruptcy Act is the priority given to the rescue of a company that has filed for insolvency. The rationale for this lies in the need to maintain levels of employment during a recessionary period, and emphasis is accordingly placed on prebankruptcy procedures. Attention is here given to the rights of creditors, remedies available to lessors and mortgages, and the procedures for auctioning of an aircraft in France. AIAA

N94-10145# *General Technology Systems Ltd., Uxbridge (England).*

ANALYSIS OF THE COST EVALUATION OF ESA PROGRAMMES AND COMPARABLE NATIONAL AND INTERNATIONAL PROGRAMMES Final Report

L. P. WHITE, S. R. DAUNCEY, and R. T. GIBSON Jun. 1992 141 p

(Contract ESA-9915/92/F/EM)

(GTS-92063) Copyright Avail: CASI HC A07/MF A02

The objective of the study is to investigate cost and cost trends of ESA programs and comparable national and international programs for the purpose of identifying cost over-runs and the reasons for these. As well as satellite programs, these include a selection of civil and military aircraft programs. The emphasis is on the main development phase in each case, though for the non-ESA programs the costs for these are usually less readily separable than is the case with ESA records. Derived from text

N94-10793# *Maryland Univ., College Park. Dept. of Fire Protection Engineering.*

DEVELOPMENT OF A HYPERMEDIA KNOWLEDGE BASE OF AIRCRAFT FIRE SAFETY REGULATIONS

SAMUEL A. DENNY and FREDERICK W. MOWRER *In* FAA, Proceedings of the International Conference for the Promotion of Advanced Fire Resistant Aircraft Interior Materials p 321-331 Mar. 1993

Avail: CASI HC A03/MF A03

A knowledge base of aircraft fire safety regulations is being developed using Hyperties, a hypermedia engine based on an encyclopedia metaphor. This knowledge base attempts to consolidate in one place the current fire safety regulations related to commercial aircraft promulgated by the Federal Aviation Administration (FAA), along with background information on the bases for these regulations and on the fire test methods adopted by the regulations. The use of a hypermedia engine permits the unprecedented storage, linkage, and retrieval of textual, graphic, audio, and video information. Electronic links between related topics in a knowledge base permit the user to rapidly transfer between topics in order to follow a common thread among different topics. Author (revised)

N94-11288# CSA Engineering, Inc., Palo Alto, CA.

FLIGHT DYNAMICS DIRECTORATE (FDD) HISTORICALLY BLACK COLLEGES AND UNIVERSITIES (HBCU'S) DATABASE MANAGMENT SYSTEM: A USER'S GUIDE Final Report, May 1991 - Sep. 1992

JAMES R. JOHNSON Nov. 1992 18 p

(Contract F33615-90-C-3211)

(AD-A264947; ASIAC-TR-92-10; WL-TR-92-3109) Avail: CASI HC A03/MF A01

Structural Research Capability Database of HBCU's was developed which can be used to recall data about HBCU faculty capabilities and research interests, and university research facilities. The records are focused toward Flight Dynamics Directorate research and technology needs and should facilitate and increase faculty and student participation in the Flight Dynamics Directorate research programs by familiarizing Flight Dynamics Directorate in-house researchers with those at the cited HBCU's. Additional records may be appended to the database. More data were obtained than was contemplated, some universities provided brochures and other additional published data. This report serves as a user's guide for the database program. DTIC

N94-12931*# Allied-Signal Aerospace Co., Phoenix, AZ. Auxiliary Power Div.

ADVANCED TURBINE TECHNOLOGY APPLICATIONS PROJECT (ATTAP) Annual Report No. 5, 1992

Mar. 1993 153 p

(Contract DEN3-335)

(NASA-CR-191088; NAS 1.26:191088; REPT-31-8071(05)) Avail: CASI HC A08/MF A02

This report is the fifth in a series of Annual Technical Summary Reports for the Advanced Turbine Technology Applications Project (ATTAP), sponsored by the U.S. Department of Energy (DOE). The report was prepared by Garrett Auxiliary Power Division (GAPD), a unit of Allied-Signal Aerospace Company, a unit of Allied Signal, Inc. The report includes information provided by Garrett Ceramic Components, and the Norton Advanced Ceramics Company, (formerly Norton/TRW Ceramics), subcontractors to GAPD on the ATTAP. This report covers plans and progress on ceramics development for commercial automotive applications over the period 1 Jan. through 31 Dec. 1992. Project effort conducted under this contract is part of the DOE Gas Turbine Highway Vehicle System program. This program is directed to provide the U.S. automotive industry the high-risk, long-range technology necessary to produce gas turbine engines for automobiles with reduced fuel consumption, reduced environmental impact, and a decreased reliance on scarce materials and resources. The program is oriented toward developing the high-risk technology of ceramic structural component design and fabrication, such that industry can carry this technology forward to production in the 1990's. The ATTAP test bed engine, carried over from the previous AGT101 project, is being used for verification testing of the durability of next generation ceramic components, and their suitability for service at Reference Powertrain Design conditions. This document reports the technical effort conducted by GAPD and the ATTAP subcontractors during the fifth year of the project. Topics covered include ceramic processing definition and refinement, design improvements to the ATTAP test bed engine and test rigs, and the methodology development of ceramic impact and fracture mechanisms. Appendices include reports by ATTAP subcontractors in the development of silicon nitride materials and processes. Author (revised)

N94-13401*# National Aeronautics and Space Administration, Washington, DC.

NASA AEROSPACE DATABASE SUBJECT SCOPE: AN OVERVIEW

Sep. 1993 28 p

(NASA-SP-7107; NAS 1.21:7107) Avail: CASI HC A03/MF A01

Outlined here is the subject scope of the NASA Aerospace Database, a publicly available subset of the NASA Scientific and Technical (STI) Database. Topics of interest to NASA are outlined and placed within the framework of the following broad aerospace subject categories: aeronautics, astronautics, chemistry and materials, engineering, geosciences, life sciences, mathematical and computer sciences, physics, social sciences, space sciences, and general. A brief discussion of the subject scope is given for each broad area, followed by a similar explanation of each of the narrower subject fields that follow. The subject category code is listed for each entry. Author (revised)

N94-14196# National Research Council of Canada, Ottawa (Ontario). Machinery and Engine Technology.
AN EXPERT SYSTEM CLASS LIBRARY FOR AUDITION [BIBLIOTHEQUE DU TYPE SYSTEME EXPERT POUR AUDITION]
DAVID M. MORTON and ANDREW M. DRINNAN Dec. 1992 13 p
(IME-MET-TR-008; CTN-93-60860) Avail: CASI HC A03/MF A01

An expert system class library for the object-oriented Audition environment has been created. The expert system is a forward chaining rule-based inference engine. It owns a set of static facts that are supplied by the user and a set of dynamic facts that the system has inferred. Dynamic facts are inferred from existing facts using a set of user-specified rules. User specified actions may also be executed based on the results of these inferences. To minimize inferencing time, rules are grouped into rulesets. Groups of rulesets that define complete sets of knowledge are organized into knowledge bases. An expert system may have multiple knowledge bases. A rule editor is provided for creating, editing and debugging. An overview is presented for the system applied for air traffic control. CISTI

N94-16134# Boeing Co., Huntsville, AL.
GOVERNMENT/CONTRACTOR DEVELOPMENT TEAMS
JAMES P. NOBLITT *In* Huntsville Association of Technical Societies, TABES 1993: 9th Annual Technical and Business Exhibition and Symposium 5 p 1993
(TABES PAPER 93-460) Avail: CASI HC A01/MF A03

As previous speakers have said, profound changes are occurring in the world and the aerospace marketplace. It seems that everyone in the industry is struggling to adapt to the new environment and to survive. To meet this challenge, new ways of doing business are being adopted. Methods that enable products to be produced better, faster, and cheaper. One of the most powerful techniques is what we call Product Development Teams (PDT's). What others may call Design-Build Teams or Concurrent Engineering. At Boeing, we have found these team approaches to be a highly effective way of increasing quality while simultaneously reducing flow time and cost. We have also found that they have a very positive effect on employee morale. Because of our successes, we are making them the standard way of operating on every program we conduct. Today, I'd like to provide a short overview of how we're using teams at Boeing with special attention to subcontractor and customer involvement. I start by reviewing why change is needed. Author (revised)

N94-16729*# National Aeronautics and Space Administration, Washington, DC.
MISSION MANAGEMENT AIRCRAFT OPERATIONS MANUAL
Mar. 1992 75 p
(NHB-7900.3; NAS 1.18:7900.3) Avail: CASI HC A04/MF A01

This manual prescribes the NASA mission management aircraft program and provides policies and criteria for the safe and economical operation, maintenance, and inspection of NASA mission management aircraft. The operation of NASA mission management aircraft is based on the concept that safety has the highest priority. Operations involving unwarranted risks will not be tolerated. NASA mission management aircraft will be designated by the Associate Administrator for Management Systems and Facilities. NASA mission management aircraft are public aircraft as defined by the Federal Aviation Act of 1958. Maintenance standards, as a minimum, will meet those required for retention of Federal Aviation Administration (FAA) airworthiness certification. Federal Aviation Regulation Part 91, Subparts A and B, will apply except when requirements of this manual are more restrictive. Derived from text

N94-16730*# National Aeronautics and Space Administration, Washington, DC.
AIRCRAFT OPERATIONS MANAGEMENT MANUAL
Mar. 1992 80 p
(NHB-7900.3(V1); NAS 1.18:7900.3(V1)) Avail: CASI HC A05/MF A01

The NASA aircraft operations program is a multifaceted, highly diverse entity that directly supports the agency mission in aeronautical research and development, space science and applications, space flight, astronaut readiness training, and related activities through research and development, program support, and mission management aircraft operations flights. Users of the program are interagency, inter-government, international, and the business community. This manual provides guidelines to establish policy for the management of NASA aircraft resources, aircraft operations, and related matters. This policy is an integral part of and must be followed when establishing field installation policy and procedures covering the management of NASA aircraft operations. Each operating location will develop appropriate local procedures that conform with the requirements of this handbook. This manual should be used in conjunction with other governing instructions, handbooks, and manuals. Author

N94-17261# Wichita State Univ., KS. National Inst. for Aviation Research.
MAXIMIZING PARTICIPATION OF WOMEN IN COLLEGIATE AVIATION EDUCATION Ph.D. Thesis
JACQUELINE R. LUEDTKE Jul. 1993 112 p
(NIAR-93-14) Avail: CASI HC A06/MF A02

The purpose of this study is to collect and analyze information which can be used to examine the reasons for the seemingly low number of women in the United States' collegiate aviation educational system. With ever-increasing global competition, it is vital to assist all qualified persons in the aviation field to succeed in their chosen area of this profession. Only by utilizing all trained persons, men and women, will the United States remain competitive in aviation. With women comprising such a large percentage of the work force, it is only logical to employ the best and brightest of both genders to accomplish this goal. Data will be collected directly from program directors and/or aviation faculty at each participating member institution in the UAA with a four-year degree program in aviation. These directors and faculty members can offer insight into whether or not women are, in fact, under-represented in higher aviation education, and, if so, what they believe can be done to rectify this situation. They will be able to evaluate the status of aviation education and what the future needs might be. This research endeavor will attempt to determine what progress has been made in recent years to increase the percentage of women in collegiate aviation education. Both factual data and perceptions from the respondents will be acquired. By analyzing the history of women aviation educators, this study hopes to offer means of maximizing participation of women in collegiate aviation education. Recommendations for improvements which will allow the integration of women more readily into this field will be sought. The information gathered through this study will allow persons in higher aviation education at all colleges and universities and at the University Aviation Association to better understand the role women should be playing in this field. Such information will also be useful to the aviation industry at large as women become a larger force in this area of study and expertise. Author

N94-18575 Institute for Defense Analyses, Alexandria, VA.
A COMPARISON OF AIR FORCE DATA SYSTEMS Final Report, Jan. - Aug. 1993
WAYNARD C. DEVERS, ELIZABETH K. BAILEY, LEE H. DYMOND, WILLIAM A. FLORAC, and STANLEY A. HOROWITZ Aug. 1993

244 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract MDA903-89-C-0003)
(AD-A269691; IDA-P-2863; IDA/HQ-93-44150) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

This report evaluates the effectiveness and cost of two alternative Air Force maintenance information systems: CAMS/REMIS and TICARRS. The evaluation considers six dimensions of effectiveness: functionality, scope, operating characteristics, data accuracy and completeness, adaptability, and logistics and operational effectiveness. Each system was found to have shortcomings. CAMS/REMIS suffers from problems in availability, responsiveness, and data integrity, and TICARRS is limited in functionality and scope. IDA considers two alternatives, each one based on one of the systems supporting the entire Air Force. A set of enhancements needed to make the two systems roughly equivalent is provided, along with their costs. The cost analysis includes estimates of the nonrecurring costs to address the system limitations and the recurring costs in system operations and maintenance from FY 1994 through FY 2003. The TICARRS-based alternative is found to be superior in effectiveness but must be expanded in scope and functionality if it is to become the Air Force's standard system. The estimated costs for the TICARRS alternative over the ten-year period are approximately $100 million less (in terms of present value) than the costs for the CAMS/REMIS alternative. DTIC

N94-19377# Federal Aviation Administration, Oklahoma City, OK. Flight Standards Service.
ADVISORY CIRCULAR: INDEX OF ARTICLES (MATERIALS, PARTS, PROCESSES, AND APPLIANCES) CERTIFIED UNDER THE TECHNICAL STANDARD ORDER SYSTEM
Oct. 1993 533 p
(AC-20-36S; ISBN-0-16-042982-X) Avail: CASI HC A23/MF A04

This publication lists those manufacturers who hold a Technical Standard Order (TSO) Authorization or a letter of TSO Design Approval. The requirements for obtaining an authorization or letter are prescribed in Part 21, Subpart O of the Federal Aviation Regulations. The page layout is arranged as follows. Column one lists the specific TSO number. A letter F in this column denotes foreign manufacturers. Column two identifies the person to whom the approval was issued. Column three lists the FAA region which issued the authorization or letter of approval. Column four shows the TSO descriptive title. This title appears one time at the beginning of each group of TSO holders meeting the requirements of a specific TSO. Column five lists the model or part number of the article approved. Author (revised)

N94-19571# Naval Surface Warfare Center, Bethesda, MD.
RESULTS OF A JOINT NAVY/AIR FORCE OPERATIONAL TEST TO EVALUATE USAF INTEGRATED MAINTENANCE INFORMATION SYSTEMS (IMIS), INTERACTIVE ELECTRONIC TECHNICAL MANUAL (IETM) TECHNOLOGY APPLIED TO THE F/A-18 AIRCRAFT Final Report, 1 Oct. 1989 - 1 Oct. 1991
MARK T. KRAMER, THEODORE J. RAINEY, and C. SAMUEL
14 Jun. 1993 151 p
(AD-A271322; CARDEROCKDIV-93/007) Avail: CASI HC A08/MF A02

In a joint effort, the U.S. Navy and Air Force have tested under operational conditions a series of improved techniques developed under the Air Force Integrated Maintenance Information System (IMIS) program for delivering maintenance technical information to squadron technicians. These improvements included use of a portable maintenance aid (PMA) for technical information display. In this test, carried out in an F/A-18 fighter squadron at Marine Corps Air Station, Beaufort, South Carolina each of 16 technicians performed six fault-isolation tasks, three supported by an Interactive Electronic Technical Manual (IETM) displayed on a PMA, and three supported by conventional paper-based work package (WP) technical manual (TM). This report presents a comparison of technician performance supported by the ITEM/PMA combination with performance using conventional paper TM's. The performance data collected during the test showed considerable reduction in performance times for complex multiple fault isolations and maintenance errors, when technicians used the IETM/PMA combination. Also, technician-preference data based on questionnaires showed strong support for virtually all IETM/PMA features. Technicians also made suggestions for improving the IETM and the PMA. DTIC

N94-19780 Institute for Defense Analyses, Alexandria, VA.
A COMPARISON AIR FORCE DATA SYSTEMS Final Report, Jul. - Aug. 1993
WAYNARD C. DEVERS, ELIZABETH K. BAILEY, LEE H. DYMOND, WILLIAM A. FLORAC, and STANLEY A. HOROWITZ Aug. 1993
177 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract MDA903-89-C-0003)
(AD-A270662; IDA-D-1400; IDA/HQ-93-44315; AD-E501701)
Avail: CASI HC A09

IDA Paper P-2863 reports on a comparison by IDA of two Air Force maintenance information systems. One of the systems is CAMS/REMIS, which combines the Core Automated Management System (CAMS) with the Reliability and Maintainability Information System (REMIS). The other is the Interim CAMS and REMIS Reporting System (TICARRS). Before Paper P-2863 was released in its final version, IDA gave interested parties the opportunity to comment upon it. This document contains the comments provided to IDA by the Office of the Secretary of Defense, the Air Force, Litton Computer Services, and Dynamics Research Corporation. It also contains IDA's responses to the comments received. DTIC

19

GENERAL

N94-11820# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AGARD HIGHLIGHTS 92/2, SEPTEMBER 1992
Sep. 1992 36 p
(AGARD-HIGHLIGHTS-92/2) Avail: CASI HC A03/MF A01

Highlights of the activities of the Advisory Group for Aerospace Research & Development (AGARD) are presented. Articles addressing the award of the von Karman Medal and the Scientific Achievement Award for 1992 are included along with a review of the 'Open Skies' negotiations in Vienna, the role of the Independent European Programme Group (IEPG), and EUCLID (European Cooperation for the Long Term in Defense). CASI

N94-12334 Naval Research Lab., Washington, DC.
NRL REVIEW FOR 1993
1993 286 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A265666; NRL/PU/5230-92-235) Avail: CASI HC A13

Recent research projects at NRL are presented: opioid peptides--X-ray characterization of two potent enkephalin analogs; ultrathin magnetic film research at NRL; communicating with chaos; trans-oceanic acoustic propagation and global warming; acoustics--electroacoustic transducer transient suppression--BiKR-A range-dependent, normal-mode reverberation model for bistatic geometries; predicting acoustic signal distortion in shallow water; chemical/biochemical research--development of polyurethane/epoxy based interpenetrating polymer networks for damping applications; ultrafast photochemical processes; chemical adhesion across composite interfaces; nanocapillarity in fullerine tubules; and neuronal patterning. DTIC

N94-13519# Institute for Aerospace Research, Ottawa (Ontario). Flight Research Lab.
ACTIVITIES OF INSTITUTE FOR AEROSPACE RESEARCH, FLIGHT RESEARCH LABORATORY Annual Progress Report, 1992
B. LEACH, ed. 1992 175 p
(CTN-93-60832) Avail: CASI HC A08/MF A02
A summary is presented of progress in the research projects of the Flight Research Laboratory during 1992 and a brief indication of future plans for continuing and new projects. Projects are described in the areas of flight mechanics, airborne science, and facility development, and major facilities at the Laboratory are also described. Subjects of specific projects include flight tests, simulator model development, microgravity experiments, flight dynamics and handling qualities, flight safety and operational problems, guidance and navigation systems, pilot-vehicle interface technologies, speech recognition, atmospheric geoscience, resource geoscience, and defense. CISTI

N94-13633* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT OPERATIONS HIGHLIGHTS, TAPES 1 AND 2 (Videotape)
Apr. 1990 Videotape: 1 hr. 40 min. playing time, in color, with sound
(NASA-TM-109293; NONP-VT-93-185308) Avail: CASI VHS A01/BETA A22
Historical film footage of the X-series aircraft (including Yeager's X-1 flight), lifting bodies, and early Apollo landing tests is presented. Author (revised)

N94-14791*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE 1991 RESEARCH AND TECHNOLOGY REPORT, GODDARD SPACE FLIGHT CENTER
GERALD SOFFEN, ed., HOWARD OTTENSTEIN, ed., HARRY MONTGOMERY, ed., WALTER TRUSZKOWSKI, ed., KENNETH FROST, ed., WALTER SULLIVAN, ed., and CHARLES BOYLE, ed. 1991 238 p Original contains color illustrations
(NASA-TM-108738; NAS 1.15:108738) Avail: CASI HC A11/MF A03; 31 functional color pages
The 1991 Research and Technology Report for Goddard Space Flight Center is presented. Research covered areas such as (1) earth sciences including upper atmosphere, lower atmosphere, oceans, hydrology, and global studies; (2) space sciences including solar studies, planetary studies, Astro-1, gamma ray investigations, and astrophysics; (3) flight projects; (4) engineering including robotics, mechanical engineering, electronics, imaging and optics, thermal and cryogenic studies, and balloons; and (5) ground systems, networks, and communications including data and networks, TDRSS, mission planning and scheduling, and software development and test. CASI

N94-15434* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
UNITARY PLAN WIND TUNNEL LANDMARK DEDICATION AND REVITALIZATION (Videotape Supplement)
Sep. 1990 Videotape: 21 min. playing time, in color, with sound
(NASA-TM-109649; NONP-VT-93-190447) Avail: CASI VHS A01/BETA A22
This video shows construction scenes of unitary plan wind tunnel, aerials, and views of various models, including an MD-II in the 11 ft, an Apollo in the 8x7, Dynasoar in the 8x7, a one inch scale shuttle in the 8x7, and an artist's concept of a 12 ft test section. CASI

N94-19147# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: CENTRAL EURASIA. AVIATION AND COSMONAUTICS, NO. 1, JANUARY 1993
16 Aug. 1993 24 p Transl. into ENGLISH from various Russian articles
(JPRS-UAC-93-007) Avail: CASI HC A03/MF A01
Papers on the following topics are included: structuring of algorithms for airborne expert systems; and procedures in satellite topography. CASI

N94-19148# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: CENTRAL EURASIA. AVIATION AND COSMONAUTICS, NO. 12, DECEMBER 1992
20 Jul. 1993 26 p Transl. into ENGLISH from various Russian articles
(JPRS-UAC-93-006) Avail: CASI HC A03/MF A01
Papers on the following topics are included: combat pilots helped by 'artificial intelligence'; safety problems in instrument landing explored; theory of more efficient propulsion method explored; and Tu-160, U.S. B-1B features, performance compared. CASI

N94-19149# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: CENTRAL EURASIA. AVIATION AND COSMONAUTICS, NO. 10, OCTOBER 1992
14 May 1993 27 p Transl. into ENGLISH from various Russian articles
(JPRS-UAC-93-004) Avail: CASI HC A03/MF A01
Papers on the following topics are included: launch-complex designer Barmin on past, future of space science; varied nature of satellite ground control operations viewed; and case made for artificial intelligence systems on combat aircraft. CASI

N94-19208# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: CENTRAL EURASIA: AVIATION AND COSMONAUTICS, NO. 11, NOVEMBER 1992
2 Jun. 1993 21 p Transl. into ENGLISH from various Russian articles
(JPRS-UAC-93-005) Avail: CASI HC A03/MF A01
Papers on the following topics are included: continued discussion of artificial intelligence to aid pilots; and importance, ways of maintaining personnel physiological reserves. CASI

N94-20150# Wichita State Univ., KS. National Inst. for Aviation Research.
ACTIVITIES OF NATIONAL INST. FOR AVIATION RESEARCH
1993 72 p Sponsored by Kansas Technology Enterprise Corp.
(NIAR-93-16) Avail: CASI HC A04/MF A01
In response to a letter from Dr. Bill Brundage, KTEC president, dated August 2, 1993, the NIAR prepared information regarding the economic benefits the state has received for its six year investment of $3,402,500 through fiscal year 1993 in the National Institute for Aviation Research. Following is the summary of measurable outcomes: Established a research, technical assistance and education center operating as the primary channel for state research and development support to the aviation industry which accounts for 11.3 percent of the state's total employee earnings; Generated $23,529,000 from non-state sources producing a return on the KTEC investment of 7.9 : 1; Constructed a research facility of 74,000 gross sq ft with laboratories and equipment valued at $17,000,000. This is a return on the KTEC $475,000 equipment investment of 42.5 : 1; Established a Manufacturing Technology Center (MAMTC) Regional Office in Wichita with KTEC and NIST funding, which has provided assistance to 168 aviation support and non-aviation manufacturing firms with a combined employment of more than 18,400 Kansas; Received industry contracts valued at $2,902,000; Received federal grants/contracts valued at $13,727,000; Provided assistantships for 257 students in engineering and science. Alumni data suggest that 50 percent of engineering graduates remain in Kansas; Conducted 320 technology transfer workshops with a total of 9,450 attendees; Published 348 technical papers; Created and saved a total of 649

jobs (84 new jobs within the NIAR - 124 new jobs reported by NIAR/MAMTC clients - 251 jobs saved reported by NIAR/MAMTC clients - 190 indirect jobs created according to CEBDR estimate); and Provided substantial technical assistance to Boeing, Beech, Cessna and Learjet, which have combined employment of 31,000 Kansans, on seven new airplane models. The total sales potential of these projects manufactured by the Kansas Aviation Industry exceeds $10 billion. Derived from text

SUBJECT INDEX

Typical Subject Index Listing

SUBJECT HEADING

ABORTED MISSIONS
STS-55 pad abort: Engine 2011 oxidizer preburner augmented spark igniter check valve leak
[NASA-CR-193830] p 138 N94-12806

TITLE | REPORT NUMBER | PAGE NUMBER | ACCESSION NUMBER

The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of document content, a title extension is added, separated from the title by three hyphens. The accession number and the page 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. Under any one subject heading, the accession numbers are arranged in sequence.

A

SUBJECT

C

D

F

G

M

T

AUTHOR

Typical Personal Author Index Listing

PERSONAL AUTHOR

ANDRISANI, DOMINICK, II
A feasibility study regarding the addition of a fifth control to a rotorcraft in-flight simulator
[NASA-CR-193240] p 112 N94-10895

TITLE | REPORT NUMBER | PAGE NUMBER | ACCESSION NUMBER

Listings in this index are arranged alphabetically by personal author. The title of the document is used to provide a brief description of the subject matter. The report number helps to indicate the type of document (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

H

I

N

Q

R

T

U

X

Y

Typical Corporate Source Index Listing

CORPORATE SOURCE

Adaptive Research Corp., Huntsville, AL.
Structured finite volume modeling of US Navy aircraft engine test cells. Task 1: Turboshaft engine, volume 1
[AD-A268176] p 135 N94-17432

TITLE | REPORT NUMBER | PAGE NUMBER | ACCESSION NUMBER

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

D

E

F

Strain sensing technology for high temperature applications
[NASA-TM-4498] p 173 N94-12874
Averaging techniques for steady and unsteady calculations of a transonic fan stage
[NASA-TM-106231] p 3 N94-13108
NDE of titanium alloy MMC rings for gas turbine engines
[NASA-TM-106188] p 148 N94-13138
Combustor technology for future small gas turbine aircraft
[NASA-TM-106312] p 101 N94-13142
Analysis of gas turbine engines using water and oxygen injection to achieve high Mach numbers and high thrust
[NASA-TM-106270] p 102 N94-13143
A future view of computational science in aircraft
[NASA-TM-109284] p 32 N94-13621
Futurepath 2
[NASA-TM-109285] p 102 N94-13623
Noise levels from a model turbofan engine with simulated noise control measures applied
[NASA-TM-106318] p 102 N94-14036
Mixing noise reduction for rectangular supersonic jets by nozzle shaping and induced screech mixing
[NASA-TM-106364] p 34 N94-14208
A hot dynamic seal rig for measuring hypersonic engine seal durability and flow performance
[NASA-TM-106294] p 179 N94-14727
Interaction of two glancing, crossing shock waves with a turbulent boundary-layer at various Mach numbers
[NASA-TM-103740] p 36 N94-14780
A new Lagrangian method for three-dimensional steady supersonic flows
[NASA-TM-106068] p 37 N94-14847
Cruise noise measurements of a scale model advanced ducted propulsor
[NASA-TM-105808] p 207 N94-15115
NASA images 6
[NASA-TM-109437] p 57 N94-15336
Development of the seeding system used for laser velocimeter surveys of the NASA Low-Speed Centrifugal Compressor flow field
[NASA-TM-4485] p 180 N94-15445
NASA Lewis 9- by 15-foot low-speed wind tunnel user manual
[NASA-TM-106247] p 134 N94-15819
Effect of wind tunnel acoustic modes on linear oscillating cascade aerodynamics
[NASA-TM-106367] p 104 N94-15866
The vibro-acoustic mapping of low gravity trajectories on a Learjet aircraft p 182 N94-16078
Development of a proposed international standard for certification of aircraft to High Intensity Radiated Fields (HIRF)
[NASA-TM-106357] p 58 N94-16520
Flow analysis for the nacelle of an advanced ducted propeller at high angle-of-attack and at cruise with boundary layer control
[NASA-TM-106371] p 41 N94-16571
Experimental and computational investigation of the NASA low-speed centrifugal compressor flow field
[NASA-TM-4481] p 104 N94-17386
Jet engine performance enhancement through use of a wave-rotor topping cycle
[NASA-TM-4486] p 105 N94-17470
Flutter analysis using transversality theory
[NASA-TM-106382] p 183 N94-17481
Mechanical Systems Technology Branch research summary, 1985 - 1992
[NASA-TM-106329] p 184 N94-17583
A comparative study of turbulence models in predicting hypersonic inlet flows p 50 N94-18553
Turbulence modeling in aircraft icing
p 185 N94-18555
Design for cyclic loading endurance of composites
[NASA-TM-106407] p 187 N94-19351
Overview of STOVL aircraft propulsion research offtakes and vertical lift systems
[NASA-TM-106387] p 105 N94-19353
Supersonic jets from bevelled rectangular nozzles
[NASA-TM-106403] p 51 N94-19484
Experimental and computational results from a large low-speed centrifugal impeller
[NASA-TM-106421] p 52 N94-20136
Quantification of uncertainties in the performance of smart composite structures
[NASA-TM-106335] p 188 N94-20171

National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
Numerical analysis of turbine blade tip treatments
[SAE PAPER 921928] p 13 A94-11976
Dynamic tester for rotor seals and bearings
[NASA-CASE-MFS-28493-1] p 130 N94-10669
Control system design for flexible structures using data models p 121 N94-14646

National Aerospace Lab., Amsterdam (Netherlands).
Future developments of the NLR research flight simulator
[NLR-TP-92143-U] p 132 N94-13498
Photogrammetric methods for trajectory measurements
[NLR-TP-91166-U] p 174 N94-13527
On the use of the method of matched asymptotic expansions in propeller aerodynamics and acoustics
[NLR-TP-91307-U] p 31 N94-13528
Clebsch variable model for unsteady, transonic flow; application to 2D airfoils
[NLR-TP-91387-U] p 31 N94-13530
A robust quasi-simultaneous interaction method for a full potential flow with a boundary layer with application to wing/body configurations
[NLR-TP-91397-U] p 31 N94-13531
Performance of gas turbine compressor cleaners
[NLR-TP-91291-U] p 103 N94-14450
Symposium on the Future of Aeronautics in the Netherlands
[ETN-93-93780] p 3 N94-15120
Expectations for the future of the National Aerospace Laboratory p 134 N94-15129
Technical evaluation report on the AGARD-PEP Specialists Meeting on Combat Aircraft Noise
[NLR-TP-91445-U] p 207 N94-15506
Study into the limits of an Euler equation method applied to leading-edge vortex flow
[NLR-TP-91350-U] p 184 N94-17627
Feasibility of a wind-ellipse criterion in a vortex advisory system for Schiphol Airport
[NLR-TP-91384-U] p 58 N94-17733
Take-off performance monitoring system algorithm and display development
[NLR-TP-91395-U] p 88 N94-17734
High-lift system analysis method using unstructured meshes p 47 N94-18426

National Aerospace Lab., Emmeloord (Netherlands).
Overview of the FAA/DCA/NLR programs related to ageing aircraft
[NLR-TR-92119-U] p 4 N94-17614

National Aerospace Lab., Kakuda (Japan).
Chemical reactions in scramjet engines: Reduced kinetic models for ignition, combustion and nozzle flow
[NAL-TR-1184] p 148 N94-13458

National Aerospace Lab., Tokyo (Japan).
An investigation on the effectiveness of the piping interference removal system for STOL aircraft wind tunnel tests
[NAL-TM-647] p 19 N94-10350
Estimation of critical values and vibration characteristics on supersonic delta wings. Part 1: On-line time series analysis of stationary random response
[NAL-TR-1153] p 20 N94-10363
A grid generation method to calculate the flow field in a three-dimensional cascade of blades
[NAL-TR-1158] p 166 N94-10364
Solving the inverse problem for incompressible potential flow through two-dimensional cascades
[NAL-TR-1162] p 166 N94-10365
Numerical calculation of scramjet inlet flow
[NAL-TR-1174T] p 100 N94-10370
Proceedings of the 10th NAL Symposium on Aircraft Computational Aerodynamics: CFD Workshop on GK Airfoil and ONERA M5 Geometry
[NAL-SP-20] p 22 N94-10466
Description of 2D problem: Aerodynamic analysis of Garabedian-Korn 75-06-12 airfoil p 22 N94-10467
Aerodynamic characteristics analysis of Garabedian-Korn 75-06-12 airfoil: Compendium of results p 23 N94-10475
Description of 3D problem: Flow analysis around ONERA model M5 configuration p 23 N94-10476
Flow analysis around ONERA model M5 configuration
[PAPER-3D-4] p 23 N94-10480
Flow analysis around ONERA model M5 configuration: Compendium of results p 24 N94-10482
Aerodynamic model identification of quiet STOL experimental aircraft ASKA from dynamic flight test data
[DE93-767967] p 79 N94-10728
Flight simulator experiment of the cockpit advisory system
[NAL-TR-1151] p 131 N94-10733
In-flight simulation of backside operating models using direct lift controller
[NAL-TR-1152] p 112 N94-10734
Simulated wake characteristics of tapered annular wings by a discrete vortex method
[NAL-TR-1156] p 25 N94-10855
Simulated and experimental aerodynamic characteristics of tapered annular wings
[NAL-TR-1157] p 25 N94-10856
New aerodynamic information obtained from the solution of the inverse problem for aerofoils
[NAL-TR-1172] p 25 N94-10860
Numerical wind tunnel project and computational fluid dynamics at National Aerospace Laboratory, Japan
[NAL-TM-648T] p 169 N94-10861
Numerical simulation of hypersonic flow for the design of the H-2 orbiting plane (HOPE), part 3
[NAL-TR-1168-PT-3] p 28 N94-12948
Identifying the NAL spaceplane aerodynamic model using dynamic wind tunnel tests
[NAL-TR-1171] p 28 N94-12951
Control system design of a cable-mounted model used for dynamic wind tunnel testing
[NAL-TR-1161] p 132 N94-13337
Development of an on-board aircraft optical fiber data bus system
[NAL-TR-1163] p 83 N94-13338
Low-speed wind tunnel tests on four types of joined-wing aircraft models
[NAL-TR-1167] p 29 N94-13340
Low-speed wind tunnel tests on a joined-wing aircraft model with various upper-fin
[NAL-TR-1169] p 30 N94-13341
Development of a high-speed mechanical drive system for oscillating an annular blade row in the bending mode
[NAL-TR-1170] p 30 N94-13342
Flight evaluations of approach/landing navigation sensor systems: Summary of 1990 flight experiments
[NAL-TR-1175] p 68 N94-13344
Estimation of critical values and vibration characteristics on supersonic delta wings. Part 2: Locally-stationary time series analysis of nonstationary random responses
[NAL-TR-1179] p 30 N94-13345
Performance evaluation tests of the GPS/DGPS navigation system installed in the NAL Dornier 228: Preliminary ground test results
[NAL-TM-649] p 68 N94-13346
Rolling moment control in the NAL 10 cm x 10 cm magnetic suspension and balance system
[NAL-TR-1164] p 120 N94-13347
Estimation of aircraft aerodynamic derivatives with the Total Least Squares Method
[NAL-TR-1150] p 30 N94-13392
Position error determination for the speedometer and altimeter of the NAL QSTOL experimental aircraft ASKA
[NAL-TR-1144] p 95 N94-13451
Experimental studies of vortex flaps and vortex plates. Part 2: 1.15m span 60 deg delta wing
[NAL-TR-1180T-PT-2] p 31 N94-13454
Flight path control for the approach and landing of the quiet STOL experimental aircraft ASKA
[NAL-TR-1183] p 68 N94-13457
Hypersonic aerodynamic characteristics of SSTO-type aerospace planes. Part 1: The NAL 0-th configuration
[NAL-TR-1186] p 83 N94-13459
Experimental studies of vortex flaps and vortex plates. Part 1: 0.53 m span 60 deg delta wing
[DE93-767969] p 33 N94-14059
Numerical simulation of dynamic stall of NACA0012 airfoil oscillating near static stall angle using the Navier-Stokes equations
[DE93-767970] p 33 N94-14061

National Defence Headquarters, Ottawa (Ontario).
Monopiece strain gauge sting mounted wind tunnel balance
[CA-PATENT-1-311-626] p 181 N94-15697

National Inst. of Standards and Technology, Gaithersburg, MD.
Computer-aided molecular design of fire resistant aircraft materials p 144 N94-10779
Developments needed to expand the role of fire modeling in material fire hazard assessment
p 145 N94-10787
Theoretical evaluation of R22 and R502 alternatives
[DE93-014767] p 205 N94-10853

National Physical Lab., Teddington (England).
An experimental assessment of the use of ground-level microphones to measure the fly-over noise of jet-engined aircraft
[NPL-RSA(EXT)-0039] p 206 N94-13885

National Research Council of Canada, Ottawa (Ontario).
The OSU heat release rate test using the oxygen consumption principle p 144 N94-10784
ADS-33C related handling qualities research performed using the NRC Bell 205 airborne simulator
p 115 N94-13295
A distributed, visual object system using aggregation objects with a local namespace
[IME-MET-TR-007] p 200 N94-13860
An expert system class library for Audition
[IME-MET-TR-008] p 210 N94-14196

National Space Development Agency, Tokyo (Japan).
Numerical simulation of hypersonic flow for the design of the H-2 orbiting plane (HOPE), part 3
[NAL-TR-1168-PT-3] p 28 N94-12948

O

P

Q

R

S

T

U

FOREIGN TECHNOLOGY INDEX

AERONAUTICAL ENGINEERING / *A Continuing Bibliography (Supplement 301)* February 1994

Typical Foreign Technology Index Listing

COUNTRY OF INTELLECTUAL ORIGIN

CHINA
The present situation and future development of Chinese aviation reliability and maintainability engineering
p 153 A94-10101

TITLE | PAGE NUMBER | ACCESSION NUMBER

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 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

B

C

CONTRACT NUMBER INDEX

Typical Contract Number Index Listing

AF PROJ. 2404 .... p 44 N94-17461

CONTRACT NUMBER | PAGE NUMBER | ACCESSION NUMBER

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.

REPORT NUMBER INDEX

Typical Report Number Index Listing

NASA SPONSORED | ON MICROFICHE

NASA-CR-167690 .... p 139 N94-12810 * #

REPORT NUMBER | PAGE NUMBER | ACCESSION NUMBER

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.

REPORT

Typical Accession Number Index Listing

NASA SPONSORED — ON MICROFICHE

A94-10717 * # p 71

ACCESSION NUMBER — PAGE NUMBER

Listings in this index are arranged alphanumerically by accession 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.

AVAILABILITY OF CITED PUBLICATIONS

OPEN LITERATURE ENTRIES (A94-10000 Series)

Inquiries and requests should be addressed to: CASI, 800 Elkridge Landing Road, Linthicum Heights, MD 21090-2934. Orders are also taken by telephone, (301) 621-0390, e-mail, help@sti.nasa.gov, and fax, (301) 621-0134. Please refer to the accession number when requesting publications.

STAR ENTRIES (N94-10000 Series)

One or more sources from which a document announced in *STAR* is available to the public is ordinarily given on the last line of the citation. The most commonly indicated sources and their acronyms or abbreviations are listed below, and their addresses are listed on page APP-3. If the publication is available from a source other than those listed, the publisher and his address will be displayed on the availability line or in combination with the corporate source line.

Avail: CASI. Sold by the NASA Center for AeroSpace Information. Prices for hard copy (HC) and microfiche (MF) are indicated by a price code following the letters HC or MF in the *STAR* citation. Current values for the price codes are given in the tables on page APP-5.

NOTE ON ORDERING DOCUMENTS: When ordering publications from CASI, use the N accession number or other report number. It is also advisable to cite the title and other bibliographic identification.

Avail: SOD (or GPO). Sold by the Superintendent of Documents, U.S. Government Printing Office, in hard copy.

Avail: BLL (formerly NLL): British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England. Photocopies available from this organization at the price shown. (If none is given, inquiry should be addressed to the BLL.)

Avail: DOE Depository Libraries. Organizations in U.S. cities and abroad that maintain collections of Department of Energy reports, usually in microfiche form, are listed in *Energy Research Abstracts*. Services available from the DOE and its depositories are described in a booklet, *DOE Technical Information Center - Its Functions and Services* (TID-4660), which may be obtained without charge from the DOE Technical Information Center.

Avail: ESDU. Pricing information on specific data, computer programs, and details on Engineering Sciences Data Unit (ESDU) topic categories can be obtained from ESDU International Ltd. Requesters in North America should use the Virginia address while all other requesters should use the London address, both of which are on page APP-3.

Avail: Fachinformationszentrum, Karlsruhe. Gesellschaft für wissenschaftlich-technische Information mbH 7514 Eggenstein-Leopoldshafen 2, Germany.

Avail: HMSO. Publications of Her Majesty's Stationery Office are sold in the U.S. by Pendragon House, Inc. (PHI), Redwood City, CA. The U.S. price (including a service and mailing charge) is given, or a conversion table may be obtained from PHI.

Avail: Issuing Activity, or Corporate Author, or no indication of availability. Inquiries as to the availability of these documents should be addressed to the organization shown in the citation as the corporate author of the document.

Avail: NASA Public Document Rooms. Documents so indicated may be examined at or purchased from the National Aeronautics and Space Administration (JBD-4), Public Documents Room (Room 1H23), Washington, DC 20546-0001, or public document rooms located at NASA installations, and the NASA Pasadena Office at the Jet Propulsion Laboratory.

Avail: NTIS. Sold by the National Technical Information Service. Initially distributed microfiche under the NTIS SRIM (Selected Research in Microfiche) are available. For information concerning this service, consult the NTIS Subscription Section, Springfield, VA 22161.

Avail: Univ. Microfilms. Documents so indicated are dissertations selected from *Dissertation Abstracts* and are sold by University Microfilms as xerographic copy (HC) and microfilm. All requests should cite the author and the Order Number as they appear in the citation.

Avail: US Patent and Trademark Office. Sold by Commissioner of Patents and Trademarks, U.S. Patent and Trademark Office, at the standard price of $1.50 each, postage free.

Avail: (US Sales Only). These foreign documents are available to users within the United States from the National Technical Information Service (NTIS). They are available to users outside the United States through the International Nuclear Information Service (INIS) representative in their country, or by applying directly to the issuing organization.

Avail: USGS. Originals of many reports from the U.S. Geological Survey, which may contain color illustrations, or otherwise may not have the quality of illustrations preserved in the microfiche or facsimile reproduction, may be examined by the public at the libraries of the USGS field offices whose addresses are listed on page APP-3. The libraries may be queried concerning the availability of specific documents and the possible utilization of local copying services, such as color reproduction.

FEDERAL DEPOSITORY LIBRARY PROGRAM

In order to provide the general public with greater access to U.S. Government publications, Congress established the Federal Depository Library Program under the Government Printing Office (GPO), with 53 regional depositories responsible for permanent retention of material, inter-library loan, and reference services. At least one copy of nearly every NASA and NASA-sponsored publication, either in printed or microfiche format, is received and retained by the 53 regional depositories. A list of the regional GPO libraries, arranged alphabetically by state, appears on the inside back cover of this issue. These libraries are *not* sales outlets. A local library can contact a regional depository to help locate specific reports, or direct contact may be made by an individual.

PUBLIC COLLECTION OF NASA DOCUMENTS

An extensive collection of NASA and NASA-sponsored publications is maintained by the British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England for public access. The British Library Lending Division also has available many of the non-NASA publications cited in *STAR*. European requesters may purchase facsimile copy or microfiche of NASA and NASA-sponsored documents, those identified by both the symbols # and * from ESA — Information Retrieval Service European Space Agency, 8-10 rue Mario-Nikis, 75738 CEDEX 15, France.

STANDING ORDER SUBSCRIPTIONS

NASA SP-7037 supplements and annual index are available from the NASA Center for AeroSpace Information (CASI) on standing order subscription. Standing order subscriptions do not terminate at the end of a year, as do regular subscriptions, but continue indefinitely unless specifically terminated by the subscriber.

ADDRESSES OF ORGANIZATIONS

British Library Lending Division
Boston Spa, Wetherby, Yorkshire
England

Commissioner of Patents and Trademarks
U.S. Patent and Trademark Office
Washington, DC 20231

Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, TN 37830

European Space Agency-
Information Retrieval Service ESRIN
Via Galileo Galilei
00044 Frascati (Rome) Italy

Engineering Sciences Data Unit International
P.O. Box 1633
Manassas, VA 22110

Engineering Sciences Data Unit
International, Ltd.
251-259 Regent Street
London, W1R 7AD, England

Fachinformationszentrum Karlsruhe
Gesellschaft für wissenschaftlich-technische
Information mbH
7514 Eggenstein-Leopoldshafen 2, Germany

Her Majesty's Stationery Office
P.O. Box 569, S.E. 1
London, England

NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934

National Aeronautics and Space Administration
Scientific and Technical Information Program
(JTT)
Washington, DC 20546-0001

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Pendragon House, Inc.
899 Broadway Avenue
Redwood City, CA 94063

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

University Microfilms
A Xerox Company
300 North Zeeb Road
Ann Arbor, MI 48106

University Microfilms, Ltd.
Tylers Green
London, England

U.S. Geological Survey Library National Center
MS 950
12201 Sunrise Valley Drive
Reston, VA 22092

U.S. Geological Survey Library
2255 North Gemini Drive
Flagstaff, AZ 86001

U.S. Geological Survey
345 Middlefield Road
Menlo Park, CA 94025

U.S. Geological Survey Library
Box 25046
Denver Federal Center, MS914
Denver, CO 80225

Page intentionally left blank

CASI PRICE TABLES

STANDARD PRICE DOCUMENTS

PRICE CODE	NORTH AMERICAN PRICE	FOREIGN PRICE
A01	$ 9.00	$ 18.00
A02	12.50	25.00
A03	17.50	35.00
A04-A05	19.50	39.00
A06-A09	27.00	54.00
A10-A13	36.50	73.00
A14-A17	44.50	89.00
A18-A21	52.00	104.00
A22-A25	61.00	122.00
A99	Call For Price	Call For Price

MICROFICHE

PRICE CODE	NORTH AMERICAN PRICE	FOREIGN PRICE
A01	$ 9.00	$ 18.00
A02	12.50	25.00
A03	17.50	35.00
A04	19.50	39.00
A06	27.00	54.00
A10	36.50	73.00

IMPORTANT NOTICE

CASI Shipping and Handling Charges
U.S.—ADD $3.00 per TOTAL ORDER
Canada and Mexico—ADD $3.50 per TOTAL ORDER
All Other Countries—ADD $7.50 per TOTAL ORDER
Does NOT apply to orders
requesting CASI RUSH HANDLING.
CASI accepts most credit/charge cards.

NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934
Telephone: (301) 621-0390
E-mail: help@sti.nasa.gov
Fax: (301) 621-0134

REPORT DOCUMENT PAGE

1. Report No. NASA SP-7037 (301)	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Aeronautical Engineering A Continuing Bibliography (Supplement 301)		5. Report Date February 1994
		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.
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546-0001		13. Type of Report and Period Covered Special Publication
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This report lists 1291 reports, articles and other documents recently announced in the NASA STI Database.

17. Key Words (Suggested by Author(s)) Aeronautical Engineering Aeronautics Bibliographies	18. Distribution Statement Unclassified - Unlimited Subject Category - 01

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	372	A16/HC

For sale by the NASA Center for AeroSpace Information, 800 Elkridge Landing Road, Linthicum Heights, MD 21090-2934

FEDERAL REGIONAL DEPOSITORY LIBRARIES

ALABAMA

AUBURN UNIV. AT MONTGOMERY LIBRARY
Documents Dept.
7300 University Dr.
Montgomery, AL 36117-3596
(205) 244-3650 Fax: (205) 244-0678

UNIV. OF ALABAMA
Amelia Gayle Gorgas Library
Govt. Documents
Box 870266
Tuscaloosa, AL 35487-0266
(205) 348-6046 Fax: (205) 348-8833

ARIZONA

DEPT. OF LIBRARY, ARCHIVES, AND PUBLIC RECORDS
Federal Documents
Third Floor State Capitol
1700 West Washington
Phoenix, AZ 85007
(602) 542-4121 Fax: (602) 542-4400, 542-4500

ARKANSAS

ARKANSAS STATE LIBRARY
State Library Services
One Capitol Mall
Little Rock, AR 72201
(501) 682-2869

CALIFORNIA

CALIFORNIA STATE LIBRARY
Govt. Publications Section
914 Capitol Mall - P.O. Box 942837
Sacramento, CA 94237-0001
(916) 322-4572 Fax: (916) 324-8120

COLORADO

UNIV. OF COLORADO - BOULDER
Norlin Library
Govt. Publications
Campus Box 184
Boulder, CO 83309-0184
(303) 492-8834 Fax: (303) 492-2185

DENVER PUBLIC LIBRARY
Govt. Publications Dept. BS/GPD
1357 Broadway
Denver, CO 80203
(303) 571-2135

CONNECTICUT

CONNECTICUT STATE LIBRARY
231 Capitol Avenue
Hartford, CT 06106
(203) 566-4971 Fax: (203) 566-3322

FLORIDA

UNIV. OF FLORIDA LIBRARIES
Documents Dept.
Library West
Gainesville, FL 32611-2048
(904) 392-0366 Fax: (904) 392-7251

GEORGIA

UNIV. OF GEORGIA LIBRARIES
Govt. Documents Dept.
Jackson Street
Athens, GA 30602
(404) 542-8949 Fax: (404) 542-6522

HAWAII

UNIV. OF HAWAII
Hamilton Library
Govt. Documents Collection
2550 The Mall
Honolulu, HI 96822
(808) 948-8230 Fax: (808) 956-5968

IDAHO

UNIV. OF IDAHO LIBRARY
Documents Section
Moscow, ID 83843
(208) 885-6344 Fax: (208) 885-6817

ILLINOIS

ILLINOIS STATE LIBRARY
Reference Dept.
300 South Second
Springfield, IL 62701-1796
(217) 782-7596 Fax: (217) 524-0041

INDIANA

INDIANA STATE LIBRARY
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 DEPOS.
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. LIB.
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
Aldermman Library
Govt. Documents
Charlottesville, VA 22903-2498
(804) 824-3133 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

POSTMASTER
Address Correction Requested
(Sections 137 and 159 Post Manual)

National Aeronautics and
Space Administration
Code JTT
Washington, DC 20546-0001

Official Business
Penalty for Private Use, $300

BULK RATE
POSTAGE & FEES PAID
NASA
PERMIT No. G-27