NASA SP-7037 (296)
October 1993

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

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

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INTRODUCTION

This issue of *Aeronautical Engineering — A Continuing Bibliography with Indexes* (NASA SP-7037) lists 592 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)	N93-31040 — N93-32425
International Aerospace Abstracts (IAA) (A-10000 Series)	A93-43876 — A93-47550

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 1993 will be published in early 1994.

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

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Category 01 Aeronautics 947

Category 02 Aerodynamics 949
Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

Category 03 Air Transportation and Safety 990
Includes passenger and cargo air transport operations; and aircraft accidents.

Category 04 Aircraft Communications and Navigation 992
Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

Category 05 Aircraft Design, Testing and Performance 995
Includes aircraft simulation technology.

Category 06 Aircraft Instrumentation 999
Includes cockpit and cabin display devices; and flight instruments.

Category 07 Aircraft Propulsion and Power 1001
Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboard auxiliary power plants for aircraft.

Category 08 Aircraft Stability and Control 1006
Includes aircraft handling qualities; piloting; flight controls; and autopilots.

Category 09 Research and Support Facilities (Air) 1010
Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.

Category 10 Astronautics 1015
Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications, spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

Category 11 Chemistry and Materials 1017
Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.

Category 12 Engineering 1020
Includes engineering (general); communications and radar; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

Category 13 Geosciences 1033
Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

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

Category 15 Mathematical and Computer Sciences 1036
Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

Category 16 Physics 1038
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

Category 17 Social Sciences 1041
Includes social sciences (general); administration and management; documentation and information science; economics and cost anaylsis; law, political science, and space policy; and urban technology and transportation.

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

Category 19 General 1041

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER →	N93-10098 * # Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.	← CORPORATE SOURCE
TITLE →	**NAVIER-STOKES DYNAMICS AND AEROELASTIC COMPUTATIONS FOR VORTICAL FLOWS, BUFFET AND AEROELASTIC APPLICATIONS Progress Report, 1 Oct. 1991 - 30 Sept. 1992**	
AUTHOR →	OSAMA A. KANDIL Sep. 1992 38 p	← PUBLICATION DATE
CONTRACT NUMBER →	(Contract NAG1-648)	
REPORT NUMBER →	(NASA-CR-190692; NAS 1.26:190692) Avail: CASI HC A03/MF A01	← AVAILABILITY AND PRICE CODE

The accomplishments achieved during the period include conference and proceedings publications, journal papers, and abstracts which are either published, accepted for publication or under review. Conference presentations and NASA highlight publications are also included. Two of the conference proceedings publications are attached along with a Ph.D. dissertation abstract and table of contents. In the first publication, computational simulation of three-dimensional flows around a delta wing undergoing rock and roll-divergence motions is presented. In the second publication, the unsteady Euler equations and the Euler equations of rigid body motion, both written in the moving frame of reference, are sequetially solved to simulate the limit-cycle rock motion of slender delta wings. In the dissertation abstract, unsteady flows around rigid or flexible delta wings with and without oscillating leading-edge flaps are considered. L.R.R.

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER →	A93-12007 * National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.	← CORPORATE SOURCE
TITLE →	**NUMERICAL SIMULATIONS OF HIGH-SPEED FLOWS ABOUT WAVERIDERS WITH SHARP LEADING EDGES**	
AUTHORS →	KEVIN D. JONES and F. C. DOUGHERTY (Colorado Univ., Boulder)	← AUTHORS' AFFILIATION
JOURNAL TITLE →	Journal of Spacecraft and Rockets (ISSN 0022-4650) vol. 29,	
PUBLICATION DATE →	no. 5 Sept.-Oct. 1992 p. 661-667. Research supported by Univ. of Colorado and DLR refs	
CONTRACT NUMBER →	(Contract NAG1-880) Copyright	

A procedure is developed for the numerical simulation of stagnation-free inviscid supersonic and hypersonic flows about waveriders with sharp leading edges. The numerical approach involves the development of a specialized grid generator (named HYGRID), an algebraic solution-adaptive grid scheme, and a modified flow solving method. A comparison of the results obtained for several waverider geometries with exact solutions, other numerical solutions, and experimental results demonstrated the ability of the new procedure to produce stagnation-free Euler solutions about sharp-edged configurations and to describe the physics of the flow in these regions. I.S.

AERONAUTICAL ENGINEERING

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AERONAUTICS (GENERAL)

A93-44508
DESIGN OF AIRCRAFT, HELICOPTERS, AND AVIATION ENGINES [USTROJSTVO SAMOLETOV, VERTOLETOV I AVIATSIONNYKH DVIGATELEJ]
KIM YA. ORLOV and VIKTOR A. PARKHIMOVICH Moscow Izdatel'stvo Transport 1991 224 p. In RUSSIAN
(ISBN 5-277-01192-7) Copyright
The history of aircraft engineering is briefly reviewed. Attention is given to the main structures of aircraft, powerplants, control systems, and navigation and radio electronic equipment of aircraft and helicopters. The discussion also covers the principal stages of aircraft manufacture, methods of ensuring the reliability and durability of structures, and characteristics and applications of fuels and lubricants. AIAA

A93-45155*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ELEMENTS OF NASA'S HIGH-SPEED RESEARCH PROGRAM
CHRISTINE M. DARDEN, ERIK D. OLSON (NASA, Langley Research Center, Hampton, VA), and ELWOOD W. SHIELDS (Lockheed Engineering & Sciences Co., Hampton, VA) Jul. 1993 19 p. AIAA, Fluid Dynamics Conference, 24th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2942) Copyright
A brief description is given of the history of supersonic transport research, of feasibility studies commissioned by NASA in 1986, and of the NASA High-Speed Research Program which is an outgrowth of those feasibility studies. The paper places particular emphasis on airport and community-noise reduction through advanced takeoff procedures and high-lift devices and sonic-boom reduction through configuration design. Sonic-boom acceptability studies and atmospheric propagation methods are also discussed. Author

A93-45659
PROBLEMS IN THE AERODYNAMICS, STRENGTH, AND FLIGHT OPERATIONS OF AIRCRAFT [VOPROSY AEHRODINAMIKI, PROCHNOSTI I LETNOJ EHKSPLUATATSII VOZDUSHNYKH SUDOV]
S. YU. SKRIPNICHENKO, ED. Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii (GosNIIGA, Trudy, No. 300) 1991 104 p. In RUSSIAN For individual items see A93-45660 to A93-45675
Copyright
The papers presented in this volume focus on the methodological aspects and results of the flight testing of civil aircraft, aircraft operation, monitoring of the condition of runways, and problems of fuel efficiency in flight operations. Other topics discussed include the prediction of fatigue crack growth kinetics in the structural elements of aircraft under biaxial loading, calculation of the position of the aircraft center of gravity on an IBM PC computer, spectroscopic analysis of aircraft loading in ground operations, and calculation of safe altitudes. AIAA

A93-45772
STRUCTURAL INTEGRITY OF AGING AIRPLANES
SATYA N. ATLURI, ED. (Georgia Inst. of Technology, Atlanta), SAM G. SAMPATH, ED., and PIN TONG, ED. (DOT, Transportation Systems Center, Cambridge, MA) Berlin and New York Springer-Verlag 1991 507 p. For individual items see A93-45773 to A93-45800
(ISBN 0-540-53461-X) Copyright
The present volume discusses computational schemes for fuselage panel integrity analysis, risk analyses for aging aircraft fleets, civil aircraft damage tolerance requirements, exfoliation corrosion of fatigued structural aluminum, damage tolerance in aging gas turbines, the NASA airframe structural integrity program, bonded repairs of multisite damage, and the application of advanced fracture mechanics to fuselages. Also treated are axial crack propagation and arrest in pressurized fuselages, fracture in the presence of lap-splice multiple site damage, a fractographic analysis of the initiation and growth of fatigue cracks at rivet holes, estimation of inspection interval requirements for panels with multiple site damage susceptibility, specifying and prolonging airframe time limits, and repair methods for damage-tolerant aircraft. AIAA

A93-45781
AGING JET TRANSPORT STRUCTURAL EVALUATION PROGRAMS
ULF G. GORANSON and MATTHEW MILLER (Boeing Commercial Airplane Group, Seattle, WA) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 131-140.
Copyright
The practices commonly used by the Boeing company for aircraft structural integrity encompass, in addition to overhaul recommendations in maintenance manuals and service bulletins, durability and damage tolerance technology standards applicable by large teams of structural engineers to aircraft that have exceeded their service life objectives and fatigue and corrosion become widespread. Attention is here given to preventive maintenance recommendations that encompass major tests and teardowns, corrosion-control programs, and supplemental structural inspections. AIAA

A93-45786
BONDED REPAIR OF MULTI-SITE DAMAGE
R. JONES, N. BRIDGEFORD, G. WALLACE, and L. MOLENT (Defence Science and Technology Organisation, Aeronautical Research Lab., Melbourne, Australia) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 199-212. refs
Copyright
Repairs using bonded composites have numerous advantages over mechanically fastened repairs. Adhesive bonding does not result in stress concentrations due to additional fastener holes. Composites are readily formed into complex shapes, permitting the repair of irregular components. In service damage monitoring is possible, with the appropriate fiber matrix system, by direct inspection through the repair using eddy current methods or by thermal emission measurements. This paper presents a bonded repair for fuselage lap joints containing multi-site damage. The

A B S T R A C T S

effectiveness of this repair is confirmed by the results of a laboratory test program.

A93-45789
STRUCTURAL INTEGRITY OF AGING AIRPLANES - A PERSPECTIVE
JAMES W. MAR (MIT, Cambridge, MA) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 241-262.
Copyright
An overview is presented of fail-safe design practices used by aircraft structural engineers to maximize structural integrity at the end of design service life periods. Attention is given to the December 22, 1969 in-flight structural failure of an F-111 wing pivot fitting, which led to the separation of the left wing after mere 107 flight hours, as well as to wing cracking problems encountered with the C-5A airlifter and B 707 horizontal stabilizer. Recommendations are made for aging fleet structural maintenance. AIAA

A93-45793
RESULTS OF REVIEW OF FOKKER F 28 'FELLOWSHIP' MAINTENANCE PROGRAM
R. ROLL, A. VAN DALEN, and A. A. JONGEBREUR (Fokker Aircraft, Schiphol, Netherlands) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 309-320.
Copyright
The F 28 commuter airliner makes extensive use of bonded structure. An account is presently given of the environmental protection and full-scale test programs conducted for all major F 28 components, as well as the mandatory fatigue inspection document that accompanies the aircraft. A corrosion-control program is being instituted that addresses specific concerns with critical, corrosion-sensitive areas of the F 28 structure. Attention is given to international maintenance task force activity. AIAA

A93-45795
ESTIMATION OF REQUIREMENTS OF INSPECTION INTERVALS FOR PANELS SUSCEPTIBLE TO MULTIPLE SITE DAMAGE
S. SAMPATH (DOT, Transportation Systems Center, Cambridge, MA) and D. BROEK (FractuResearch, Inc., Galena, OH) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 339-389. refs
Copyright
The objectives of the work reported in this paper were to assess the probability of detection of Multi-Site Damage (MSD) in fuselage lap-splices in aging airplanes. The results indicate that a reduction in the mandated period between inspections should be considered. Perforce, the model had to rely on NDI inspection reliability measured on samples devoid of MSD. A recommendation is made for a program to acquire such data for MSD.

A93-45796
EVALUATION METHODOLOGIES APPLIED FOR PRESSURIZED FUSELAGES OF AIRBUS A/C
H.-J. SCHMIDT (Airbus Industrie, Blagnac, France; Deutsche Airbus GmbH, Hamburg, Germany) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 391-407.
Copyright
An account is given of the implementation of FAR amendment 45 and JAR 25.571, concerning damage-tolerance requirements, for recent Airbus airliners, giving attention to the calculation methods used and the employment of full-scale fatigue testing for certification. Special investigations have been conducted to evaluate the effects of corrosion on airframe fatigue and crack propagation. Activities associated with aging-related structural inspection programs which study the effects of periodic pressurized fuselage overloads on fatigue and crack-propagation behavior. AIAA

A93-45797
EXPERIENCE IN SPECIFYING/PROLONGING THE AIRFRAME TIME LIMITS
A. F. SELIKHOV, V. L. RAJKHER, V. G. LEJBOV, and G. I. NESTERENKO (TsAGI, Zhukovski, Russia) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 409-419.
Copyright
An overview is presented of airframe fatigue-related design practices of Soviet transport aircraft manufacturers since the 1950s. Soviet-period practices differ from those adopted throughout the world in that an airframe is considered to have begun aging from the very outset of fleet service. Attention is given to the methodological and managerial basis of the system, encompassing an onboard fatigue-loading meter, full-scale testing, and the system of 'reliability coefficients'. AIAA

A93-45799
REPAIRS TO DAMAGE TOLERANT AIRCRAFT
T. SWIFT (FAA, Long Beach, CA) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 433-483. refs
Copyright
The ways in which structural repairs can unwittingly degrade the fatigue-initiation life and damage tolerance capability of transport aircraft primary structures are here discussed in light of the results of a displacement compatibility analysis for various repair-doubler and lap-splice configurations. Fatigue-initiation life is directly related to peak loads induced in the first fastener rows, at the edges of repair doublers. Critical fastener loads are parametrically presented for a range of skin and doubler thicknesses, and guidelines are given for ways in which repair designs can be modified to improve fatigue-initiation life and subsequent fatigue-crack detectability. AIAA

A93-45800
CASE STUDY AND SIMULATION OF FATIGUE DAMAGES AND DTE OF AGING AIRCRAFT - A REVIEW OF RESEARCHES IN JAPAN
H. TERADA (National Aerospace Lab., Chofu, Japan) and K. OHTSUKA (Association of Air Transport Engineering and Research, Tokyo, Japan) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 485-496. refs
Copyright
This is a review paper on the study of aging aircraft structures conducted in Japan. The paper consists of four parts. Part 1 is the event report of aging aircraft structural damages. Part 2 describes fatigue strength evaluation technique and the evaluation of nondestructive inspection method. Part 3 presents investigation for SID of YS-11, turbo-prop transport. Part 4 presents crack propagation of riveted joint with initial damage simulating multisite damage. Author (revised)

A93-46608 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PASSIVE RANGE ESTIMATION FOR ROTORCRAFT LOW-ALTITUDE FLIGHT
B. SRIDHAR, R. SUORSA, and B. HUSSIEN (NASA, Ames Research Center, Moffett Field, CA) Machine Vision and Applications (ISSN 0932-8092) vol. 6 1993 p. 10-24. Previously announced in STAR as N92-10003 refs
(Contract RTOP 505-66-11)
Copyright
The automation of rotorcraft low-altitude flight presents challenging problems in control, computer vision and image understanding. A critical element in this problem is the ability to detect and locate obstacles, using on-board sensors, and modify the nominal trajectory. This requirement is also necessary for the safe landing of an autonomous lander on Mars. This paper examines some of the issues in the location of objects using a sequence of images from a passive sensor, and describes a Kalman filter approach to estimate the range to obstacles. The Kalman filter is also used to track features in the images leading to a

significant reduction of search effort in the feature extraction step of the algorithm. The method can compute range for both straight line and curvilinear motion of the sensor. A laboratory experiment was designed to acquire a sequence of images along with sensor motion parameters under conditions similar to helicopter flight. Range estimation results using this imagery are presented.

N93-32232# Wichita State Univ., KS. National Inst. for Aviation Research.
INTERNATION AIRCRAFT OPERATOR INFORMATION SYSTEM Final Report
JOHN J. HUTCHINSON, JOHN M. ELLIS, YAN YANG, JIM NORTH, and LISA ONG Apr. 1993 132 p
(DOT/FAA/CT-93/4) Avail: CASI HC A07/MF A02

The purpose of this program is to deliver to the Federal Aviation Administration (FAA) an automated information system which will provide useful aircraft information on all United States type certificated aircraft worldwide. The product is a system which is periodically updated and accessible to all FAA offices. The system makes use of commercially available data and other data from the public domain. From these data over 70 different tables were created and maintained. In order to identify aircraft, a unique coding system was created which extends the Aviation Safety Analysis System (ASAS) to all the world's aircraft. A similar coding system was created to identify and validate the names of the owners and operators of aircraft. In order for the FAA to use this information, a series of menu driven forms was created. FAA personnel can log into the system via modem to obtain and download a variety of reports. A user knowledgeable in Oracle can also prepare and download specialized reports without compromising the security of the system. Author

N93-32404* National Aeronautics and Space Administration, Washington, DC.
EUROPEAN AEROSPACE SCIENCE AND TECHNOLOGY, 1992: A BIBLIOGRAPHY WITH INDEXES
Jun. 1993 485 p
(NASA-SP-7105; NAS 1.21:7105) Avail: CASI HC A21

This bibliography contains 1916 annotated references to reports and journal articles of European intellectual origin entered into the NASA Scientific and Technical Information System during 1992. Representative subject areas include: spacecraft and aircraft design, propulsion technology, chemistry and materials, engineering and mechanics, earth and life sciences, communications, computers and mathematics, and the natural space sciences. Author (revised)

02

AERODYNAMICS

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

A93-44099* National Aeronautics and Space Administration, Washington, DC.
IT'S TIME TO GO SUPERSONIC
DANIEL S. GOLDIN (NASA, Washington) Air & Space (ISSN 0886-2257) vol. 8, no. 2 June-July 1993 p. 54, 55.
Copyright

An overview is presented of the most compelling technological and economic arguments for NASA's agressive coordination of an SST-development program that would enlist all available U.S. aerospace industry resources. Attention is given to the minimization of upper atmosphere pollution through the use of low-NO(x) emission combustors and the reduction of sonic boom through wing/fuselage optimization. It is projected that a successful SST program would boost U.S. civil aircraft market share to nearly 80 percent; this represents the creation of 140,000 new jobs. AIAA

A93-44227*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ZONALLY-DECOUPLED DSMC SOLUTIONS OF HYPERSONIC BLUNT BODY WAKE FLOWS
RICHARD G. WILMOTH, ROBERT A. MITCHELTREE, JAMES N. MOSS (NASA, Langley Research Center, Hampton, VA), and VIRENDRA K. DOGRA (Vigyan, Inc., Hampton, VA) Jul. 1993 12 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2808) Copyright

Direct simulation Monte Carlo (DSMC) solutions are presented for the hypersonic flow behind a blunt body in which the wake region is solved in a zonally-decoupled manner. The forebody flow is solved separately using either a DSMC or a Navier-Stokes method, and the forebody exit plane solution is specified as the inflow condition to the decoupled DSMC solution of the wake region. Results are presented for a 70-deg, blunted cone at flow conditions that can be accommodated in existing low-density wind tunnels with the Knudsen number based on base diameter ranging from 0.03 to 0.001. The zonally-decoupled solutions show good agreement with fully-coupled DSMC solutions of the wake flow densities and velocities. The wake closure predicted by the zonally-decoupled solutions is in better agreement with fully-coupled results than that predicted by a fully-coupled Navier-Stokes method indicating the need to account for rarefaction in the wake for the cases considered. The combined use of Navier-Stokes for the forebody with a decoupled DSMC solution for the wake provides an efficient method for solving transitional blunt-body flows where the forebody flow is continuum and the wake is rarefied. Author

A93-44228*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN APPROXIMATE METHOD FOR CALCULATING HEATING RATES ON THREE-DIMENSIONAL VEHICLES
H. H. HAMILTON, II, FRANCIS A. GREENE (NASA, Langley Research Center, Hampton, VA), and FRED R. DEJARNETTE (North Carolina State Univ., Raleigh) Jul. 1993 16 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2881) Copyright

An approximate method for calculating heating rates on three-dimensional vehicles at angle of attack is presented. The method is based on the axisymmetric analog for three-dimensional boundary layers and uses a generalized body fitted coordinate system. Edge conditions for the boundary layer solution are obtained from an inviscid flowfield solution, and because of the coordinate system used the method is applicable to any blunt body geometry for which a inviscid flowfield solution can be obtained. It is validated by comparing with experimental heating data and with Navier-Stokes calculations on the Shuttle orbiter at both wind tunnel and flight conditions and with Navier-Stokes calculations on the HL-20 at wind tunnel conditions. Author

A93-44229*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
UNSTRUCTURED GRIDS FOR SONIC-BOOM ANALYSIS
KAMRAN FOULADI (Lockheed Engineering and Sciences Co., Hampton, VA) Jul. 1993 13 p. AIAA, Fluid Dynamics Conference, 24th, Orlando, FL, July 6-9, 1993 refs
(Contract NAS1-19000)
(AIAA PAPER 93-2929) Copyright

A fast and efficient unstructured grid scheme is evaluated for sonic-boom applications. The scheme is used to predict the near-field pressure signatures of a body of revolution at several body lengths below the configuration, and those results are compared with experimental data. The introduction of the 'sonic-boom grid topology' to this scheme make it well suited for sonic-boom applications, thus providing an alternative to conventional multiblock structured grid schemes. Author

A93-44232#
UNSTRUCTURED GRIDS ON NURBS SURFACES

JAMSHID SAMAREH-ABOLHASSANI (Computer Sciences Corp., Hampton, VA) Aug. 1993 12 p. AIAA, Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993 refs
(AIAA PAPER 93-3454)

A simple and efficient computational method for unstructured surface grid generation based on a combination of an advancing front technique and a projection technique that uses a Newton-Raphson method is presented. Two test cases are considered: the projection of an unstructured grid on bilinear surfaces and the projection of a grid for an X-15 configuration onto ten NURBS (non-uniform rational B-splines) surfaces. It is concluded that the proposed projection technique makes it possible to generate structured and unstructured grids on CAD surfaces. AIAA

A93-44374
THREE-DIMENSIONAL CALCULATION OF A HYDROGEN JET INJECTION INTO A SUPERSONIC AIR FLOW
A. K. HAYASHI and MASAHIRO TAKAHASHI (Nagoya Univ., Japan) *In* Dynamics of gaseous combustion; International Colloquium on Dynamics of Explosions and Reactive Systems, 13th, Nagoya, Japan, July 28-Aug. 2, 1991, Technical Papers Washington American Institute of Aeronautics and Astronautics, Inc. 1993 p. 402-412. refs
Copyright

Three-dimensional, Reynolds averaged, full Navier-Stokes equations with an algebraic eddy viscosity model of Baldwin and Lomax are integrated to simulate a secondary hydrogen jet transversely injected into a supersonic air flow. The second-order implicit Harten-Yee type total variation diminishing (TVD) scheme and the second-order central difference scheme are used to difference the convective and viscous terms, respectively. The numerical results are investigated to understand the three-dimnensional flowfield of the interaction between the main and injected flows. The results show the three-dimensional phenomena such as a secondary vortex underneath the primary vortex. The recirculations are predicted at several places, some of which are not detected in the two-dimensional calculation. Author

A93-44375
COMPRESSIBILITY, EXOTHERMICITY, AND THREE DIMENSIONALITY IN SPATIALLY EVOLVING REACTIVE SHEAR FLOWS
F. F. GRINSTEIN and K. KAILASANATH (U.S. Navy, Naval Research Lab., Washington) *In* Dynamics of gaseous combustion; International Colloquium on Dynamics of Explosions and Reactive Systems, 13th, Nagoya, Japan, July 28-Aug. 2, 1991, Technical Papers Washington American Institute of Aeronautics and Astronautics, Inc. 1993 p. 413-436. Research supported by U.S. Navy refs

The effects of chemical-reaction exothermicity, diffusive transport, free stream reactant molar fraction, and three-dimensional spanwise excitation on shear layer growth in reactive flows were investigated. Numerical simulations of a compressible, subsonic reactive mixing layer were carried out using modeling of basic diffusive transport and chemical processes. Results indicate that energy release reduces shear layer growth and the amount of chemical product formed. It is suggested that expansion effects influence the Kelvin-Helmholtz growth rates by increasing the initial vorticity thickness of the shear layer. Enhanced entrainment and chemical production may be obtained by introducing sinusoidal spanwise perturbation of inflowing streams. These simulations allow an improved characterization of fluid dynamical processes and mechanisms effecting combustion in reactive turbulent shear flows. AIAA

A93-44999#
COMPUTATIONS OF INVISCID COMPRESSIBLE FLOWS USING FLUCTUATION-SPLITTING ON TRIANGULAR MESHES
H. PAILLERE, H. DECONINCK, R. STRUIJS (Von Karman Inst. for Fluid Dynamics, Rhode-St.-Genese, Belgium), P. L. ROE, L. M. MESAROS, and J.-D. MUELLER (Michigan Univ., Ann Arbor) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 36-50. refs
(Contract CEC-AER2-CT92-0040/PL-2037)
(AIAA PAPER 93-3301) Copyright

The multidimensional upwind approach for the Euler equations discussed in this paper generalizes to 2D the well-known flux difference scheme of Roe. The method, which uses grids composed of triangles, is based on a conservative decomposition of the flux balance for each cell into scalar wave contributions, which are then upwinded to the vertices using a high-resolution compact monotone scalar advection scheme. Whereas the advection part and the conservative linearization have been extensively treated in the past, the present paper concentrates on the choice of the wave model generalizing the characteristic decomposition at the base of the ID flux difference splitters. Contrary to the ID case, many possibilities exist and a thorough review and comparison of existing and new models are given, emphasizing performance in subsonic as well as supersonic flows. The numerical results presented for a wide range of internal and external flows show the strong potential of the method. Author

A93-45000*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FIELD BY FIELD HYBRID UPWIND SPLITTING METHODS
FREDERIC COQUEL (ONERA, Chatillon, France) and MENG-SING LIOU (NASA, Lewis Research Center, Cleveland, OH) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 51-61. refs
(AIAA PAPER 93-3302) Copyright

A new and general approach to upwind splitting is presented. The design principle combines the robustness of flux vector splitting schemes in the capture of nonlinear waves and the accuracy of some flux difference splitting schemes in the resolution of linear waves. The new schemes are derived following a general hybridization technique performed directly at the basic level of the field by field decomposition involved in FDS methods. The scheme does not use a spatial switch to be tuned up according to the local smoothness of the approximate solution. AIAA

A93-45001*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A MULTI-DIMENSIONAL KINETIC-BASED UPWIND SOLVER FOR THE EULER EQUATIONS
W. M. EPPARD and B. GROSSMAN (Virginia Polytechnic Inst. and State Univ., Blacksburg) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 62-80. refs
(Contract NAG1-776)
(AIAA PAPER 93-3303) Copyright

A multidimensional kinetic fluctuation-splitting scheme has been developed for the Euler equations. The scheme is based on an N-scheme discretization of the Boltzmann equation at the kinetic level for triangulated Cartesian meshes with a diagonal-adaptive strategy. The resulting Euler scheme is a cell-vertex fluctuation-splitting scheme where fluctuations in the conserved-variable vector Q are obtained as moments of the fluctuation in the Maxwellian velocity distribution function at the kinetic level. Encouraging preliminary results have been obtained for perfect gases on Cartesian meshes with first-order spatial accuracy. The present approach represents an improvement to the well-established dimensionally-split upwind schemes. AIAA

A93-45002#
NEW UPWIND DISSIPATION MODELS WITH A MULTIDIMENSIONAL APPROACH
P. VAN RANSBEECK and CH. HIRSCH (Brussel, Vrije Univ., Brussels, Belgium) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and

Astronautics 1993 p. 81-91. refs
(Contract CEC-AERO-0003; CEC-AERO-2037-P)
(AIAA PAPER 93-3304) Copyright

A new class of upwind dissipation models based on a genuinely 2D space discretization are constructed in a cell-centered structured context for solving the Euler/Navier-Stokes equations. In contrast with grid-dependent classical methods, where a 2D problem is solved by superposition of 1 D dissipation models along the meshlines, the 2D upwind dissipation models are based on a multidimensional flux extrapolation. This leads to additional dissipation terms containing 2nd and 3rd mixed differences. The 2D models are based on a family of 1st and 2nd order compact upwind algorithms for a scalar linear convection equation. Conditions are given for monotone 2nd order dissipation models using non-linear classical limiters applied to 2D ratios of flux differences in both mesh directions. Extension to the Euler equations consists of applying the scalar dissipation model to each of the 4 characteristic wave equations constructed by a diagonalization method. Application of the 2D upwind models to supersonic, transonic and subsonic inviscid testcases shows a better accuracy in comparison with ID upwind dissipation models.
Author

A93-45003*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AN EXTENDED LAGRANGIAN METHOD

MENG-SING LIOU (NASA, Lewis Research Center, Cleveland, OH) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 92-105. refs
(AIAA PAPER 93-3305)

A unique formulation of describing fluid motion is presented. The method, referred to as 'extended Lagrangian method', is interesting from both theoretical and numerical points of view. The formulation offers accuracy in numerical solution by avoiding numerical diffusion resulting from mixing of fluxes in the Eulerian description. Meanwhile, it also avoids the inaccuracy incurred due to geometry and variable interpolations used by the previous Lagrangian methods. The present method is general and capable of treating subsonic flows as well as supersonic flows. The method proposed in this paper is robust and stable. It automatically adapts to flow features without resorting to clustering, thereby maintaining rather uniform grid spacing throughout and large time step. Moreover, the method is shown to resolve multidimensional discontinuities with a high level of accuracy, similar to that found in 1D problems.
Author (revised)

A93-45010#

ADAPTIVE-PRISMATIC-GRID METHOD FOR EXTERNAL VISCOUS FLOW COMPUTATIONS

KAZUHIRO NAKAHASHI (Osaka Prefecture Univ., Sakai, Japan) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 195-203. refs
(AIAA PAPER 93-3314) Copyright

A new approach to compute external viscous flow fields around an airplane is discussed. Three-dimensional flow field is discretized using a prismatic grid where the bases of the grid cells are triangles that cover the three-dimensional surface in an unstructured manner. The direction away from the body surface is structured so as to achieve efficient and accurate computations for high-Reynolds number viscous flows. The unstructured surface grid allows a solution-adaptive grid refinement for the accuracy improvement. The prismatic grid is generated by a marching-type procedure in which grid spacings are controlled by a variational method. The flow field is computed using a finite-volume method. The capability of the method is demonstrated by applying it to a viscous flow computation around an aircraft configuration.
Author

A93-45011#

AN IMPLICIT TIME-MARCHING PROCEDURE FOR HIGH SPEED FLOW

D. C. LOBAO (Inst. de Aeronautica e Espacio, Sao Jose dos Campos, Brazil) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 204-213. Research supported by Inst. de Aeronautica e Espaco refs
(AIAA PAPER 93-3315) Copyright

A new implicit TVD-LU factorization finite difference algorithm applied to three dimensional Euler equations in general curvilinear coordinates is presented for internal supersonic flow in a arc bamp box and external supersonic freestream flow about blunt body geometries. The principal difference between the popular LU scheme which follows initially the ideas of the alternating direction implicit scheme lies in the form of the approximate factoring of the implicit operator associated with the TVD 'smart' dissipation terms which make a such scheme diagonally dominant. With this new scheme there is no need at all to provide any kind of mathematical artifact in order to assure diagonal dominance to the implicit operators. This new numerical TVD-LU scheme is an efficient and robust nonoscillatory shock capturing technique for high Mach number flows.
Author

A93-45012#

VARIANT BI-CONJUGATE GRADIENT METHODS FOR THE COMPRESSIBLE NAVIER-STOKES SOLVER WITH A TWO-EQUATION MODEL OF TURBULENCE

HERNG LIN, D. Y. YANG, and CHING-CHANG CHIENG (National Tsing Hua Univ., Hsinchu, Taiwan) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 214-222. refs
(AIAA PAPER 93-3316) Copyright

Three variants of preconditioned biconjugate gradient methods have been successfully implemented in compressible Navier-Stokes solvers with a k-epsilon two-equation model for transonic separated flows. It is found that convergence characteristics are largely improved by the application of the biconjugate gradient stable method and the transpose of free quasi-minimal residual method, as compared with the approximated factorization method or even the conjugate gradient squared method. The improvement makes the computation of the complex turbulent flow with the two-equation model of turbulence feasible with regard to computer time and accuracy.
AIAA

A93-45013*# National Aeronautics and Space Administration, Washington, DC.

A COARSE-GRID CORRECTION/NONLINEAR RELAXATION ALGORITHM FOR THE THREE-DIMENSIONAL, COMPRESSIBLE NAVIER-STOKES EQUATIONS

JACK R. EDWARDS and D. S. MCRAE (North Carolina State Univ., Raleigh) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 223-233. Research supported by USAF and U.S. Navy refs
(Contract NAGW-1072)
(AIAA PAPER 93-3317) Copyright

A combined coarse-grid correction/upwind relaxation strategy to provide rapid convergence for 3D high-speed viscous flowfields is discussed an evaluated. The construction and analysis of a simple two-grid acceleration procedure based on 'hyperbolic' multigrid concepts is presented. Numerical simulations of a 2D compression-corner flowfield, a 3D crossing shock/turbulent boundary layer interaction, and a 3D scramjet inlet flowfield are presented to illustrate the benefits of the approach. Results indicate that the procedure generally converges two or more times faster than the baseline algorithm.
AIAA

A93-45014*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TWO-DIMENSIONAL CFD MODELING OF WAVE ROTOR FLOW DYNAMICS
GERARD E. WELCH and RODRICK V. CHIMA (NASA, Lewis Research Center, Cleveland, OH) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 234-247. refs
(AIAA PAPER 93-3318) Copyright
A two-dimensional Navier-Stokes solver developed for detailed study of wave rotor flow dynamics is described. The CFD model is helping characterize important loss mechanisms within the wave rotor. The wave rotor stationary ports and the moving rotor passages are resolved on multiple computational grid blocks. The finite-volume form of the thin-layer Navier-Stokes equations with laminar viscosity are integrated in time using a four-stage Runge-Kutta scheme. The Roe approximate Riemann solution scheme or the computationally less expensive Advection Upstream Splitting Method (AUSM) flux-splitting scheme are used to effect upwind-differencing of the inviscid flux terms, using cell interface primitive variables set by MUSCL-type interpolation. The diffusion terms are central-differenced. The solver is validated using a steady shock/laminar boundary layer interaction problem and an unsteady, inviscid wave rotor passage gradual opening problem. A model inlet port/passage charging problem is simulated and key features of the unsteady wave rotor flow field are identified. Lastly, the medium pressure inlet port and high pressure outlet port portion of the NASA Lewis Research Center experimental divider cycle is simulated and computed results are compared with experimental measurements. The model accurately predicts the wave timing within the rotor passage and the distribution of flow variables in the stationary inlet port region. Author

A93-45016*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AERODYNAMIC SHAPE OPTIMIZATION USING PRECONDITIONED CONJUGATE GRADIENT METHODS
GREG W. BURGREEN and OKTAY BAYSAL (Old Dominion Univ., Norfolk, VA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 278-288. refs
(Contract NAG1-1188)
(AIAA PAPER 93-3322) Copyright
In an effort to further improve upon the latest advancements made in aerodynamic shape optimization procedures, a systematic study is performed to examine several current solution methodologies as applied to various aspects of the optimization procedure. It is demonstrated that preconditioned conjugate gradient-like methodologies dramatically decrease the computational efforts required for such procedures. The design problem investigated is the shape optimization of the upper and lower surfaces of an initially symmetric (NACA-012) airfoil in inviscid transonic flow and at zero degree angle-of-attack. The complete surface shape is represented using a Bezier-Bernstein polynomial. The present optimization method then automatically obtains supercritical airfoil shapes over a variety of freestream Mach numbers. Furthermore, the best optimization strategy examined resulted in a factor of 8 decrease in computational time as well as a factor of 4 decrease in memory over the most efficient strategies in current use. Author

A93-45017*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CALCULATION OF OPTIMUM AIRFOILS USING DIRECT SOLUTIONS OF THE NAVIER-STOKES EQUATIONS
FORT F. FELKER (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 289-296. refs
(AIAA PAPER 93-3323) Copyright
A method has been developed which calculates the optimum airfoil shape at a specified operating condition. The Reynolds-averaged Navier-Stokes equations with a turbulence model are used as the governing equations for the fluid flow, and are explicitly introduced into the optimization analysis as constraint equations. The locations of all grid points which define the surface of the airfoil are design variables, eliminating the need for shape functions to describe changes in the airfoil geometry. A generalized reduced-gradient method is used to find the optimum airfoil shape. The use of a direct solution technique (Newton's method) to solve the Navier-Stokes equations allows for the efficient solution of the problem. This paper describes the optimization method and presents sample results. Author

A93-45018#
NUMERICAL EXPERIMENT OF THE FLIGHT TRAJECTORY SIMULATION BY FLUID DYNAMICS AND FLIGHT DYNAMICS COUPLING
KOZO FUJII (Inst. of Space and Astronautical Science, Sagamihara, Japan) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 297-308. refs
(AIAA PAPER 93-3324) Copyright
A flight trajectory computation was performed by simultaneously solving the flight dynamics and fluid dynamics equations for a 2D airfoil using the Adams-Bashforth time integration method. The results indicate that the approach needs further study. The integration of time-accurate Navier-Stokes equations with the method should be done carefully even for the linear region of the flight path. AIAA

A93-45022#
PROGRESS IN LOCAL PRECONDITIONING OF THE EULER AND NAVIER-STOKES EQUATIONS
DOHYUNG LEE and BRAM VAN LEER (Michigan Univ., Ann Arbor) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 338-348. Research sponsored by USAF refs
(AIAA PAPER 93-3328) Copyright
Research in local preconditioning of the Euler equations is reported. Analysis shows that there are a large number of DOFs available in designing Euler preconditioners. For obtaining the most optimal preconditioner, minimum deviation from the associated eigenvector orthogonality must be obtained as well as minimum spread of characteristic speeds. A study of the cell aspect ratio effect reveals that obtaining an ideal wavefront is restrictive even though many DOFs are utilized. Difference scheme-based analysis instead of the PDE-based one not only improves the Euler preconditioning but also enable Navier-Stokes (NS) preconditioning to be developed from the Euler preconditioning. The idea of making the size of Fourier footprint independent of the cell Reynolds number is analyzed and demonstrated in first and higher-order schemes for NS preconditioning. AIAA

A93-45023#
PSEUDO-COMPRESSIBILITY METHODS FOR THE INCOMPRESSIBLE FLOW EQUATIONS
E. TURKEL (Tel Aviv Univ., Israel) and A. ARNONE (Florence Univ., Italy) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 349-357. refs
(AIAA PAPER 93-3329) Copyright
We consider preconditioning methods to accelerate convergence to a steady state for the incompressible fluid dynamic equations. The analysis relies on the inviscid equations. The preconditioning consists of a matrix multiplying the time derivatives. Thus the steady state of the preconditioned system is the same as the steady state of the original system. We compare our method to other types of pseudo- compressibility. For finite difference

methods preconditioning can change and improve the steady state solutions. An application to viscous flow around a cascade with a non-periodic mesh is presented. Author

A93-45025#

NUMERICAL WAVE PROPAGATION AND STEADY STATE SOLUTIONS. II - BULK VISCOSITY DAMPING

K. MAZAHERI and P. L. ROE (Michigan Univ., Ann Arbor) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 375-384. refs
(AIAA PAPER 93-3331) Copyright

Error waves in the computational field may be damped by adding a bulk viscosity term to the momentum equations. We analyze the effects on the linearized differential equations, and study its explicit and implicit implementations in one space dimension. Optimum values of the Bulk Viscosity Damping (BVD) coefficients are discussed. After generalizing the idea to two space dimensions, its performance both alone and in combination with a soft wall boundary condition and residual smoothing in central differencing codes is reviewed. It is shown that BVD is complementary to residual smoothing, and acts independently of it. It is also shown how this new term can stabilize and accelerate the computation of low Mach number flows. Author

A93-45027*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

EULER SOLUTIONS FOR BLUNT BODIES USING TRIANGULAR MESHES - ARTIFICIAL VISCOSITY FORMS AND NUMERICAL BOUNDARY CONDITIONS

R. WINTERSTEIN and M. HAFEZ (California Univ., Davis) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 394-410. refs
(Contract NCA2-663; NCA2-644)
(AIAA PAPER 93-3333) Copyright

A finite volume method is used to calculate compressible inviscid flows over blunt bodies using, in general, unstructured grids. Artificial viscosity forms are derived based on a simplified least squares procedure. The extra second order terms are consistent with the governing equations, hence a systematic treatment of the numerical boundary conditions can be easily implemented. A special treatment of blunt bodies may be required. The discrete equations are linearized and the resulting system is solved by a relaxation method. Preliminary results indicate that the effect of the numerical dissipation is minimal. For subsonic flows over smooth bodies, the solution is practically vorticity-free and the total pressure loss is of the same order as the truncation error. Finally, some extensions of the present method are briefly discussed. Author

A93-45028*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SURFACE BOUNDARY CONDITIONS FOR THE NUMERICAL SOLUTION OF THE EULER EQUATIONS

A. DADONE (Bari, Politecnico, Italy) and B. GROSSMAN (Virginia Polytechnic Inst. and State Univ., Blacksburg) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 411-422. Research supported by MURST refs
(Contract NSF INT-88-14895; NAG1-776)
(AIAA PAPER 93-3334) Copyright

We consider the implementation of boundary conditions at solid walls in inviscid Euler solutions by upwind, finite-volume methods. We review some current methods for the implementation of surface boundary conditions and examine their behavior for the problem of an oblique shock reflecting off a planar surface. We show the importance of characteristic boundary conditions for this problem and introduce a method of applying the classical flux-difference splitting of Roe as a characteristic boundary condition. Consideration of the equivalent problem of the intersection of two (equal and opposite) oblique shocks was very illuminating on the role of surface boundary conditions for an inviscid flow and led to the introduction of two new boundary-condition procedures, denoted as the symmetry technique and the curvature-corrected symmetry technique. Examples of the effects of the various surface boundary conditions considered are presented for the supersonic blunt body problem and the subcritical compressible flow over a circular cylinder. Dramatic advantages of the curvature-corrected symmetry technique over the other methods are shown, with regard to numerical entropy generation, total pressure loss, drag and grid convergence. Author

A93-45029*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AN ACCURACY ASSESSMENT OF CARTESIAN-MESH APPROACHES FOR THE EULER EQUATIONS

WILLIAM J. COIRIER (NASA, Lewis Research Center, Cleveland, OH) and KENNETH G. POWELL (Michigan Univ., Ann Arbor) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 423-437. refs
(AIAA PAPER 93-3335) Copyright

A critical assessment of the accuracy of Cartesian-mesh approaches for solving the Euler equations is made. An exact solution of the Euler equations (Ringleb's flow) is used not only to infer the order of error of the Cartesian mesh approaches, but also to compare the magnitude of the error directly to that obtained with a structured mesh approach. The effect of cell merging is investigated as well as the use of two different K-exact reconstruction procedures. The solution methodology of the schemes is explained and tabulated results are presented to compare the solution accuracies. Adaptive and uniform mesh refinement is evaluated for Ringleb's flow and the supersonic flow through an axisymmetric inlet. Author

A93-45030#

AN EFFICIENT METHOD TO CALCULATE ROTOR FLOW IN HOVER AND FORWARD FLIGHT

DONG-HO LEE and SEONG-HWAN KIM (Seoul National Univ., Republic of Korea) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 438-447. Research supported by Korea Science and Engineering Foundation refs
(AIAA PAPER 93-3336) Copyright

3D steady/unsteady flows around a helicopter rotor in hover and forward flight have been calculated using Euler equations with a moving grid system. To develop an efficient 3D Euler code, previous implicit schemes such as Beam and Warming's ADI, Hybrid, and LU-SGS have been compared with respect to accuracy and efficiency. Numerical analysis for steady hovering shows that Hybrid is more efficient than the other schemes, while for unsteady calculations the LU-SGS scheme coupled with a delta sup k-correction iterative scheme can have a larger allowable time step and reduce overall computing time. Author (revised)

A93-45031*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THREE-DIMENSIONAL UNSTRUCTURED GRID EULER COMPUTATIONS USING A FULLY-IMPLICIT, UPWIND METHOD

DAVID L. WHITAKER (Analytical Services and Materials, Inc., Hampton, VA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 448-461. refs
(Contract NAS1-19320)
(AIAA PAPER 93-3337)

A method has been developed to solve the Euler equations on a three-dimensional unstructured grid composed of tetrahedra.

The method uses an upwind flow solver with a linearized, backward-Euler time integration scheme. Each time step results in a sparse linear system of equations which is solved by an iterative, sparse matrix solver. Local-time stepping, switched evolution relaxation (SER), preconditioning and reuse of the Jacobian are employed to accelerate the convergence rate. Implicit boundary conditions were found to be extremely important for fast convergence. Numerical experiments have shown that convergence rates comparable to that of a multigrid, central-difference scheme are achievable on the same mesh. Results are presented for several grids about an ONERA M6 wing. Author

A93-45033#

A 3D UNSTRUCTURED ADAPTIVE MULTIGRID SCHEME FOR THE EULER EQUATIONS

STUART D. CONNELL and D. G. HOLMES (GE Corporate Research and Development Center, Schenectady, NY) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 471-480. refs
(AIAA PAPER 93-3339) Copyright

This paper presents a solution adaptive multigrid scheme for the three dimensional Euler equations. The procedure begins with an initial coarse mesh and enriches this mesh by h-refinement in regions of high solution gradient. This adaptive procedure is used to generate the multigrid levels required by the solver. New boundary nodes are added in a way to reflect the underlying surface representation of the geometry. The h-refinement procedure is extremely fast and results in a scheme where only a small percentage of the overall cpu time is spent in the meshing and refinement part of the algorithm. The multigrid flow solver typically reduces the cpu time by an order of magnitude over the same case without multigrid. Initial mesh generation is achieved through the destructuring of a structured mesh or use of the advancing front method. The algorithm is demonstrated on a range of cases. Author

A93-45037*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

NUMERICAL VORTICITY CAPTURING FOR VORTEX-SOLID BODY INTERACTION PROBLEMS

CLIN M. WANG (Flow Analysis, Inc., Tullahoma, TN), JOHN S. STEINHOFF, and YONGHU WENREN (UTSI; Flow Analysis, Inc., Tullahoma, TN) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 506-515. Research supported by NASA refs
(AIAA PAPER 93-3343) Copyright

A new numerical method based on adding a term to the Euler/Navier-Stokes equations has been demonstrated it can effectively treat vortex-dominated flows using low-order numerical schemes and coarse grids. The numerical diffusion introduced by convection schemes can be eliminated by modifying the velocity field as a result of solving the modified flow governing equations. The modification of the velocity field, which conserves the total vorticity, essentially convects the vorticity toward its local extreme to offset the numerical diffusion. This method preserves the vortex structure even when vortices travel on coarse grid region. The method is implemented with two distinctive codes: a Navier-Stokes flow solver based on vorticity-velocity formulation and an Euler code based on velocity-pressure formulation. Problems presented in this paper include airfoil dynamic stall, vortex airfoil interaction, and vortex-fuselage interactions. Author

A93-45043#

A THREE-DIMENSIONAL DELAUNAY UNSTRUCTURED GRID GENERATOR AND FLOW SOLVER FOR BODIES IN RELATIVE MOTION

RALPH W. NOACK and DAVID G. BISHOP (MDA Engineering, Inc., Arlington, TX) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 565-575. Research sponsored by USAF refs
(AIAA PAPER 93-3349) Copyright

A scheme to generate dynamic unstructured grids and an implicit upwind Euler solver are presented to compute solutions on dynamic grids in three-dimensions. The grid generation scheme produces Delaunay unstructured triangular or tetrahedral meshes for static and dynamic grid cases. To obtain a solution for multiple bodies in relative motion, dynamic grid restructuring and smoothing are implemented to provide a high quality unstructured grid for the flow solver. The scheme uses the boundary node location and a user specified clustering parameter to determine where nodes on the interior should be added and deleted to maintain a smooth variation in cell volume. In this analysis, numerical results are compared to experimental data for a complex wing-pylon/finned-store configuration. Author

A93-45044*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

MOVING BODY OVERSET GRID METHODS FOR COMPLETE AIRCRAFT TILTROTOR SIMULATIONS

ROBERT L. MEAKIN (Overset Methods, Inc.; NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 576-588. refs
(Contract NCC2-747)
(AIAA PAPER 93-3350) Copyright

A hypothetical, but realistic, set of flight conditions for the V-22 aircraft is established to facilitate rigorous testing of a new domain connectivity algorithm, and to carry out an overset grid proof-of-concept tiltrotor simulation. Relative motion and interference effects between the V-22 airframe and rotor-blades are directly simulated within the context of an unsteady, thin-layer Navier-Stokes computation. The domain connectivity algorithm is verified to perform at rates equal to or greater than those realized previously for store-separation-like applications. The feasibility of carrying out unsteady Navier-Stokes analyses of rotorcraft problems is demonstrated. Author

A93-45045#

A GRAPHICALLY INTERACTIVE APPROACH TO STRUCTURED AND UNSTRUCTURED SURFACE GRID QUALITY ANALYSIS

JOHN E. STEWART and JAMSHID S. ABOLHASSANI (Computer Sciences Corp., Hampton, VA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 589-597. refs
(AIAA PAPER 93-3351)

A graphically interactive approach to structured and unstructured surface grid quality analysis is described. A Surface Analysis Code (SurfACe) is developed to help a user analyze surface grid quality based on surface normal vectors, first and second derivatives of these vectors, normal, Gaussian, and mean curvatures, orthogonality, aspect ratio, and cell area. The results demonstrate how this approach can be used to reduce surface grid generation errors and increase the cost effectiveness of Computational Fluid Dynamics as an aircraft design tool. Author

A93-45051*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

MULTIGRID CONVERGENCE OF AN IMPLICIT SYMMETRIC RELAXATION SCHEME

SEOKKWAN YOON, LEON CHANG (MCAT Inst., Moffett Field, CA), and DOCHAN KWAK (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 666-675. refs
(AIAA PAPER 93-3357) Copyright

Multigrid has been applied to an existing three-dimensional compressible Euler solver to accelerate the convergence of the implicit symmetric relaxation scheme. This lower-upper symmetric Gauss-Seidel implicit scheme is shown to be an effective multigrid driver in three-dimensions. A grid refinement study is performed including the effects of large cell aspect ratio meshes. Performance figures of the present multigrid code on Cray computers including the new C90 are presented. A reduction of three orders of of magnitude in the residual for a three-dimensional transonic inviscid flow using 920K grid points is obtained in less than 4 minutes on a Cray C90. Author

A93-45052*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
IMPLICIT MULTIGRID EULER SOLUTIONS WITH SYMMETRIC TOTAL-VARIATION-DIMINISHING DISSIPATION
DAVID A. CAUGHEY (Cornell Univ., Ithaca, NY) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 676-684. Research supported by NSF, IBM Corp., and Corporate Research Inst. refs
(Contract NAG2-665)
(AIAA PAPER 93-3358) Copyright

A symmetric Total-Variation-Diminishing (TVD) formulation of the numerical dissipation terms has been incorporated into a diagonalized alternating direction implicit multigrid algorithm to solve the Euler equations of inviscid compressible flow. The new treatment of the dissipation makes is possible to capture both very strong and very weak shocks, virtually without oscillation for the steady flows of interest here. In addition, the TVD constraint fixes one of the two previously arbitrary constants in the formulation of the dissipation, and results in both converged solutions and convergence rates which are relatively insensitive to the choice of the remaining dissipation parameter. Author

A93-45056*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VIRTUAL ZONE NAVIER-STOKES COMPUTATIONS FOR OSCILLATING CONTROL SURFACES
G. H. KLOPFER and S. OBAYASHI (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 711-721. refs
(Contract NCC2-616; NCC2-605)
(AIAA PAPER 93-3363) Copyright

A new zoning method called 'virtual zones' has been developed for application to an unsteady finite difference Navier-Stokes code. The virtual zoning method simplifies the zoning and gridding of complex configurations for use with patched multi-zone flow codes. An existing interpolation method has been extensively modified to bring the run time for the interpolation procedure down to the same level as for the flow solver. Unsteady Navier-Stokes computations have been performed for transonic flow over a clipped delta wing with an oscillating control surface. The computed unsteady pressure and response characteristics of the control-surface motion compare well with experimental data. Author

A93-45059# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LINE RELAXATION METHODS FOR THE SOLUTION OF 2D AND 3D COMPRESSIBLE FLOWS
O. HASSAN, E. J. PROBERT, K. MORGAN (Univ. College, Swansea, United Kingdom), and J. PERAIRE (Imperial College of Science, Technology, and Medicine, London, United Kingdom) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 743-750. Research supported by NASA and Dassault Aviation refs
(Contract NAGW-1809)
(AIAA PAPER 93-3366) Copyright

An implicit finite element based algorithm for the compressible Navier-Stokes equations is outlined, and the solution of the resulting equation by a line relaxation on general meshes of triangles or tetrahedra is described. The problem of generating and adapting unstructured meshes for viscous flows is reexamined, and an approach for both 2D and 3D simulations is proposed. An efficient approach appears to be the use of an implicit/explicit procedure, with the implicit treatment being restricted to those regions of the mesh where viscous effects are known to be dominant. Numerical examples demonstrating the computational performance of the proposed techniques are given. AIAA

A93-45064*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EFFECTS OF SPATIAL ORDER OF ACCURACY ON THE COMPUTATION OF VORTICAL FLOWFIELDS
J. A. EKATERINARIS (U.S. Navy-NASA Joint Inst. of Aeronautics, Moffett Field, CA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 797-804. Research supported by U.S. Navy refs
(AIAA PAPER 93-3371) Copyright

The effect of the order-of-accuracy, used for the spatial discretization, on the resolution of the leading edge vortices over sharp-edged delta wings is investigated. The flowfield is computed using a viscous/inviscid zonal approach. The viscous flow in the vicinity of the wing is computed using the conservative formulation of the compressible, thin-layer Navier-Stokes equations. The leeward-side vortical flowfield and the other flow regions away from the surface are computed as inviscid. The time integration is performed with both an explicit fourth-order Runge-Kutta scheme and an implicit, factorized, iterative scheme. High-order-accurate inviscid fluxes are computed using both a conservative and a non-conservative (primitive variable) formulation. The nonlinear, inviscid terms of the primitive variable form of the governing equations are evaluated with a finite-difference numerical scheme based on the sign of the eigenvalues. High-order, upwind-biased, finite difference formulas are used to evaluate the derivatives of the nonlinear convective terms. Computed results are compared with available experimental data, and comparisons of the flowfield in the vicinity of the vortex cores are presented. Author

A93-45076#
ADAPTIVE CARTESIAN GRID METHODS FOR REPRESENTING GEOMETRY IN INVISCID COMPRESSIBLE FLOW
RICHARD B. PEMBER, JOHN B. BELL (Lawrence Livermore National Lab., Livermore, CA), PHILLIP COLELLA (California Univ., Berkeley), WILLIAM Y. CRUTCHFIELD, and MICHAEL L. WELCOME (Lawrence Livermore National Lab., Livermore, CA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 948-958. Research supported by DNA and DARPA refs
(Contract W-7405-ENG-48; DE-FG03-92ER-25140; NSF DMS-89-19074; NSF ACS-89-58522)
(AIAA PAPER 93-3385) Copyright

In this paper we describe a Cartesian grid algorithm for modeling time-dependent compressible flow in complex geometry. In this approach problem geometry is treated as an interface embedded in a regular Cartesian mesh. The discretization near the embedded boundary is based on a volume-of-fluid approach with a redistribution procedure to avoid time-step restrictions arising from small cells where the boundary intersects the mesh. The algorithm is coupled to an unsplit second-order Godunov algorithm and is fully conservative, maintaining conservation at the boundary. The Godunov/Cartesian grid integration scheme is coupled to a local adaptive mesh refinement algorithm that selectively refines regions of the computational grid to achieve a desired level of accuracy. Examples showing the results of the combined Cartesian grid/local refinement algorithm for both two- and three-dimensional flows are presented. Author

A93-45077*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
3D AUTOMATIC CARTESIAN GRID GENERATION FOR EULER FLOWS
JOHN E. MELTON, FRANCIS Y. ENOMOTO (NASA, Ames Research Center, Moffett Field, CA), and MARSHA J. BERGER (New York Univ., NY) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 959-969. refs
(Contract DE-FG02-88ER-25053; AF-AFOSR-91-0063; NSF ASC-88-58101)
(AIAA PAPER 93-3386) Copyright
We describe a Cartesian grid strategy for the study of three dimensional inviscid flows about arbitrary geometries that uses both conventional and CAD/CAM surface geometry databases. Initial applications of the technique are presented. The elimination of the body-fitted constraint allows the grid generation process to be automated, significantly reducing the time and effort required to develop suitable computational grids for inviscid flowfield simulations. Author

A93-45078*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TIME-ACCURATE SIMULATION OF A SELF-EXCITED OSCILLATORY SUPERSONIC EXTERNAL FLOW WITH A MULTI-BLOCK SOLUTION-ADAPTIVE MESH ALGORITHM
CLINT L. INGRAM, D. S. MCRAE, and RUSTY A. BENSON (North Carolina State Univ., Raleigh) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 970-977. Research supported by North Carolina Supercomputing Center refs
(Contract NAG1-1340)
(AIAA PAPER 93-3387) Copyright
Results are presented of an investigation of the time-accurate simulation of supersonic unsteady flow oscillations over spike-tipped bodies using the multistage Runge-Kutta scheme coupled with a dynamic solution-adaptive grid algorithm modified for multiblock capabilities. The inviscid fluxes are described by a modified advective upwind split method to obviate the need for artificial dissipation. If a time-varying, solution-adaptive mesh algorithm is incorporated, resolution of the details of the unsteady spike-tipped body flow is improved. The adaptive algorithm is also shown to resolve multiple and diverse features of the flow simultaneously, with the adapted regions in the mesh convecting with these features as they translate. AIAA

A93-45079#
AN ADAPTIVE FINITE ELEMENT METHOD FOR TURBULENT FREE SHEAR FLOW PAST A PROPELLER
DOMINIQUE PELLETIER, FLORIN ILINCA, and JEAN-FRANCOIS HETU (Ecole Polytechnique, Montreal, Canada) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 978-989. refs
(AIAA PAPER 93-3388) Copyright
This paper presents an adaptive finite element method based on remeshing to solve incompressible turbulent free shear flows. Solutions are obtained in primitive variables using a highly accurate finite element approximation on unstructured grids. Turbulence is modeled by a mixing length formulation. Two error general purpose estimators, that take into account swirl and the variation of the eddy viscosity, are presented and applied to turbulent flow near a propeller. Predictions compare well with experimental measurements. The proposed adaptive scheme is robust, reliable and cost effective. Author

A93-45081#
ADAPTIVE INVISCID FLOW SOLUTIONS FOR AEROSPACE GEOMETRIES ON EFFICIENTLY GENERATED UNSTRUCTURED TETRAHEDRAL MESHES
N. P. WEATHERILL, O. HASSAN, M. J. MARCHANT (Univ. College, Swansea, United Kingdom), and D. L. MARCUM (NSF Engineering Research Center, Mississippi State, MS) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1002-1012. Research supported by SERC anf NSF refs
(AIAA PAPER 93-3390) Copyright
Unstructured tetrahedral grids are generated using a new, very efficient procedure based upon the Delaunay triangulation. The new algorithm automatically creates points within the field and ensures boundary integrity using direct transformations on tetrahedra. The generation procedure is extremely fast having a capability to generate large grids in minutes on workstations. To maximize this computational performance a new form of adaptivity has been developed which involves the use of sources placed within regions requiring adaption. The paper discusses the new generation process and emphasizes the new solution adaption capability. Several examples are presented for both 2 and 3-dimensional flows. Author

A93-45082#
A SIMULATION TECHNIQUE FOR 2-D UNSTEADY INVISCID FLOWS AROUND ARBITRARILY MOVING AND DEFORMING BODIES OF ARBITRARY GEOMETRY
SAMI A. BAYYUK, KENNETH G. POWELL, and BRAM VAN LEER (Michigan Univ., Ann Arbor) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1013-1024. Research supported by McDonnell Aircraft Co refs
(AIAA PAPER 93-3391) Copyright
An approach for the simulation of Euler flows around arbitrarily moving and deforming bodies of arbitrary geometry is presented. The approach differs from other approaches developed thus far primarily in that a stationary grid is used and body motion across grid lines is allowed. Ways in which grid-line crossing in conjunction with a Quadtree-based Cartesian grid can eliminate the grid distortion problem simply and can intrinsically ensure the global smoothness of the grid are shown. It is demonstrated that the technique has computational requirements consistent with an unstructured-grid technique. Over the long term, Cartesian grids can be used to solve the moving and deforming body problem in 2D. Unlike Delaunay triangulation, the present technique generalizes to 3D without additional grid-generation difficulties. AIAA

A93-45083#
A 3-D FINITE-VOLUME SCHEME FOR THE EULER EQUATIONS ON ADAPTIVE TETRAHEDRAL GRIDS
VIJAYAN PARTHASARATHY and Y. KALLINDERIS (Texas Univ., Austin) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1025, 1026. refs
Copyright
The development and application of a new Euler solver for adaptive tetrahedral grids are described. Spatial discretization uses a finite-volume, node-based scheme that is of the central-differencing type. Special upwindlike smoothing operators for unstructured grids are developed for shock-capturing as well as for suppression of solution oscillations. Application cases include transonic flow around the ONERA M6 wing and transonic flow past a transport aircraft configuration. AIAA

A93-45087#
A SIMPLE MULTIGRID PROCEDURE FOR EXPLICIT TIME-MARCHING ON UNSTRUCTURED GRIDS
T. C. CURRIE (National Research Council of Canada, Ottawa) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1033, 1034. refs
Copyright

A simple multigrid procedure for explicit time-marching which typically provides a threefold increase in convergence rate is described. Mach contours and residual histories for a cascade test case and for a bent plate cascade flow are illustrated. AIAA

A93-45088*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AN UPWIND MULTIGRID ALGORITHM FOR CALCULATING FLOWS ON UNSTRUCTURED GRIDS

DARYL L. BONHAUS (NASA, Langley Research Center, Hampton, VA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1035, 1036. refs

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An algorithm is described that calculates inviscid, laminar, and turbulent flows on triangular meshes with an upwind discretization. A brief description of the base solver and the multigrid implementation is given, followed by results that consist mainly of convergence rates for inviscid and viscous flows over a NACA four-digit airfoil section. The results show that multigrid does accelerate convergence when the same relaxation parameters that yield good single-grid performance are used; however, larger gains in performance can be realized by doing less work in the relaxation scheme. Author

A93-45092#

AN ACCELERATION TECHNIQUE FOR TIME ACCURATE CALCULATIONS

DAVID L. MODIANO and EARLL M. MURMAN (MIT, Cambridge, MA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1043, 1044.

(Contract AF-AFOSR-89-0395)

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Numerical simulation of the unsteady flow around a pitching delta wing using explicit methods requires a time step for stability far below that needed for accuracy. A method is introduced to relax the time step stability constraint and allow faster simulation of this unsteady flow. A 2D calculation is presented as an illustration. AIAA

A93-45093#

A NOVEL ALGORITHM FOR THE SOLUTION OF COMPRESSIBLE EULER EQUATIONS IN WAVE/PARTICLE SPLIT (WPS) FORM

D. W. HALT and R. K. AGARWAL (McDonnell Douglas Corp., Saint Louis, MO) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1045, 1046. refs

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The paper introduces a new scheme for modeling the compressible Euler equations in a WPS form. The scheme is formed by the separate treatment of various flux terms relating to the transfer of information by either acoustic wave propagation or by convection with the fluid particle. The new WPS scheme has been consistently more accurate than the advection upwind split method scheme for a variety of cases. It also requires less CPU time than the Roe (1981) and van Leer (1982) schemes. AIAA

A93-45095#

SIMULATION OF FLOW PAST COMPLEX GEOMETRIES USING A PARALLEL IMPLICIT INCOMPRESSIBLE FLOW SOLVER

RAVI RAMAMURTI (U.S. Navy, Naval Research Lab., Washington) and RAINALD LOEHNER (George Washington Univ., Washington) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1049, 1050. Research supported by DARPA refs

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The parallel simulation of transient flows with high Reynolds number is addressed. The pressure as well as the advection-diffusion terms of the Navier-Stokes equations are treated in an implicit manner. A preconditioned conjugate gradient algorithm is used to solve the elliptic equations for pressure and the velocities. AIAA

A93-45096*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PRECONDITIONED DOMAIN DECOMPOSITION SCHEME FOR THREE-DIMENSIONAL AERODYNAMIC SENSITIVITY ANALYSIS

MOHAMMED E. ELESHAKY and OKTAY BAYSAL (Old Dominion Univ., Norfolk, VA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1055, 1056. refs

(Contract NAG1-1188)

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A preconditioned domain decomposition scheme is introduced for the solution of the 3D aerodynamic sensitivity equation. This scheme uses the iterative GMRES procedure to solve the effective sensitivity equation of the boundary-interface cells in the sensitivity analysis domain-decomposition scheme. Excluding the dense matrices and the effect of cross terms between boundary-interfaces is found to produce an efficient preconditioning matrix. AIAA

A93-45099*# 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 & Sciences Co., Hampton, VA) and KENNETH J. WEILMUENSTER (NASA, Langley Research Center, Hampton, VA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1067, 1068. refs

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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 definitions, within the framework of GRIDGEN2D. The incorporation of a face decomposition reduces complex surfaces to simple shapes. These simple shapes are recombined 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 generating matching block faces, and simplified boundary conditions. Author

A93-45101*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ADVANCING-LAYERS METHOD FOR GENERATION OF UNSTRUCTURED VISCOUS GRIDS

SHAHYAR PIRZADEH (Vigiyan, Inc., Hampton, VA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1071, 1072. refs

(Contract NAS1-19672)

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A novel approach for generating highly stretched grids which is based on a modified advancing-front technique and benefits from the generality, flexibility, and grid quality of the conventional advancing-front-based Euler grid generators is presented. The method is self-sufficient for the insertion of grid points in the boundary layer and beyond. Since it is based on a totally unstructured grid strategy, the method alleviates the difficulties stemming from the structural limitations of the prismatic techniques. AIAA

A93-45102#

DIRECT AND ITERATIVE ALGORITHMS FOR THE THREE-DIMENSIONAL EULER EQUATIONS

K. J. VANDEN (USAF, Wright Lab., Wright-Patterson AFB, OH)

and D. L. WHITFIELD (NSF Engineering Research Center, Starkville, MS) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1074-1084. refs
(AIAA PAPER 93-3378)

A discretization developed for first- and second-order spatially accurate solutions of the 3D Euler equations is presented. The advantage of this discretization is that the Jacobian terms are computed numerically to remain consistent with the numerical flux vector. Complex derivations of analytical Jacobians using symbolic mathematics software are not required. Two 3D direct solvers were developed and optimized to run small test cases. A two-pass factorization, modified two-pass factorization, Newton-relaxation (NR), and discretized Newton-relaxation (DNR) algorithms are compared, with the best performers being the DNR and the NR algorithms. The DNR algorithm is compared to the direct solver; the NR approach is found to be capable of providing direct solver performance while needing only a fraction of the memory and CPU time. AIAA

A93-45103*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
A MULTIGRID NONOSCILLATORY METHOD FOR COMPUTING HIGH SPEED FLOWS
C. P. LI and T. H. SHIEH (NASA, Johnson Space Center, Houston, TX) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1085-1096. refs
(AIAA PAPER 93-3319)

A multigrid method using different smoothers has been developed to solve the Euler equations discretized by a nonoscillatory scheme up to fourth order accuracy. The best smoothing property is provided by a five-stage Runge-Kutta technique with optimized coefficients, yet the most efficient smoother is a backward Euler technique in factored and diagonalized form. The singlegrid solution for a hypersonic, viscous conic flow is in excellent agreement with the solution obtained by the third order MUSCL and Roe's method. Mach 8 inviscid flow computations for a complete entry probe have shown that the accuracy is at least as good as the symmetric TVD scheme of Yee and Harten. The implicit multigrid method is four times more efficient than the explicit multigrid technique and 3.5 times faster than the single-grid implicit technique. For a Mach 8.7 inviscid flow over a blunt delta wing at 30 deg incidence, the CPU reduction factor from the three-level multigrid computation is 2.2 on a grid of 37 x 41 x 73 nodes. Author

A93-45134
S-PLANE AERODYNAMICS OF NONPLANAR LIFTING SURFACES
JINSOO CHO (Pohang Inst. of Science and Technology, Republic of Korea) and MARC H. WILLIAMS (Purdue Univ., West Lafayette, IN) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 433-438. refs
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A compressible unsteady panel method for predicting generalized force transfer functions for nonplanar lifting surfaces is described. The scheme is suitable for both subsonic and supersonic flow, and is valid everywhere in the complex Laplace s-plane. The effort of constructing the influence coefficient matrix is minimized by using the symmetry and scale properties of the kernel function. Results of steady and unsteady analyses for numerous configurations are compared with a doublet lattice method, a doublet point method, and a hybrid doublet lattice-doublet point method, showing excellent agreement. With a view toward application to rotating machinery, an analysis is given of a circular duct with guide vanes in both steady and unsteady flow. Author

A93-45135
TIME DOMAIN PANEL METHOD FOR WINGS
MAX BLAIR (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) and MARC H. WILLIAMS (Purdue Univ., West Lafayette, IN) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 439-445. AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Pt. 3, p. 1417-1426. Previously cited in issue 12, p. 1776, Accession no. A89-30800 refs
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A93-45136* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATION OF INDUCED DRAG FOR ELLIPTICAL AND CRESCENT-SHAPED WINGS
STEPHEN C. SMITH (NASA, Ames Research Center, Moffett Field, CA) and ILAN M. KROO (Stanford Univ., CA) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 446-452. AIAA, Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990, AIAA Paper 90-3063. Previously cited in issue 23, p. 3660, Accession no. A90-50638 refs
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A93-45138
WAKE STRUCTURE OF A HELICOPTER ROTOR IN FORWARD FLIGHT
G. BRIASSULIS and J. ANDREOPOULOS (City College, New York) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 459-466. AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991, AIAA Paper 91-1753. Previously cited in issue 17, p. 2858, Accession no. A91-42575 refs
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A93-45140
CFD ANALYSIS OF THE X-29 INLET AT HIGH ANGLE OF ATTACK
R. H. TINDELL and W. G. HILL, JR. (Grumman Corp., Bethpage, NY) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 480-487. International Symposium on Air Breathing Engines, 10th, Nottingham, United Kingdom, Sept. 1-6, 1991, Proceedings. Vol. 2, p. 703-711. Previously cited in issue 24, p. 4200, Accession no. A91-56174 refs
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A93-45141* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
REYNOLDS NUMBER EFFECTS ON SUPERSONIC ASYMMETRICAL FLOWS OVER A CONE
J. L. THOMAS (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 488-495. AIAA, Applied Aerodynamics Conference, 9th, Baltimore, MD, Sept. 23-25, 1991, AIAA Paper 91-3295. Previously cited in issue 23, p. 4008, Accession no. A91-53870 refs
Copyright

A93-45142* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SENSITIVITY ANALYSIS OF A WING AEROELASTIC RESPONSE
RAKESH K. KAPANIA, LLOYD B. ELDRED (Virginia Polytechnic Inst. and State Univ., Blacksburg), and JEAN-FRANCOIS M. BARTHELEMY (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 496-504. AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1, p. 497-505. Previously cited in issue 12, p. 1904, Accession no. A91-31882 refs
(Contract NAS1-18471)
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A93-45146* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NAVIER-STOKES ANALYSIS OF THREE-DIMENSIONAL S-DUCTS
G. J. HARLOFF, C. F. SMITH, J. E. BRUNS, and J. R. DEBONIS (Sverdrup Technology, Inc., Brook Park, OH) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 526-533. refs
(Contract NAS3-25266)
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Full 3D Navier-Stokes computational results are presented for compressible flows within nondiffusing and diffusing S-ducts. The present study provides an understanding of the performance characteristics of typical S-ducts with attached and separated flows and provides a frame of reference for future computational fluid dynamic studies of internal flows with strong secondary flows. The predicted results, which were obtained using both H- and O-grids, are compared with the experimental wall pressures, static and total pressure fields, and velocity vectors. In addition, computed boundary-layer thickness, velocity profiles in wall coordinates and skin friction values are presented. The inviscid contributions to the secondary flows are quantified. The S-duct entrance Mach number was 0.6, and the Reynolds number was 1.76 x 10 exp 6 based on the upstream duct diameter. Author (revised)

A93-45149
AIR DISSOCIATION EFFECTS ON AERODYNAMIC CHARACTERISTICS OF AN AEROSPACE PLANE
V. YA. NEJLAND (TsAGI, Moscow, Russia) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 547-549. refs
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A program aimed at calculating the flow about an aircraft with a real nonsimplified configuration is presented. Preflight data and flight test results obtained for a large-scale (1:8) model of the Buran aerospace plane are compared. Conclusions are made concerning the applicability limits of the obtained results and the possibility of improving the aerodynamic characteristics of aerospace planes. In particular, it is clear a priori that the developed approach requires a substantial modification for the vehicles of this class with a long re-entry lateral range. AIAA

A93-45153
EFFECTS OF WING-TIP VORTEX FLAPS
LANCE W. TRAUB and ALAN NURICK (Witwatersrand Univ., Johannesburg, South Africa) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 557-560. refs
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Sheared tips modified to form a wing tip vortex flap (WTVF) were experimentally studied at a low Reynolds number. It is suggested that a flap placed on the wing tip and appropriately deflected may reduce drag by utilizing the suction of the tip vortex if the vortex is captured by the flap. Data obtained show that, in the nonlinear lift range at lift coefficients greater than 0.6, all the sheared wing WTVF angles exhibit a drag reduction compared to a basic wing. AIAA

A93-45154*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LEADING-EDGE TRANSITION AND RELAMINARIZATION PHENOMENA ON A SUBSONIC HIGH-LIFT SYSTEM
C. P. VAN DAM (California Univ., Davis), P. M. H. W. VIJGEN (High Technology Corp., Hampton, VA), L. P. YIP (NASA, Langley Research Center, Hampton, VA), and R. C. POTTER (California Univ., Davis) Jul. 1993 15 p. AIAA, Fluid Dynamics Conference, 24th, Orlando, FL, July 6-9, 1993 refs
(Contract NCC1-163; NAS1-19299)
(AIAA PAPER 93-3140) Copyright

Boundary-layer transition and relaminarization may have a critical effect on the flow development about multielement high-lift systems of subsonic transport aircraft with swept wings. The purpose of this paper is a study of transition phenomena in the leading-edge region of the various elements of a high-lift system. The flow phenomena studied include transition of the attachment-line flow, relaminarization, and crossflow instability. The calculations are based on pressure distributions measured in flight on the NASA Transport Systems Research Vehicle (Boeing 737-100) at a wing station where the flow approximated infinite swept wing conditions. The results indicate that significant regions of laminar flow can exist on all flap elements in flight. In future flight experiments the extent of these regions will be measured, and the transition mechanisms and the effect of laminar flow on the high-lift characteristics of the multi-element system will be further explored. Author

A93-45325
NUMERICAL SIMULATION OF SUPERSONIC FLOWS WITH CHEMICAL REACTIONS
NOBUHIKO YAMASAKI (Kyushu Univ., Fukuoka, Japan), YUKIFUMI UEDA (All Nippon Airways, Tokyo, Japan), and MASANOBU NAMBA (Kyushu Univ., Fukuoka, Japan) Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160) vol. 52, no. 4 Dec. 1992 p. 433-462. refs

Finite-difference method solutions are presented for the 2D Navier-Stokes equations in a conservative-law form for supersonic flows with no reaction or H2-air combustion. TVD schemes are used to avoid numerical oscillation caused by discontinuities in the flowfield. By using the improved point implicit technique together with the automatic time-step switching technique, the strong stiffness inherent to chemically reacting flow problems is successfully overcome. The computational code is applied to three types of geometrical configurations and flow conditions relevant to scramjet engines. The computational results well simulate such quite complicated flowfields including shock waves, expansions, boundary layers, and chemical reactions with high resolution. The present codes are robust, and can be used routinely for analysis and design purposes. In the case of nonreacting, i.e., mixing flows, the numerical results are in good agreement with experimental Schlieren pictures. Author (revised)

A93-45494
PLUME EFFECTS AT HYPERSONIC SPEEDS
J. L. STOLLERY, N. P. B. SPERINCK, and P. ATCLIFFE (Cranfield Inst. of Technology, United Kingdom) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 575-582. Research sponsored by Ministry of Defence Procurement Executive refs
Copyright

A 70 semiangle blunted cone has been tested at a Mach number of 8.2 in an intermittent hypersonic wind tunnel. The Reynolds number based on cone base-diameter was 2.8 x 10 exp 5. The heat transfer rate distribution was measured along the cones surface and schlieren pictures were taken of the whole flow field. Initially the plume was simulated by a solid disk at the rear of the cone but subsequently some tests were made using a radial jet of air, or foreign gas, in place of the disk. With no disk, the flow was attached over the entire forward surface of the cones and the measured heat transfer rates indicated a wholly laminar boundary layer. Fitting a disk causes the flow to separate and, as the disk diameter is increased, so the separation point rapidly moves forward, leading to an extensive separated shear layer with reattachment at the rim of the disk. The flow was laminar at separation but the separated shear layer rapidly underwent transition to the turbulent state. The heat transfer beneath the laminar region was reduced but, following transition, rose rapidly to substantially exceed the laminar value over the rest of the conical surface. Thus, under the given test conditions at M = 8.2, the simulated plume could cause extensive separation, early transition of the shear layer, and an increase in total heat transfer to the cone surface. Author (revised)

A93-45507
AERODYNAMIC HEATING PHENOMENON IN THREE DIMENSIONAL SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTION INDUCED BY SWEPTBACK FINS IN HYPERSONIC FLOWS
S. ASO, S. NAKAO, S. MAEKAWA (Kyushu Univ., Fukuoka, Japan), and M. HAYASHI (Nishinippon Inst. of Technology, Fukuoka, Japan) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 663-670. refs
Copyright

The detailed structure of aerodynamic heating phenomena in 3D shock wave/turbulent boundary layer interaction induced by sweptback blunt and sharp fins in hypersonic flows is investigated carefully in order to study the effects of the shape and sweep angle of the leading edge of the fin on aerodynamic heating phenomena on the body. A new method of measuring heat flux developed by the present authors is used, and is based on a new type of thin-film heat transfer gauge with high spatial resolution and fast response. Heat transfer experiments were performed Mach number 4, wall temperature ratio T(omega)/T0 of 0.65 and Reynolds number of 1.2 x 10 exp 7. Sweptback blunt fins with semi-circular leading edge and sweptback sharp fins with wedge angle of 30 deg in the plane normal to the leading edge were used for the present experiments. Sweep angles are 0, 15, 30, and 45 deg, with the fins placed normal to the flat plate model. The flow fields are visualized by oil flow and detailed surface pressure and surface heat flux distributions in the interaction regions for various sweep angles were measured. The results that the effects of the shape and sweep angle of the leading edge on aerodynamic heating load are quite significant. Author (revised)

A93-45542
A SINGULARITIES TRACKING CONSERVATION LAW SCHEME FOR COMPRESSIBLE DUCT FLOWS
J. FALCOVITZ and A. BIRMAN (Technion - Israel Inst. of Technology, Haifa) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 1107-1112. refs
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The study presents a singularities tracking version of the GFRP scheme for the integration of the Euler equations for compressible duct flows. Flow singularities corresponding to contact (material), shock or gradient discontinuities are represented by special grid points that move through the fixed grid at the appropriate speed of propagation. Interactions between singular points are treated accurately by solving the appropriate generalized Rieman problem. The singularities tracking scheme is applied to three sample problems: a planar shock tube, an exploding helium sphere, and a helium/air shock tube having an area converging section. It is shown that singularities tracking improves resolution and accuracy at a given grid density. This scheme combines some merits of computation by characteristics, with a robustness approaching that of a finite difference conservation law scheme. AIAA

A93-45543
COMPUTATION OF UNSTEADY NOZZLE FLOWS
P. PRODROMOU and R. HILLIER (Imperial College of Science, Technology, and Medicine, London, United Kingdom) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 1113-1118. Research sponsored by SERC refs
Copyright

This paper presents computations of the unsteady starting processes in convergent-divergent nozzles, using a second-order Godunov-type Euler scheme. The computation satisfactorily models the main flow features such as the primary and secondary shock waves, multiple shock wave reflections, slip surfaces and vortices. At later stages in the flow development, boundary layer separation by the rearward facing secondary shock system may occur, which is not modelled by the present calculation and future work will be directed to the efficient implementation of a Navier-Stokes solver.

A93-45545
COMPUTATIONAL FLUID DYNAMICS CODE VALIDATION USING A FREE PISTON HYPERVELOCITY SHOCK TUNNEL
R. R. BOYCE (Australian National Univ., Canberra, Australia) and CH. MUNDT (Australian National Univ., Canberra, Australia; Deutsche Aerospace AG, Munich, Germany) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 1127-1132. Research supported by Sir Ross and Sir Keith Smith Fund refs
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Results of the second stage of a CFD code validation project are presented in this paper. A coupled Euler/boundary layer code, developed by Messerschmitt-Boeklow-Blohm Deutsche Aerospace, is compared to low stagnation enthalpy nitrogen (6 MJ/kg) flows over a simple blunt body (hyperboloid), at various angles of attack. The flows, generated in the Australian National University T3 shock tunnel, had freestream Mach number, velocity, temperature and pressure of 5.97, 3.19 km/s, 704 K and 5.07 kPa respectively. Non-equilibrium vibration effects were predicted and were observed in the shock comparisons. The CFD calculations predict shock shapes which form the frozen and equilibrium boundaries of the experimental shocks. This gives confidence in the physics and numerical methods used in the inviscid shock layer calculations. Heat transfer and pressure results are to be examined to test the boundary layer calculation.

A93-45546
NUMERICAL SIMULATION OF TWO-DIMENSIONAL AND AXI-SYMMETRIC COMPRESSIBLE FLOWS
J. F. MILTHORPE (Australian Defence Force Academy, Campbell, Australia) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 1133-1138. refs
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A convection algorithm for simulation of time-dependent supersonic and hypersonic flows of a perfect but viscous gas is described. The previously described two-dimensional version of the algorithm is extended to axi-symmetric geometries in this paper. The algorithm is based on conservation and convection of mass, momentum and energy in a grid of rectangular cells. Examples are given for starting flow in a shock-tube and the oblique shock generated by a wedge. Examples of axi-symmetric flows about a sharp and a blunt cone are given. Good comparisons are achieved with well-known perfect gas flows.

A93-45547
HYPERSONIC FLOW CALCULATIONS USING A MULTIDOMAIN MUSCL EULER SOLVER
PH. GUILLEN (ONERA, Chatillon, France), F. JACQUOT (Aerospatiale, Les Mureaux, France), M. BORREL, and J. L. DA COSTA (ONERA, Chatillon, France) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 1139-1144. refs
Copyright

The aim of this paper is to show the capabilities of a newly developed code named FLU3M to perform hypersonic flow calculations. It points out the usefulness and the flexibility of the multidomain approach in which grids are not necessarily continuous between different zones. This computational technique allows grid refinement wherever needed and permits complex geometries to be handle. The code is based on an explicit/implicit finite volume scheme of MUSCL type using structured grids. Calculations can be performed by time marching for subsonic regions or by space marching for supersonic ones. Perfect gas or equilibrium air flow can be assumed. Here three examples of computations are shown. The first two deal with hypersonic delta wing flow at high incidence. They were proposed as test cases at the INRIA workshop on hypersonic flow in 1990 and 1991. The third case concerns a computation around the HERMES shuttle at Mach number 25.

A93-45726* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATION OF CROSSING SHOCK/TURBULENT BOUNDARY LAYER INTERACTION AT MACH 8.3
N. NARAYANSWAMI (Rutgers Univ., Piscataway, NJ), C. C. HORSTMAN (NASA, Ames Research Center, Moffett Field, CA), and D. D. KNIGHT (Rutgers Univ., Piscataway, NJ) AIAA Journal (ISSN 0001-1452) vol. 31, no. 8 Aug. 1993 p. 1369-1376. refs
(Contract AF-AFOSR-86-0266)
Copyright
A three-dimensional (3D) hypersonic crossing shock wave/turbulent boundary-layer interaction is examined numerically at Mach 8.3. The test geometry consists of a pair of opposing sharp fins of angle alpha = 15 deg, mounted on a flat plate. Two theoretical models are evaluated. The full (3D) Reynolds-averaged Navier-Stokes equations are solved using the Baldwin-Lomax and the Rodi (modified k-epsilon) turbulence models. Computed results for both cases show good agreement with experiment for flat plate surface pressure and for flowfield profiles of pitot pressure and yaw angle, indicating that the flowfield is primarily rotational and inviscid. Fair to poor agreement is obtained for surface heat transfer, indicating a need for more accurate turbulence models. The overall flowfield structure is similar to that observed in previous crossing shock interaction studies. Author (revised)

A93-45727
NUMERICAL INVESTIGATION OF SUBSONIC AND SUPERSONIC ASYMMETRIC VORTICAL FLOW
K. J. VANDEN and D. M. BELK (USAF, Wright Lab., Eglin AFB, FL) AIAA Journal (ISSN 0001-1452) vol. 31, no. 8 Aug. 1993 p. 1377-1383. AIAA Atmospheric Flight Mechanics Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers, p. 212-222. Previously cited in issue 20, p. 3409, Accession no. A91-47172 refs

A93-45728
INSTANTANEOUS TOPOLOGY OF THE UNSTEADY LEADING-EDGE VORTEX AT HIGH ANGLE OF ATTACK
C. MAGNESS, O. ROBINSON, and D. ROCKWELL (Lehigh Univ., Bethlehem, PA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 8 Aug. 1993 p. 1384-1391. refs
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A new topological structure is defined for flow over a delta wing undergoing transient pitching maneuvers at high angle of attack. This instantaneous structure differs substantially from the traditional topology observed for stationary wings at low angle of attack. The leading edge vortex is found to exhibit an outward-spiraling motion corresponding to an unstable focus. In addition, the streamlines separating from the leading edge are not entrained into the vortex core in the instantaneous sense. The instantaneous topology is determined from high-resolution measurements over the crossflow plane by locating and categorizing the critical points of the instantaneous sectional streamlines. The three-dimensional, instantaneous streamline pattern corresponding to this topological structure is constructed by phase referencing the velocity fields at various chordwise locations. This approach allows three-dimensional characterization of the unstable focus of the leading-edge vortex and its relation to the feeding sheet.

A93-45730
ORGANIZED STRUCTURE IN A COMPRESSIBLE TURBULENT SHEAR LAYER
Y. R. SHAU, D. S. DOLLING, and K. Y. CHOI (Texas Univ., Austin) AIAA Journal (ISSN 0001-1452) vol. 31, no. 8 Aug. 1993 p. 1398-1405. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0180. Previously cited in issue 08, p. 1169, Accession no. A92-23790 refs
(Contract N00014-89-J-1221)
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A93-45735
ADAPTIVE REFINEMENT-COARSENING SCHEME FOR THREE-DIMENSIONAL UNSTRUCTURED MESHES
Y. KALLINDERIS and P. VIJAYAN (Texas Univ., Austin) AIAA Journal (ISSN 0001-1452) vol. 31, no. 8 Aug. 1993 p. 1440-1447. refs
(Contract AF-AFOSR-91-0022)
Copyright
The paper describes the development and application of an adaptive algorithm for tetrahedral grids. An initial unstructured grid is adapted by employing local division, as well as deletion of the tetrahedral cells. The process is dynamic, and the adapted grid changes follow evolution of the solution. Adaptation of the cells consists of normal division of a tetrahedron into eight subcells, as well as directional division into two or four subcells. A major issue of such adaptive grid algorithms is elimination of hanging nodes that appear on the edges in the interface between the embedded and unembedded zones. A novel technique has been developed for treatment of such interface cells that can be applied 10 eliminate any possible hanging node configuration in a simple way. A special data structure based on octrees has been developed, which is flexible to handle all different types of cell division/deletion. Application cases include a moving source, as well as transonic flow around the ONERA M6 wing.

A93-45750
INITIAL ACCELERATION EFFECTS ON FLOW EVOLUTION AROUND AIRFOILS PITCHING TO HIGH ANGLES OF ATTACK
MANOOCHEHR M. KOOCHESFAHANI and VANCO SMILJANOVSKI (Michigan State Univ., East Lansing) AIAA Journal (ISSN 0001-1452) vol. 31, no. 8 Aug. 1993 p. 1529-1531. refs
(Contract AF-AFOSR-89-0417; AF-AFOSR-89-0130)
Copyright
Flow visualization was used to monitor the onset of leading-edge separation and dynamic stall vortex development with varying initial accelerations. Incompressible flow at low-chord Reynolds numbers and high pitch rate was considered. The experiments were performed in a water tunnel and flow evolution was monitored by the hydrogen bubble technique and laser sheet illumination. Results indicate that the onset of leading edge separation is delayed to a larger angle of attack with increasing pitch rate. The angle of attack at which leading edge separation occurs is not affected by the initial acceleration. These results imply that a convenient acceleration profile may be selected for experimental studies without seriously impacting the dynamics of the unsteady stall process. AIAA

A93-45751
DECAY OF AIRCRAFT VORTICES NEAR THE GROUND
MILTON E. TESKE, ALAN J. BILANIN (Continuum Dynamics, Inc., Princeton, NJ), and JOHN W. BARRY (USDA, Forest Service, Davis, CA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 8 Aug. 1993 p. 1531-1533. refs
Copyright
The effects of atmospheric turbulence on the aging of vortex pairs are discussed. Vortex motion near the ground was studied using test results from aircraft flybys. Numerical methods were used to determine vertical vortex velocities and initial vortex strength. The behavior of vortex decay with initial vortex circulation strength is described and vortex decay coefficients were estimated. AIAA

A93-45754
COMMENT ON 'FLOW NEAR THE TRAILING EDGE OF AN AIRFOIL'
LUCIEN Z. DUMITRESCU (Aix-Marseille I, Univ., Marseille, France) AIAA Journal (ISSN 0001-1452) vol. 31, no. 8 Aug.

1993 p. 1538, 1539. refs
Copyright
It is argued that the trailing edge shape of a real airfoil should be cusped and locally have a certain amount of negative camber. To satisfy the requirement of a finite streamwise pressure gradient, the airfoil contour would have to be shaped in such a way to ensure compliance with a defined condition. AIAA

A93-46406* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SOLUTION STRATEGY FOR THREE-DIMENSIONAL CONFIGURATIONS AT HYPERSONIC SPEEDS
K. J. WEILMUENSTER and PETER A. GNOFFO (NASA, Langley Research Center, Hampton, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650) vol. 30, no. 4 July-Aug. 1993 p. 385-394. AIAA, Thermophysics Conference, 27th, Nashville, TN, July 6-8, 1992, AIAA Paper 92-2921. Previously cited in issue 20, p. 3470, Accession no. A92-47893 refs
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A93-46408* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ENHANCEMENTS TO VISCOUS-SHOCK-LAYER TECHNIQUE
ROOP N. GUPTA (NASA, Langley Research Center, Hampton, VA), KAM-PUI LEE (Vigyan, Inc., Hampton, VA), and ERNEST V. ZOBY (NASA, Langley Research Center, Hampton, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650) vol. 30, no. 4 July-Aug. 1993 p. 404-413. AIAA, Thermophysics Conference, 27th, Nashville, TN, July 6-8, 1992, AIAA Paper 92-2897. Previously cited in issue 20, p. 3469, Accession no. A92-47873 refs
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A93-46476#
A STRATEGY FOR THE OPTIMAL DESIGN OF NOZZLE CONTOURS
STEPHEN L. KEELING (Calspan Corp., Arnold AFB, TN) Jul. 1993 13 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2720)
A strategy is proposed and analyzed for the aerodynamic design of optimally contoured, high-enthalpy, hypersonic nozzles. The approach involves expressing the desired contour as an optimal convex combination of trial configurations. The methods used are given a firm theoretical foundation. This includes mathematical uniqueness results that show what exit conditions guarantee uniform flow in a neighborhood of the nozzle exit. Also, convergence results are verified for the design scheme. Based upon this theoretical foundation, a modular, robust, axisymmetric nozzle design code is implemented. This design package is used successfully to design a nozzle that accelerates a turbulent, viscous perfect gas to a uniform Mach Number 4.0 flow in a neighborhood of the exit plane.

A93-46477*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VISCOUS HYPERSONIC SHOCK-SHOCK INTERACTION ON A BLUNT BODY AT HIGH ALTITUDE
KEITH A. COMEAUX, DEAN R. CHAPMAN, and ROBERT W. MACCORMACK (Stanford Univ., CA) Jul. 1993 10 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 Research supported by National Defense Science and Engineering Graduate Fellowship Program and NASA refs
(Contract AF-AFOSR-91-0005)
(AIAA PAPER 93-2722) Copyright
The shock interaction produced when an incident oblique shock impinges on a blunt body, such as an engine inlet cowl lip of a hypersonic vehicle, is investigated for high altitude flight conditions. A perfect gas, Navier-Stokes numerical simulation of this problem at various altitudes representing continuum through transitional conditions is performed using the modified flux vector splitting method of Steger and Warming (1979). Two series of solutions are produced. First, a number-of-shock-positions are studied at a particular altitude and Mach number. Second, given a fixed shock position and Mach number, the interaction is investigated at several altitudes ranging from continuum to transitional flow conditions. It is shown that the interaction becomes fundamentally different as the density is lowered, and its effect on the overheating problem is progressively diminished. The maximum stagnation point heating at the highest altitude is reached only when the incident shock misses the cowl lip completely, and any interaction with the cowl bow shock that does occur takes place downstream and thus has little effect on the conditions at the stagnation point.
Author (revised)

A93-46478*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
HYPERSONIC STAGNATION LINE MERGED LAYER FLOW ON BLUNT AXISYMMETRIC BODIES OF ARBITRARY SHAPE
AMOLAK S. JAIN (Remtech, Inc., Huntsville, AL) Jul. 1993 11 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(Contract NAS8-37400)
(AIAA PAPER 93-2723) Copyright
The problem of hypersonic stagnation line merged-layer flow of variously shaped blunt asisymmetric bodies is here formulated in such a way as to allow analytical calculations for bodies generated by a conic section. The governing equations encompass, apart from the usual parameters, the eccentricity of the conic section that generates the body-of-revolution for the effect of body shape on the solution obtained. The stagnation-point surface pressure increases as the favorable pressure gradient decreases, in the course of a change of body shape from spherical to hyperboloid. AIAA

A93-46479*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PNS PREDICTIONS OF AXISYMMETRIC HYPERSONIC BLUNT-BODY AND AFTERBODY FLOWFIELDS
BILAL A. BHUTTA and CLARK H. LEWIS (VRA, Inc., Blacksburg, VA) Jul. 1993 15 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(Contract NAS1-19551)
(AIAA PAPER 93-2725) Copyright
A new space-marching full-body PNS algorithm capable of treating the complete blunt-body and afterbody flowfields over typical wide-bodied configurations is developed and demonstrated. A hybrid differencing scheme involving Flux-Vector Splitting (FVS) across embedded shocks and flowfield discontinuities, and central differencing in smooth (shock-free) regions is used. It is demonstrated that this new full-body PNS scheme can be marched from the spherical stagnation point over the entire body using bow-shock capturing, and provides an efficient and effective way for predicting blunt-body flowfields for various reentry application. The Mach 20 flow over a 30-deg sphere cone is predicted and comparisons are made with an existing VSL scheme for the blunt-body region and an existing PNS scheme for the conical afterbody region. The predicted flowfield and surface-measurable quantities are in excellent agreement, and demonstrate the accuracy and efficiency of the new full-body PNS scheme.

A93-46480*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
BURNETT SOLUTIONS ALONG THE STAGNATION LINE OF A COOLED CYLINDER IN LOW-DENSITY HYPERSONIC FLOWS
G. S. LIAW, K. L. GUO (Alabama Agricultural and Mechanical Univ., Normal), and L. C. CHOU (NASA, Marshall Space Flight Center, Huntsville, AL) Jul. 1993 8 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(Contract F33657-90-C-2296)
(AIAA PAPER 93-2726) Copyright
The Burnett equations in the cylindrical coordinate system have been applied to the hypersonic flow over a cylinder in low density environments. Through a local similarity transformation, the Burnett equations are degenerated into nonlinear third-order ordinary differential equations which are only valid along the stagnation line. These equations are solved by the multi-staged Runge-Kutta

integration technique. Steady state solutions are asymptotically reached by the time-marching procedure. A newly-developed computer code is used to solve both the Navier-Stokes and the Burnett equations within the shock layer. The computed heat transfer coefficients are consistent with wind-tunnel and STS flight data. Comparisons with the DSMC solutions and the Boltzmann solutions show that the Burnett equations are more appropriate as the governing equations than the Navier-Stokes equations in the transitional flow regime.

A93-46493#
A PRELIMINARY INVESTIGATION OF THE HELMHOLTZ RESONATOR CONCEPT FOR HEAT FLUX REDUCTION
B. YUCEIL, D. S. DOLLING, and D. WILSON (Texas Univ., Austin) Jul. 1993 13 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2742) Copyright

Surface temperatures have been measured over a hemispherical blunt body with a nose cavity in a Mach 4.9 air flow. The cavity diameter (D) has two discrete values with respect to model nose diameter (Dn) given by D = Dn/2 and D = Dn/4, whereas the length (L) of the cavity can be changed continuously from L/D = 0 to 0.7. Fluctuating pressure measurements were also made at the cavity base. For the global surface temperature measurements an infrared camera system was used. The results demonstrate that this approach may have promise with respect to reducing surface temperatures over part of the nose. Preliminary results indicate that the larger diameter shallow cavities (L/D between 0.15-0.35) reduce the temperatures in the vicinity of the cavity edge. Author (revised)

A93-46500*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A VISCOUS SHOCK-LAYER ANALYSIS OF 2-D AND AXISYMMETRIC FLOWS
ROOP N. GUPTA (NASA, Langley Research Center, Hampton, VA), KAM-PUI LEE (Vigyan, Inc., Hampton, VA), and ERNEST V. ZOBY (NASA, Langley Research Center, Hampton, VA) Jul. 1993 14 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2751) Copyright

Results are obtained for cylindrical leading edges of proposed transatmospheric vehicles by employing a 2D viscous shock-layer code for nonequilibrium and perfect gas flows. The accuracy and efficiency of the planar code is verified through detailed comparisons with other predictions. It is found to be as accurate and robust as its axisymmetric counterpart. This study includes results for nose radii ranging from 0.01 to 2.0 ft and half-angles of 5 and 6 deg for both cylindrically-blunted wedges and spherically blunted cones (included for comparison). Some results are presented as a ratio of the noncatalytic to the corresponding fully catalytic heating value to illustrate the maximum potential for a heating reduction in dissociated nonequilibrium flows. This ratio and the individual heating rates are smaller for cylindrically-blunted wedges with small nose radii, relative to the spherically-blunted cones (at the same radius). Therefore, a larger potential exists for heating reduction in cylindrically-blunted as compared with the spherically-blunted surfaces for finite-rate chemistry.
Author (revised)

A93-46509*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
TWO-LAYER CONVECTIVE HEATING PREDICTION PROCEDURES AND SENSITIVITIES FOR BLUNT BODY REENTRY VEHICLES
STANLEY A. BOUSLOG, MICHAEL Y. AN, K. C. WANG, LUEN T. TAM (Lockheed Engineering and Sciences Co., Houston, TX), and JOSE M. CARAM (NASA, Johnson Space Center, Houston, TX) Jul. 1993 22 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2763) Copyright

This paper provides a description of procedures typically used to predict convective heating rates to hypersonic reentry vehicles using the two-layer method. These procedures were used to compute the pitch-plane heating distributions to the Apollo geometry for a wind tunnel test case and for three flight cases. Both simple engineering methods and coupled inviscid/boundary layer solutions were used to predict the heating rates. The sensitivity of the heating results in the choice of metrics, pressure distributions, boundary layer edge conditions, and wall catalycity used in the heating analysis were evaluated. Streamline metrics, pressure distributions, and boundary layer edge properties were defined from perfect gas (wind tunnel case) and chemical equilibrium and nonequilibrium (flight cases) inviscid flow-field solutions. The results of this study indicated that the use of CFD-derived metrics and pressures provided better predictions of heating when compared to wind tunnel test data. The study also showed that modeling entropy layer swallowing and ionization had little effect on the heating predictions. Author (revised)

A93-46510#
AN INVESTIGATION OF AERODYNAMIC HEATING TO SPHERICALLY BLUNTED CONES AT ANGLE OF ATTACK
JASON P. SHIMSHI (Aerospace Corp., El Segundo, CA) and GERALD D. WALBERG (North Carolina State Univ., Raleigh) Jul. 1993 13 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2764) Copyright

The heat-transfer characteristics of axisymmetric spherically-blunted cones at angle-of-attack. Heat transfer predictions were obtained via the axisymmetric analog assumption with two boundary layer codes: AA3DBL, which uses an integral correlation for the heat transfer coefficient, and SABLE, which solves the nonaxisymmetric boundary-layer equations. Significant variations in heating distribution due to angle of attack, cone half-angle, and corner-radius are noted. AIAA

A93-46512*# National Aeronautics and Space Administration, Washington, DC.
AERODYNAMIC HEATING IN THE VICINITY OF HYPERSONIC, AXISYMMETRIC, SHOCK-WAVE BOUNDARY-LAYER INTERACTIONS
M. J. FLANAGAN, JR. (Dayton Univ., OH) Jul. 1993 10 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 Research supported by NASA refs
(AIAA PAPER 93-2766) Copyright

Aerodynamic heating rates are calculated from time-dependent temperature measurements in the vicinity of shock-wave boundary-layer interactions due to conical compression ramps on an axisymmetric body. The data were acquired at the Ohio State University Aeronautical and Astronautical Research Laboratory and at the Air Force Flight Dynamics Laboratory at Mach numbers of 6 and 10. The model is a cylindrical body with a 10 deg conical nose. Conical ramps with half-angles of 10, 20, 25, 30, and 35 deg serve as shock-wave generators. Flowfield surveys are made in the vicinity of the ramp vertices, separation points, and reattachment points. Experimental results quantify temperature response and the resulting heat transfer rates as a function of ramp angle, Reynolds number and freestream Mach number. The temperature responses within the flowfield appear to be steady-state for all angles and all Reynolds numbers, and hence, the heat transfer rates appear to be steady-state.
Author (revised)

A93-46534*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF AN ENGINEERING INVISCID-BOUNDARY LAYER METHOD TO SLENDER THREE-DIMENSIONAL VEHICLE FOREBODIES
CHRISTOPHER J. RILEY (NASA, Langley Research Center, Hampton, VA) Jul. 1993 10 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2793) Copyright

An engineering inviscid-boundary layer method has been modified for application to slender three-dimensional (3-D) forebodies which are characteristic of transatmospheric vehicles.

An improved shock description in the nose region has been added to the inviscid technique which allows the calculation of a wider range of body geometries. The modified engineering method is applied to the perfect gas solution over a slender 3-D configuration at angle of attack. The method predicts surface pressures and laminar heating rates on the windward side of the vehicle that compare favorably with numerical solutions of the thin-layer Navier-Stokes equations. These improvements extend the 3-D capabilities of the engineering method and significantly increase its design applications.

A93-46538*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A SYSTEMS APPROACH TO A DSMC CALCULATION OF A CONTROL JET INTERACTION EXPERIMENT
PAUL V. TARTABINI, RICHARD G. WILMOTH, and DIDIER F. G. RAULT (NASA, Langley Research Center, Hampton, VA) Jul. 1993 13 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2798) Copyright

This study deals with the development of a methodology for numerically simulating the interaction of a reaction control system (RCS) jet with a low-density external flow. A European Space Agency (ESA) experiment was chosen as a test case since it provided experimental data that could validate some of the numerical results. The initial approach was to focus on several subproblems having direct relevance to the full interaction problem. This enabled different numerical methods to be separately investigated and validated for each part of the interaction problem. In this manner, the best methodology for solving the full interaction problem was developed. The subproblems considered in this study included typical RCS nozzle and plume flows, a flat plate at zero incidence, and the flow past the experimental test model without the control jet firing. Once these calculations were completed, a simulation was performed with a control jet operating at a relatively low density. The results from this latter simulation provided qualitative insight into the complex interaction process.

A93-46546*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLOW RESOLUTION AND DOMAIN OF INFLUENCE IN RAREFIED HYPERSONIC BLUNT-BODY FLOWS
BRIAN L. HAAS (Eloret Inst., Palo Alto, CA) Jul. 1993 11 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(Contract NCC2-582)
(AIAA PAPER 93-2806)

The study assesses the effects of the upstream domain size and grid resolution upon flow properties and body aerodynamics computed for rarefied flows over cold blunt bodies with a direct simulation Monte Carlo (DSMC) particle method. Empirical correlations are suggested for aerodynamic coefficients for two-dimensional flows past a perpendicular flat plate. Free-stream parameters which were varied in the study include the Mach number, Knudsen number, surface temperature, and intermolecular potential. Insufficient grid resolution leads to overprediction of aerodynamic heating and forces in the DSMC method. Solution accuracy correlates well with the Reynolds number defined at the wall temperature and the stagnation mean free path relative to the cell dimension. Insufficient upstream domain size in the DSMC method leads to overprediction of heating and drag. Errors in aerodynamic coefficients correlate well with the distance ahead of the body where flow temperature reaches half of its peak value. Simulation of a hard-sphere gas is more sensitive to grid resolution, while simulation of a Maxwell gas is more sensitive to upstream domain size. Author (revised)

A93-46547*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HYPERSONIC BLUNT BODY WAKE COMPUTATIONS USING DSMC AND NAVIER-STOKES SOLVERS
JAMES N. MOSS, ROBERT A. MITCHELTREE (NASA, Langley Research Center, Hampton, VA), VIRENDRA K. DOGRA (Vigyan, Inc., Hampton, VA), and RICHARD G. WILMOTH (NASA, Langley Research Center, Hampton, VA) Jul. 1993 19 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2807) Copyright

Numerical results obtained with direct simulation Monte Carlo (DSMC) and Navier-Stokes methods are presented for Mach 20 nitrogen flow about a 70-deg blunted cone. The flow conditions simulated are those that can be obtained in existing low-density hypersonic wind tunnels. Three sets of flow conditions are considered with freestream Knudsen numbers ranging from 0.03 to 0.001. The focus is on the wake structure: how does the wake structure change as a function of rarefaction, what are the afterbody levels of heating, and to what limits are continuum models realistic as rarefaction in the wake is progressively increased. Calculations are made with and without an afterbody sting. Results for the afterbody sting are emphasized in anticipation of an experimental study for the current flow conditions and model configuration. The Navier-Stokes calculations were made with and without slip boundary conditions. Comparisons of the results obtained with the two simulation methodologies are made for both flowfield structure and surface quantities.

A93-46548# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MONTE CARLO SIMULATION OF RADIATING REENTRY FLOWS
JEFF C. TAYLOR (North Carolina State Univ., Raleigh), ANN B. CARLSON (NASA, Langley Research Center, Hampton, VA), and H. A. HASSAN (North Carolina State Univ., Raleigh) Jul. 1993 13 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(Contract NCC1-112; NAGW-1331)
(AIAA PAPER 93-2809) Copyright

The Direct Simulation Monte Carlo (DSMC) method is applied to a radiating, hypersonic, axisymmetric flow over a blunt body in the near continuum regime. The ability of the method to predict the flowfield radiation and the radiative heating is investigated for flow over the Project Fire II configuration at 11.36 kilometers per second at an altitude of 76.42 kilometers. Two methods that differ in the manner in which they treat ionization and estimate electronic excitation are employed. The calculated results are presented and compared with both experimental data and solutions where radiation effects were not included. Differences in the results are discussed. Both methods ignore self absorption and, as a result, overpredict measured radiative heating.

A93-46549# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPARISONS BETWEEN DSMC AND THE NAVIER-STOKES EQUATIONS FOR REENTRY FLOWS
DAVID R. OLYNICK (NASA, Ames Research Center, Moffett Field, CA), JEFF C. TAYLOR, and H. A. HASSAN (North Carolina State Univ., Raleigh) Jul. 1993 14 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(Contract NCC1-112; NAGW-1331)
(AIAA PAPER 93-2810) Copyright

A detailed comparison is made between Navier-Stokes and DSMC calculations for flows near the continuum limit to assess the accuracy of the continuum equations in this regime. Meaningful comparisons require the use of similar physical models. This necessitates the inclusion of a separate rotational energy equation and use of slip boundary conditions. Inclusion of slip boundary conditions resulted in improved agreement between surface properties. Moreover, good agreement was obtained for the various temperatures in the nonequilibrium portion of the flow field that does not contain the shock region. Departures are noted in the shock region and in regions where thermal diffusion effects are important.

A93-46552*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

NAVIER-STOKES SIMULATIONS OF THE SHUTTLE ORBITER AERODYNAMIC CHARACTERISTICS WITH EMPHASIS ON PITCH TRIM AND BODYFLAP

K. J. WEILMUENSTER, PETER A. GNOFFO, and FRANCIS A. GREENE (NASA, Langley Research Center, Hampton, VA) Jul. 1993 21 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs

(AIAA PAPER 93-2814) Copyright

An analysis of the longitudinal aerodynamics of the Shuttle Orbiter in the hypersonic flight regime is made through the use of computational fluid dynamics (CFD). Particular attention is given to establishing the cause of the 'pitching moment anomaly' which occurred on the Orbiter's first flight and to computing the aerodynamics of a complete Orbiter configuration at flight conditions. Data from ground based facilities as well as Orbiter flight data are used to validate the computed results. Analysis shows that the 'pitching moment anomaly' is a real gas chemistry effect which cannot be simulated in ground-based facilities. Computed flight aerodynamics for the Orbiter are within 5 percent of the measured flight values and trim bodyflap deflections are predicted to within 10 percent.

A93-46553*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AERODYNAMICS OF SHUTTLE ORBITER AT HIGH ALTITUDES

DIDIER F. G. RAULT (NASA, Langley Research Center, Hampton, VA) Jul. 1993 20 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs

(AIAA PAPER 93-2815) Copyright

The high-altitude/high-Knudsen number aerodynamics of the Shuttle Orbiter are computed from Low-Earth Orbit down to 100 km using three-dimensional direct simulation Monte Carlo and free molecule codes. Results are compared with Blanchard's latest Shuttle aerodynamic model, which is based on in-flight accelerometer measurements, and bridging formula models. Good comparison is observed, except for the normal force and pitching moment coefficients. The present results were obtained for a generic Shuttle geometry configuration corresponding to a zero deflection for all control surfaces.

A93-46699

A NUMERICAL SOLUTION OF THE ASYMPTOTIC PROBLEM OF BOUNDARY LAYER SEPARATION IN AN INCOMPRESSIBLE LIQUID UPSTREAM OF THE CORNER POINT OF A BODY [CHISLENNOE RESHENIE ASIMPTOTICHESKOJ ZADACHI OB OTRYVE POGRANICHNOGO SLOYA NESZHIMAEMOJ ZHIDKOSTI PERED UGLOVOJ TOCHKOJ KONTURA TELA]

M. A. KRAVTSOVA Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki (ISSN 0044-4669) vol. 33, no. 3 March 1993 p. 439-449. In RUSSIAN refs

Copyright

A solution is obtained for the flow separation problem for an incompressible liquid, upstream of the corner point of a body. The problem is analyzed in the framework of the asymptotic theory of interaction between the laminar boundary layer and the inviscid outer flow layer, using Veldman's (1981) quasi-simultaneous method to calculate the interaction of the flow layers. AIAA

A93-46744 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

STRONG VORTEX/BOUNDARY LAYER INTERACTIONS. II - VORTICES LOW

A. D. CUTLER (George Washington Univ.; NASA, Langley Research Center, Hampton, VA) and P. BRADSHAW (Stanford Univ., CA) Experiments in Fluids (ISSN 0723-4864) vol. 14, no. 6 May 1993 p. 393-401. refs

(Contract NAGW-581; NCC1-24; NAS1-18458)

Copyright

This is the second of two papers on the interaction between a longitudinal vortex pair, produced by a delta-wing at angle of attack, and a turbulent boundary layer developing on a flat plate. In the first paper only the outer parts of the vortices entered the boundary layer whereas in this paper the vortices merge with it. In the resultant interaction, the boundary layer between the vortices is kept thin by lateral divergence and a three-dimensional separation line is formed outboard of each vortex. Turbulent, momentum-deficient fluid containing longitudinal vorticity is entrained from the boundary layer along these lines and wrapped around the vortices. As a consequence, the turbulent region of the vortices increases in size and the circulation slowly decreases. It is shown that the flow near the separation line and in the vortices is complicated, and this interaction is expected to be more difficult to calculate than the first. Detailed mean flow and turbulence measurements are reported.

A93-46748

OBSERVATIONS OF LARGE-SCALE STRUCTURES IN WAKES BEHIND AXISYMMETRIC BODIES

S. CANNON (McDonnell Douglas Electronic Systems Co., Santa Ana, CA), F. CHAMPAGNE (Arizona Univ., Tucson), and A. GLEZER (Georgia Inst. of Technology, Atlanta) Experiments in Fluids (ISSN 0723-4864) vol. 14, no. 6 May 1993 p. 447-450. refs

Copyright

Wakes behind disk-shaped axisymmetric bodies of varying solidity are studied using flow visualization and 2D Fourier decomposition of velocity measurements. Evidence of a reverse flow region behind some of the bodies is observed to coincide with the presence of large-scale structures in the near and far wake. Fourier analysis shows that these large-scale structures are predominately helical ($m = +/- 1$) and occur at a characteristic frequency which corresponds to their wavelength, as observed from flow visualization. Our measured value for this characteristic frequency agrees with vortex shedding frequencies observed for these types of wakes. Author (revised)

A93-46750

VISUAL OBSERVATIONS OF SUPERSONIC TRANSVERSE JETS

D. PAPAMOSCHOU and D. G. HUBBARD (California Univ., Irvine) Experiments in Fluids (ISSN 0723-4864) vol. 14, no. 6 May 1993 p. 468-471. refs

(Contract F33615-88-C-2889)

Copyright

We present experimental results on penetration of round sonic and supersonic jets normal to a supersonic cross flow. It is found that penetration is strongly dependent on momentum ratio, weakly dependent on free-stream Mach number, and practically independent of jet Mach number, pressure ratio, and density ratio. The overall scaling of penetration is not very different from that established for subsonic jets. The flow is very unsteady, with propagating pressure waves seen emanating from the orifice of helium jets.

A93-46787#

FREE SHEAR LAYER CONTROL AND ITS APPLICATION TO FAN NOISE

TZONG-SHYNG LEU and CHIH-MING HO (California Univ., Los Angeles) Jul. 1993 10 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 refs

(Contract N00014-92-J-1148; N00014-92-J-1731)

(AIAA PAPER 93-3242) Copyright

Free shear layers are known to be sensitive to the imposed perturbations or geometrical variations at the origin of the flow. The streamwise development of the free shear layer can be effectively controlled by using this property. In this experiment, we have found that the flow pattern of a wake or a mixing layer can be dramatically changed by applying suction at the trailing edge of the splitter plate. In an axial fan, the noise is produced by the interaction of the rotor wake and the stator. By altering the characteristics of the wake, the noise is expected to be greatly modified. In the present study, we demonstrate that the wake-blade flow can be stabilized by the combination of suction and a thin control rod.

A93-46789#
ENHANCED MIXING VIA GEOMETRIC MANIPULATION OF A SPLITTER PLATE
B. KOCK AM BRINK and J. F. FOSS (Michigan State Univ., East Lansing) Jul. 1993 8 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research supported by United Technologies Corp refs
(AIAA PAPER 93-3244) Copyright

A planar cambered surface, placed m a square section wind tunnel, creates a small velocity ratio two-stream shear layer. The strong effect of a rippled trailing edge (RTE), with lobe height h, is made evident by data comparisons with the planar trailing edge (PTE) condition. The initial (x/h = 1) orientation of the RTE secondary flows are aligned with the lobes. The flow at x/h = 10 has essentially recovered an orientation expected for a planar wake producing object. The data clearly show the strong mixing enhancement of the RTE condition.

A93-46790#
ACTIVE FORCING OF AN AXISYMMETRIC LEADING-EDGE TURBULENT SEPARATION BUBBLE
M. KIYA, M. SHIMIZU, O. MOCHIZUKI, Y. IDO, and H. TEZUKA (Hokkaido Univ., Sapporo, Japan) Jul. 1993 12 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-3245) Copyright

A study aimed at controlling the turbulent leading-edge separation bubble of the blunt circular cylinder by single- and two-frequency sinusoidal disturbances uniformly introduced along the square-cut separation edge is presented. It is concluded that the frequency of shedding of large-scale vortices from the reattachment region can be explained by assuming that the separation bubble is a self-excited system maintained by a feedback loop. If the level of the single-frequency forcing is less than three percent of the main-flow velocity, the reattachment length attains a minimum at a forcing frequency which is about 1/4-1/5 of the vortex-shedding frequency. Its maximum is larger than that of the unforced flow at another forcing frequency of about a half of the frequency of the Kelvin-Helmholtz instability near the separation edge. AIAA

A93-46791#
A VISUAL STUDY OF RECESSED ANGLED SPANWISE BLOWING METHOD ON A DELTA WING
K. FITZPATRICK, H. JOHARI, and D. OLINGER (Worcester Polytechnic Inst., MA) Jul. 1993 8 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research supported by Worcester Polytechnic Inst refs
(AIAA PAPER 93-3246) Copyright

An innovative vortex control technique implemented on a beveled 60-degree delta wing has been investigated in a water tunnel. Three pairs of blowing ports were placed at 0.2, 0.3, and 0.4 chord location on top of the wing. The ports were canted outward in the spanwise direction such that the injected flow is parallel to the beveled edge. Flow visualization experiments were accomplished using dye injected into the leading edge vortices near the wing apex and the vortex burst location was visually observed. Blowing coefficient values up to O.1 were used in the experiments. Moderate improvements in vortex breakdown location up to 15 percent chord were obtained when this blowing technique was utilized. The effects of blowing at a single chord location diminish above blowing coefficients of 0.05. Additionally, it was found that this technique, under certain circumstances, can be used to induce vortex breakdown near the designated blowing ports. This ability can be useful in improving maneuverability at high angles of attack.

A93-46792#
THE USE OF STREAMWISE VORTICITY TO ENHANCE EJECTOR PERFORMANCE
M. J. CARLETTI, C. B. ROGERS (Tufts Univ., Medford, MA), and D. E. PAREKH (McDonnell Douglas Corp., Saint Louis, MO) Jul. 1993 12 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research supported by McDonnell Douglas Corp. and Tufts Univ refs
(AIAA PAPER 93-3247) Copyright

The following work documents the effect of streamwise vortices generated at the nozzle exit of an axisymmetric air jet on the pumping performance of an ejector. In an experimental analysis of the mass entrainment of circular jet ejectors, we found that the introduction of half delta wing vortex generators in the exit of the jet nozzle (Reynolds number of 50,000) increased the amount of entrained mass by as much as 50 percent over the amount of increase provided by the ejector alone. The effectiveness of the generators was studied for several cases varying spacing, diameter, length, and Reynolds number. Although the performance of an ejector is a strong function of these parameters, the increase in mass entrainment due to the vortex generators was relatively consistent. Finally, through image analysis, we found that the introduced vorticity caused the jet to mix up to 60 percent faster inside the ejector.

A93-46793*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONTROL OF A SUPERSONIC REATTACHING SHEAR LAYER
J. POGGIE and A. J. SMITS (Princeton Univ., NJ) Jul. 1993 14 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 refs
(Contract NAG1-1072; AF-AFOSR-90-0217)
(AIAA PAPER 93-3248)

A reattaching supersonic shear layer was perturbed by transverse air injection, and the effects were investigated using flow visualization. It was found that shear layer mixing was increased and that the shock system was strongly disturbed due to the heightened three dimensionality of the flow. Mixing enhancement was also achieved in an incompressible downstream-facing step flow using the same blowing procedure.

A93-46794#
PASSIVE CONTROL OF SHOCK WAVE/BOUNDARY LAYER INTERACTION AT HYPERSONIC SPEED
SUXUN LI and YUEDING SHI (Beijing Inst. of Aerodynamics, China) Jul. 1993 7 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research sponsored by NNSFC refs
(AIAA PAPER 93-3249) Copyright

A passive control study of 3D shock wave/boundary layer interaction was carried out in a hypersonic wind tunnel with free stream Mach number of 5 and Reynolds number per meter of 5 x 1O exp 7/m in this paper. A 3D incident shock was incoming to a thick turbulent boundary layer on a received plate, then the turbulent boundary layer was separated and reattached on the surface. The passive control of shock wave/boundary layer was studied to influence on interactive flow field. A piece of porous surface was mounted on the middle of received plate with a cavity under the porous plate, the porosity distribution is uniform and the ratio of porous to solid surface area is P = 0.03 or P = 0.047. A set of schlieren photographs and static pressure distributions were shown. Author (revised)

A93-46798#
ACTIVE BOUNDARY-LAYER CONTROL IN DIFFUSERS
A. H. M. KWONG and A. P. DOWLING (Cambridge Univ., United Kingdom) Jul. 1993 9 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research supported by Cambridge Univ refs
(AIAA PAPER 93-3255) Copyright

Flow separation in diffusers leads to loss in energy recovery and is often a source of unsteadiness due to stall movements. This paper investigates the use of wall jets as a remedy to these problems. New jet geometries are compared to the conventional annular blowing. Steady wall jets are found to be capable of raising the mean pressure recovery in both conical and rectangular air diffusers, but high injected mass flow rates are required before the flow in rectangular diffusers becomes steady. Active feedback control is applied to reduce this flow unsteadiness. To implement the control, the air supplied through the wall jets is modulated in response to the unsteady pressures within the diffuser. Results are presented for two feedback mechanisms. Both are found effective with the level of attenuation well predicted by theory. A combination of steady and unsteady blowing is found capable of giving both a good mean pressure recovery and reduced pressure oscillations.

A93-46799#

ARTIFICIAL TRANSITION - A TOOL FOR HIGH REYNOLDS NUMBER SIMULATION?

YOUNGGUANG TENG (Nanjing Aeronautical Inst., China) and HANS-ULRICH MEIER (DNW German-Dutch Wind Tunnel, Emmeloord, Netherlands) Jul. 1993 8 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 refs

(AIAA PAPER 93-3258) Copyright

The problem of artificial boundary-layer transition was studied on a large 1:3.5 scale half mode1 of the CASA 3000 turboprop aircraft in the DNW. The experimental results concerning the influence of a local roughness immersed in a turbulent boundary layer were supplemented by a theoretical estimation and a methodical experiment on a 2D test model in the 1:10 scale model wind tunnel of DNW. Based on these results some fundamental limitations for the artificial boundary-layer tripping were derived. It was found that the application of electro-acoustic generators as a transition device can avoid most of the shortcomings resulting from the use of artificial roughnesses. Author (revised)

A93-46800*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

EFFECTS OF BLEED-HOLE GEOMETRY AND PLENUM PRESSURE ON THREE-DIMENSIONAL SHOCK-WAVE/BOUNDARY-LAYER/BLEED INTERACTIONS

WEI J. CHYU (NASA, Ames Research Center, Moffett Field, CA), MARK J. RIMLINGER, and TOM I.-P. SHIH (Carnegie Mellon Univ., Pittsburgh, PA) Jul. 1993 19 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 refs

(AIAA PAPER 93-3259)

A numerical study was performed to investigate 3D shock-wave/boundary-layer interactions on a flat plate with bleed through one or more circular holes that vent into a plenum. This study was focused on how bleed-hole geometry and pressure ratio across bleed holes affect the bleed rate and the physics of the flow in the vicinity of the holes. The aspects of the bleed-hole geometry investigated include angle of bleed hole and the number of bleed holes. The plenum/freestream pressure ratios investigated range from 0.3 to 1.7. This study is based on the ensemble-averaged, 'full compressible' Navier-Stokes (N-S) equations closed by the Baldwin-Lomax algebraic turbulence model. Solutions to the ensemble-averaged N-S equations were obtained by an implicit finite-volume method using the partially-split, two-factored algorithm of Steger on an overlapping Chimera grid. Author (revised)

A93-46804* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

HIGH SPEED PROPELLER ACOUSTICS AND AERODYNAMICS - A BOUNDARY ELEMENT APPROACH

F. FARASSAT (NASA, Langley Research Center, Hampton, VA), M. K. MYERS (George Washington Univ., Hampton, VA), and M. H. DUNN (Planning Research Corp., Hampton, VA) Oct. 1989 8 p. International Symposium on Boundary Element Methods, East Hartford, CT, Oct. 2-4, 1989, Paper refs

The Boundary Element Method (BEM) is applied in this paper to the problems of acoustics and aerodynamics of high speed propellers. The underlying theory is described based on the linearized Ffowcs Williams-Hawkings equation. The surface pressure on the blade is assumed unknown in the aerodynamic problem. It is obtained by solving a singular integral equation. The acoustic problem is then solved by moving the field point inside the fluid medium and evaluating some surface and line integrals. Thus the BEM provides a powerful technique in calculation of high speed propeller aerodynamics and acoustics.

A93-46812* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A MULTIBLOCK, MULTIGRID SOLUTION PROCEDURE FOR MULTIELEMENT AIRFOILS

MARK D. SANETRIK (West Virginia Univ., Morgantown) and R. C. SWANSON (NASA, Langley Research Center, Hampton, VA) May 1991 9 p. SIAM, Conference on Domain Decomposition Methods for Partial Differential Equations, 5th, Norfolk, VA, May 6-8, 1991, Paper refs

A block-structured grid formulation is presented and discussed. The compressible Euler equations are solved on the decomposed domain with a multigrid method based on Runge-Kutta time stepping and centered spatial differencing. The flexibility of the multiblock approach is demonstrated by computing low speed inviscid flow over two different multielement airfoil configurations.

A93-46816* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SUPERSONIC/HYPERSONIC AERODYNAMIC METHODS FOR AIRCRAFT DESIGN AND ANALYSIS

ABEL O. TORRES (NASA, Langley Research Center, Hampton, VA) Nov. 1992 10 p. Society of Hispanic Professional Engineers, Region IV, Annual Eastern Technical and Career Conference, 6th, Washington, Nov. 12-14, 1992, Paper refs

A methodology employed in engineering codes to predict aerodynamic characteristics over arbitrary supersonic/hypersonic configurations is considered. Engineering codes use a combination of simplified methods, based on geometrical impact angle and freestream conditions, to compute pressure distribution over the vehicle's surface in an efficient and timely manner. These approximate methods are valid for both hypersonic (Mach greater than 4) and lower speeds (Mach down to 2). It is concluded that the proposed methodology enables the user to obtain reasonable estimates of vehicle performance and engineering methods are valuable in the design process of these type of vehicles. AIAA

A93-46817* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

TRANSITION IN SUPERSONIC FLOW PAST AXISYMMETRIC BODIES

M. R. MALIK (High Technology Corp., Hampton, VA) and M. G. MACARAEG (NASA, Langley Research Center, Hampton, VA) May 1990 4 p. U.S. National Congress of Applied Mechanics, 11th, Tucson, AZ, May 21-25, 1990, Paper refs

The paper reviews some recent work on the stability of supersonic flow past axisymmetric bodies. Results indicate that tranverse curvature effect can both be stabilizing or destabilizing depending upon the particular instability modes involved. Small nose bluntness is found to have a stabilizing influence on the flow past a cone. The relevance of these results to supersonic boundary-layer transition is brought out and comparison with the experimental data is made where possible.

A93-46823* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

COMPARATIVE WIND TUNNEL TESTS AT HIGH REYNOLDS NUMBERS OF NACA 64 621 AIRFOILS WITH TWO AILERON CONFIGURATIONS

G. M. GREGOREK (Ohio State Univ., Columbus) May 1984 14 p. Horizontal-Axis Wind Turbine Technology Workshop, Cleveland, OH, May 8-10, 1984, Paper

(Contract NAG3-330)

An experimental program to measure the aerodynamic characteristics of the NACA 64-621 airfoil when equipped with plain ailerons of 0.38 chord and 0.30 chord and with 0.38 chord balanced aileron has been conducted in a pressurized 6 x 12-inch High Reynolds Number Wind Tunnel. Surface pressures were measured and integrated to yield lift and pressure drag coefficients for angles of attack from -3 deg to +42 deg, and for selected aileron deflections from 0 to -90 deg at nominal Mach and Reynolds numbers of 0.25 and 5 x l0 exp 6, respectively. When resolved into thrust coefficient for wind turbine aerodynamic control applications, the data indicated the anticipated decrease in thrust coefficient with negative aileron deflection at low angles of attack; however, as angle of attack increased, thrust coefficients eventually became positive. All aileron configurations, even at -90 deg deflections, showed this trend. Hinge moments for each configuration complete the data set. Author (revised)

A93-46826#

THE COUNTERCURRENT MIXING LAYER - STRATEGIES FOR SHEAR-LAYER CONTROL

P. J. STRYKOWSKI (Minnesota Univ., Minneapolis) and A. KROTHAPALLI (Florida Agricultural and Mechanical Univ.; Florida State Univ., Tallahassee) Jul. 1993 15 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 refs
(Contract NSF CTS-91-16532; N00014-92-J-1406; F49620-92-J-0426)
(AIAA PAPER 93-3260) Copyright

The dynamics of a spatially developing countercurrent mixing layer is studied in a parameter space including velocity ratio, density ratio, and convective Mach number. Under an appropriate set of operating conditions, the countercurrent mixing layer displays strong global oscillations which significantly alter the spatial development of the flow. Evidence is presented which suggests these oscillations are associated with a transition from convective to absolute instability. Countercurrent mixing is examined as a novel control strategy of supersonic free shear flows. Experiments indicate that counterflow can be used effectively to enhance mixing in supersonic axisymmetric jets. It is also demonstrated that counterflow can be successfully employed for the thrust vector control of high-speed rectangular jets.

A93-46827#

THRUST VECTORING CONTROL FROM UNDEREXPANDED ASYMMETRIC NOZZLES

KENNETH C. CORNELIUS and GERALD A. LUCIUS (Wright State Univ., Dayton, OH) Jul. 1993 9 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research supported by Wright State Univ refs
(AIAA PAPER 93-3261) Copyright

Experimental measurements of side force for an underexpanded 2-D nozzle and an axisymmetric contraction for a 3-D nozzle with side wall translation demonstrate that vectored angles of 20 degrees can be obtained at a pressure ratio of 11. For a vectored control jet the magnitude of side force can be increased by the translation of the side wall where the optimum length is dependent on the pressure ratio value. The inviscid wave equation results are in excellent agreement with the experimental 2-D measurements. The optimum length of extension for the 3-D nozzle occurs at 1.6 times the throat dimension with similar thrust vectoring capability. The physics of the expansion and the jet momentum turning are qualitatively described using an optical Schlierien system.

A93-46828#

PASSIVE CONTROL OF COHERENT VORTICES IN COMPRESSIBLE MIXING LAYERS

KEN YU, EFFIE GUTMARK, and KLAUS C. SCHADOW (U.S. Navy, Naval Air Warfare Center, China Lake, CA) Jul. 1993 10 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research supported by ASEE/ONT Postdoctoral Fellowship refs
(AIAA PAPER 93-3262) Copyright

Passive control of coherent vortex formation is demonstrated in three axisymmetric compressible mixing layers. The layers are created (1) between Mach 2 and Mach 1.3 coflowing supersonic jets, (2) between Mach 3 and Mach 1.3 jets, or (3) by a free flowing Mach 2 supersonic jet. All the supersonic jets are fully expanded in the experiments. The convective Mach numbers were 0.23, 0.47, and 0.85, respectively. In the first two cases, which use coaxial jets, coherent vortex formation is controlled by having a finite-thickness nozzle lip and varying its thickness. The interaction between the lip-created wake and the shear flow results in highly coherent large-scale structures. The lip thickness is systematically varied and the resulting compressible shear layers are visualized using a planar Mie scattering technique. The Mie scattering images are digitized and processed, using the FFT to quantify the streamwise wavelength. The results show that the streamwise wavelength varies monotonically with the lip thickness. In a resonating cavity's use for passively controlling free shear layers, the cavity draws acoustic energy from the supersonic jet noise and amplifies certain frequency oscillations by the acoustic resonance. When forced in this manner, the spreading rate of the compressible shear layer is drastically increased. Author (revised)

A93-46829#

THE EFFECTS OF FORCED OSCILLATIONS ON THE PERFORMANCE OF AIRFOILS

A. SEIFERT, A. DARABY, B. NISHRI, and I. WYGNANSKI (Tel Aviv Univ., Israel) Jul. 1993 16 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research sponsored by Ministry of Defence of Israel refs
(AIAA PAPER 93-3264) Copyright

A study aimed at determining the most important dimensionless parameters scaling the flow and their effect on the performance of a flapped NACA 0015 airfoil when oscillatory blowing emanated from its leading edge is presented. Results are compared with similar experiments performed on the same airfoil when the blowing emanated from the flap-shoulder located at 75 percent of the chord. It is concluded that the introduction of 2D, periodic oscillations into a turbulent boundary layer enables it to resist larger adverse pressure gradient without separating. It increases the lift and reduces the form drag generated by airfoils. The most effective frequency of forcing the flow over airfoils is considered to be one in which the length of the surface was comparable to the imposed wave length. AIAA

A93-46830#

VORTEX CAPTURE BY A TWO-DIMENSIONAL AIRFOIL WITH A SMALL OSCILLATING LEADING-EDGE FLAP

M. D. ZHOU (Arizona Univ., Tucson), H. H. FERNHOLZ (Berlin Technical Univ., Germany), H. Y. MA, J. Z. WU, and J. M. WU (Tennessee Univ., Tullahoma) Jul. 1993 9 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research supported by Volkswagen-Stiftung and Univ. of Tennessee refs
(AIAA PAPER 93-3266) Copyright

In order to explore the possibility of capturing a vortex on the upper surface of an airfoil at high angle of attack by unsteady excitations, a sharp-leading-edge airfoil with oscillating leading edge flap was tested in a low speed wind tunnel and simulated by numerical computation. The most important experimental result is that a 60 percent-70 percent of lift increment was achieved with little or even no penalty on drag at post stall condition, when the excitation changed the massively separated flow to a closed separation bubble in the mean sense, and thus held a strong vortex on the upper surface of the airfoil. As a complement to this experimentally obtained time-averaged picture, preliminary numerical computation revealed the corresponding instantaneous process. The result shows that, with excitation, vortices are still shedding, but the probability of a well-organized lifting vortex staying above the airfoil is much larger than that without excitation. This finding suggests a potential of designing innovative high-lift airfoils and wings.

A93-46831#

THE EFFECT OF REYNOLDS NUMBER ON CONTROL OF FOREBODY ASYMMETRY BY SUCTION AND BLEED

JOHN BERNHARDT and DAVID R. WILLIAMS (Illinois Inst. of Technology, Chicago) Jul. 1993 8 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 refs
(Contract F49620-86-C-033)
(AIAA PAPER 93-3265) Copyright

The response of the side force to controlled forcing and the behavior of the flow field behind a forebody model at high angles of attack has been studied using steady bleed, steady suction and unsteady bleed. The distortion in the mean velocity profiles has been quantified and shown to grow exponentially in space. The spatial growth rate and the wave propagation speed have been measured at one set of flow conditions. The effect of forcing with suction at the tip is shown to be opposite to the blowing type of forcing. As the Reynolds number increases, the side force response to the forcing changes from bistable, to two-state, to a continuous variation with bleed coefficient. The critical bleed coefficient that produces a symmetric flow is shown to be proportional to Re exp 3.9. Author (revised)

A93-46832#

CONTROL OF THE DYNAMIC-STALL VORTEX OVER A PITCHING AIRFOIL BY LEADING-EDGE SUCTION

M. A. KARIM and MUKUND ACHARYA (Illinois Inst. of Technology, Chicago) Jul. 1993 10 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 refs
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(AIAA PAPER 93-3267) Copyright

Experiments to control the dynamic-stall vortex (DSV) over the suction surface of a 2D NACA 0012 airfoil, undergoing a 'hold-pitch-hold' motion, are described. Measurements were performed over a range of Reynolds number from 30,000 to 118,000 and pitch rate in the 0.072 to 0.31 range, using leading-edge suction during a prescribed period of the airfoil motion. The results indicate that formation of the DSV can be suppressed by removing an appropriate amount of the reverse-flowing fluid to prevent its accumulation in the near-leading-edge region, thereby preventing lift up of the shear layer. The influence of different parameters such as pitch rate, Reynolds number, suction timing, and suction-slot size and location on the control of the DSV is described. A scaling is developed for the suction flow rate which provides valuable information about the growth of the reverse-flow region and its dependency on different parameters. Parameter ranges are identified for which complete or partial suppression of the DSV can be achieved. Author (revised)

A93-46835#

AN INVESTIGATION OF THE EFFECTS OF A REAR STAGNATION JET ON THE WAKE BEHIND A CYLINDER

J. D. MO and M. R. DUKE, JR. (Memphis State Univ., TN) Jul. 1993 11 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research supported by Memphis State Univ refs
(AIAA PAPER 93-3274) Copyright

A numerical analysis and experimental flow visualization on the behavior of the wake flow behind a cylinder with a rear stagnation jet has been conducted. This inherently unsteady laminar flow was simulated numerically by solving the time-dependent incompressible Navier-Stokes equations in primitive variable form. A new pressure-based method has been developed with an explicit pressure correction term to ensure mass continuity. The numerical and experimental results both showed that a rear stagnation jet can be applied to effectively reduce the massively separated wake flow behind a cylinder, and that the jet forced the alternating nature of the wake to become symmetric. The numerical analysis showed that the form drag increases exponentially as the jet speed increases. The comparisons of the numerical results and experimental flow visualization were in fairly good agreement.

A93-46839*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

CONTROL OF UNSTEADY SHOCK-INDUCED TURBULENT BOUNDARY LAYER SEPARATION UPSTREAM OF BLUNT FINS

K. KLEIFGES and D. S. DOLLING (Texas Univ., Austin) Jul. 1993 17 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research supported by USAF refs
(Contract NAG1-1005)
(AIAA PAPER 93-3281) Copyright

Fluctuating wall pressure measurements have been made on centerline upstream of blunt fins in a Mach 5 turbulent boundary layer. Standard time series analysis and conditional sampling algorithms have been used to examine the effects of leading edge sweepback, leading edge shape, and fin root modifications on the fluctuating pressures. 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, and the separation length. The frequency of pressure fluctuations in the intermittent region increases with leading edge sweepback, while the spectral content of pressure fluctuations in the separated region is virtually unchanged by leading edge sweep. A swept hemicylindrically blunted root fillet reduces the centerline upstream influence and intermittent region length by 50 percent, and reduces the mean and rms pressure loading at the fin root by about 75 percent and 95 percent respectively. Experiments using hemicylindrical, wedge shaped and flat leading edges show that while separated flow scales increase with increasing 'bluntness', intermittent region length and root loading decrease, and separation shock frequency increases. Author (revised)

A93-46841#

TRANSONIC FLUTTER SUPPRESSION USING ACTIVE ACOUSTIC EXCITATIONS

PONG-JEU LU and DUN-YANN YEH (National Cheng Kung Univ., Tainan, Taiwan) Jul. 1993 12 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-3285) Copyright

The objective of this work is to study the feasibility of using acoustic wave as a means for suppressing the flutter instability of a typical section in the transonic flow. A high-resolution upwind TVD flow solver of acoustic accuracy is first constructed and validated on a dynamic mesh system. Geometric conservation law is implemented consistently with the physical conservation law via a suitably defined cell boundary speed. This developed structure/fluid/acoustic solver is then integrated in the time-domain to see whether flutter can be suppressed using active acoustic excitations. Successful demonstration of acoustic flutter suppression is attained in the transonic region via an appropriate choice of the feedback control law. Large amplitude limit cycle type oscillation is also simulated. The results show that the present acoustic control technique can only be effective when the amplitude of the oscillation is small which confirms the findings experimentally obtained in wind tunnel test.

A93-46842#

VORTICITY DYNAMICS IN SPATIALLY DEVELOPING RECTANGULAR JETS

FERNANDO F. GRINSTEIN (U.S. Navy, Naval Research Lab., Washington) Jul. 1993 13 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research supported by U.S. Navy refs
(AIAA PAPER 93-3286) Copyright

We report results of time-dependent numerical simulation of spatially developing initially-laminar rectangular jets, with special focus on the near field of jets with aspect ratio 1-2, Mach number 0.3-0.6, and moderately high Reynolds numbers. Validation of the numerical studies is based on comparison with the available data from laboratory experiments. Instantaneous flow visualization and analysis of time-averaged global properties are used to investigate the dynamics of large scale vortical structures developing from thin rectangular vortex sheets with slightly rounded corners. Comparative entrainment measurements are obtained based on both time-averaged and instantaneous evaluations of the streamwise mass-flux. The rotational fluid contribution in these measurements is assessed by calculating the streamwise vortical-fluid-flux, where the mass-flux evaluation is restricted to using only fluid-elements with vortical content above a small specified threshold-value. In the initial near-jet region investigated here, vortex-ring self-deformation and the dynamics of related additional vortical structures associated with the presence of corners in the nozzle, are found to be crucial in determining entrainment rates significantly larger than those for round jets.

A93-46857

ON THE CONSTRUCTION AND CALCULATION OF OPTIMAL NONLIFTING CRITICAL AIRFOILS

D. W. SCHWENDEMAN, M. C. A. KROPINSKI, and J. D. COLE (Rensselaer Polytechnic Inst., Troy, NY) Zeitschrift fuer Angewandte Mathematik und Physik (ISSN 0044-2275) vol. 44, no. 3 May 1993 p. 556-571. Research supported by IBM Corp. refs
(Contract AF-AFOSR-88-0037; NSF DMS-91-57546)
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Numerical calculations are carried out in the hodograph plane to construct optimal critical airfoil shapes and the flow about them. These optimal airfoil shapes give the highest free-stream Mach number M-infinity for a given thickness ratio delta and tail angle Theta(T) (nonlifting) for which the flow is nowhere supersonic. A relationship between M-infinity and delta for various Theta(T) is given. Analytical and numerical solutions to the same problem are found on the basis of transonic small-disturbance theory. These results provide a limiting case as M-infinity goes to 1, delta goes to 0 and agree well with the calculations of the full problem. Using a numerical method to calculate the flow about general (subsonic) airfoils, a comparison is made between the critical free-stream Mach numbers for some standard airfoil shapes and the optimal free-stream Mach number of the corresponding delta and Theta(T). A significant increase in the critical free-stream Mach number is found for the optimal airfoils. Author (revised)

A93-46885
ON THE LEGITIMACY AND ACCURACY OF DOWNWASH COMPUTATIONS BY PANEL METHODS ON 3D WINGS
LUCIEN Z. DUMITRESCU (Aix-Marseille I, Univ., Marseille, France; Inst. of Aeronautics, Bucharest, Romania) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X) no. 1 1993 p. 31-35. refs
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During the practice of panel methods for the computation of 3D wings in subsonic flow, one finds instances for which, although the overall coefficients (lift, drag) are evaluated fairly well, the downwash velocities are obviously aberrant. However, these latter are of importance in wing design exercises, for the study of winglets, wingtip stores, close-coupled tandem wings, etc. To better grasp these problems, one adopts the framework of Prandtl's lifting line theory, for which reference analytical results are available, and one develops a simplified version of the panel method. Numerical experiments show that, in order to recover the correct downwash values, the wing paneling, as well as the choice of the collocation points, have to be carried out in a specific manner (cosine law). These findings are also shown to have a more rigorous mathematical justification.

A93-46886
METHOD OF CHARACTERISTICS FOR COMPUTING THREE-DIMENSIONAL BOUNDARY LAYERS
R. HOUDEVILLE, C. MAZIN, and A. CORJON (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X) no. 1 1993 p. 37-49. refs
Copyright

A numerical method is presented for solving the three-dimensional boundary layer equations for bodies of arbitrary shape (3C3D code). In laminar flows, the application domain extends from incompressible to hypersonic flows, with the assumption of chemical equilibrium. For turbulent boundary layers, the application domain is limited by the validity of the mixing length model used. In order to retain the hyperbolic nature of the equations reduced to first order partial derivative terms, the momentum equations are discretized along the local streamlines using the osculator tangent plane at each node of the body-fitted coordinate system. With this original approach, it is possible to avoid the need for generalized coordinates and therefore it is not necessary to introduce further hypotheses concerning the regularity of the mesh in which the boundary conditions are given. This makes it possible to limit and sometimes even avoid altogether having to preprocess the data from an inviscid calculation. Although the proposed scheme is only semi-implicit, the method is still numerically very efficient.

A93-46888
EXPERIMENTS ON SHOCK WAVE/BOUNDARY LAYER INTERACTION IN HYPERSONIC FLOW
MARIE-CLAIRE COET and BRUNO CHANETZ (ONERA, Chatillon, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X) no. 1 1993 p. 61-74. Research supported by Dassault Aviation refs
Copyright

Shock wave/boundary layer interactions in hypersonic flow constitute a major problem with very important consequences in aerodynamics field, in particular as concerns wall heating at reattachment when separation occurs. Thus, in order to simulate interactions occurring on hypersonic vehicles during reentry, an experimental study was undertaken for two-dimensional and three-dimensional configurations. In order to obtain more realistic simulation of the ratio of the wall temperature to the recovery temperature, the models used were cooled by an internal circulation of liquid nitrogen. Experiments performed at freestream Mach numbers of 5 and 10 concerned laminar or turbulent boundary layers at the beginning of the interaction. In each case the phenomena were characterized by oil-flow and heat-sensitive paint visualizations, plus surface pressure and heat-transfer measurements.

A93-46907
ON THE STEADY SUBSONIC SHEAR FLOW PAST A SLENDER BODY OF REVOLUTION
SHIGEAKI SUWA (National Defense Academy, Yokosuka, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811) vol. 36, no. 111 May 1993 p. 12-20. refs

The influence of compressibility on a subsonic axisymmetric shear flow over a slender prolate spheroid is studied by the M(0)-squared expansion method where M(0) denotes the Mach number on the body axis. The value of the reciprocal of a dimensionless vorticity parameter which denotes the dividing stream detached from the slender body is obtained in terms of the slenderness ratio and the Mach number. Author (revised)

A93-46908
EFFECTS OF WALL CONDITIONS ON CHEMICALLY NONEQUILIBRIUM SHOCK-LAYER FLOW OVER HYPERSONIC REENTRY BODIES
KOJIRO SUZUKI and TAKASHI ABE (Inst. of Space and Astronautical Science, Sagamihara, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811) vol. 36, no. 111 May 1993 p. 21-35. refs

The aerothermodynamic environment around hypersonic reentry bodies is studied in the flight regime of a severe wall heating rate with emphasis on the effects of the wall catalycity and temperature by using the axisymmetric viscous shock-layer equations with the seven-air-species nonequilibrium chemistry. Comparisons with the experimental data and the Navier-Stokes analysis demonstrate that the present analysis has a potential to provide useful information not only on the wall heating rate but also on the flow properties in the shock-layer with sufficient accuracy. A finite catalytic wall model is introduced in order to evaluate the wall catalycity. The sensitivities of the wall heating rate and the electron number density over the body to the uncertainties in the wall condition models are investigated parametrically. The extent of the influences of the wall conditions on the shock-layer flow properties depends strongly on the extent of flow nonequilibrium.

A93-46916
THE PRACTICAL APPLICATION OF SOLUTION-ADAPTION TO THE NUMERICAL SIMULATION OF COMPLEX TURBOMACHINERY PROBLEMS
W. N. DAWES (Cambridge Univ., United Kingdom) Progress in Aerospace Sciences (ISSN 0376-0421) vol. 29, no. 3 1992 p. 221-269. refs
Copyright

This paper describes some recent developments in the application of unstructured mesh, solution-adaptive methods to the solution of the three-dimensional Navier-Stokes equations in turbomachinery flows. By adopting a simple, pragmatic but systematic approach to mesh generation, the variety of simulations which can be attempted ranges from simple turbomachinery blade-blade primary paths towards complex secondary gas paths and can include the interactions between the two paths. By adopting a hierarchical data structure, mesh refinement and derefinement can be performed sufficiently economically that it becomes practical to perform unsteady flow simulations with zones of mesh refinement 'following' unsteady flow features, like vortices and wakes, through a coarse background mesh. The combined benefits of the approach result in a powerful analytical ability. Solutions for a wide range of steady flows are presented including a transonic compressor rotor, a centrifugal impellor, the internal coolant passage of a radial inflow turbine and a turbine disc-cavity flow. Unsteady solutions are presented for a cylinder shedding vortices and for a turbine wake/rotor interaction.

A93-46922

UNSTEADY AERODYNAMIC RESPONSE OF TWO-DIMENSIONAL SUBSONIC AND SUPERSONIC OSCILLATING CASCADES WITH CHORDWISE DISPLACEMENT AND FLEXIBLE DEFORMATION

M. NAMBA and K. TOSHIMITSU (Kyushu Univ., Fukuoka, Japan) Journal of Sound and Vibration (ISSN 0022-460X) vol. 162, no. 3 April 22, 1993 p. 503-527. refs

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In this paper the double linearization theory applied to lightly loaded two-dimensional subsonic and supersonic cascades undergoing oscillation with chordwise displacement or flexible deformation is presented. Numerical computation based on this theory have been conducted to demonstrate parametric dependence of the unsteady aerodynamic work on blades. The translational oscillation can be destabilized by chordwise displacement for both subsonic and supersonic cascades. The contribution of chordwise displacement to the unsteady aerodynamic work is strongly dependent upon the phase difference between the chordwise and normal components of the blade motion. The unsteady aerodynamic work for flexible blade motion also is substantially influenced by steady loading. For the supersonic cascades, the effect of displacement of Mach line reflection points due to the chordwise blade motion gives a significant contribution to the unsteady aerodynamic force.

A93-46927

THE THREE DIMENSIONAL FLOW IN A COMPRESSOR CASCADE AT DESIGN AND OFF-DESIGN CONDITIONS

S. KANG (Brussel, Vrije Univ., Brussels, Belgium; Harbin Inst. of Technology, China) and CH. HIRSCH (Brussel, Vrije Univ., Brussels, Belgium) Revue Francaise de Mecanique (ISSN 0373-6601) no. 3 1992 p. 193-201. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 refs

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This paper presents experimental and calculational results on the three dimensional flow in a linear compressor cascade without tip clearance at design and off design conditions. The experimental study includes surface flow visualizations, wall static pressure measurements and 3D flow surveys with a five hole probe. To compare with the experimental observations, a 3D Navier-Stokes solver was run at the experimental conditions. The solver predicted well all the steady flow phenomena observed from the experiments.

A93-46929

INVERSE PROBLEM USING S2-S1 APPROACH FOR THE DESIGN OF THE TURBOMACHINE WITH SPLITTER BLADES

T. S. LUU, B. VINEY, and L. BENCHERIF (CNRS, Lab. d'Informatique pour la Mecanique et les Sciences pour l'Ingenieur, Orsay, France) Revue Francaise de Mecanique (ISSN 0373-6601) no. 3 1992 p. 209-220. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 Research supported by SEP refs

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It is shown how to design turbomachine blading by solving the inverse problem in which the boundary conditions are related to the bound vorticity distribution on the blades. The boundary conditions are prescribed in order to pose the flow field problem for any initial leading geometry so that the solution leads to the rectification of the blading to satisfy the loading distribution and the thickness distribution required by the structural analysis. To define the flow field, the stream function and the pseudopotential formations are developed. The description loss scheme suggested by Horlock (1971) is used with an efficiency coefficient related to the total pressure loss introduced to the momemtum equation. This model enables the design of a machine which preserves both the desired total pressure jump and the exit swirl distribution by modifying the swirl only between blade rows constituting a stage. AIAA

A93-46932

ADAPTATION OF A 3-D PRESSURE CORRECTION NAVIER-STOKES SOLVER FOR THE ACCURATE MODELLING OF TIP CLEARANCE FLOWS

K. GIANNAKOGLOU, N. LYMBEROPOULOS (Athens National Technical Univ., Greece), A. TOURLIDAKIS (Cranfield Inst. of Technology, United Kingdom), I. NIKOLAOU (Athens National Technical Univ., Greece), R. L. ELDER (Cranfield Inst. of Technology, United Kingdom), and K. D. PAPAILIOU (Athens National Technical Univ., Greece) Revue Francaise de Mecanique (ISSN 0373-6601) no. 3 1992 p. 247-255. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 Research supported by EEC refs

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The flow leakage through the tip clearance of Turbomachines is proved to be detrimental to their efficiency and range of operation. Three-dimensional Navier-Stokes solvers are often used in an attempt to reproduce numerically the complex flow patterns in the tip-clearance region. Particular emphasis is put to the accurate representation of geometrical details, the mesh and the turbulence models to be implemented. In the present paper, a 3-D Navier-Stokes solver is suitably adapted so that the flat tip surface of a blade and its sharp edges could be accurately modelled, in order to improve the precision of the calculation in the tip region. The adapted code solves the fully elliptic, steady, Navier-Stokes equations through a space-marching algorithm and a pressure correction technique; the H-type topology is retained, even in cases with thick leading edges. The analysis is applied to two different cases, a linear cascade and a spinning rotor, and comparisons are provided.

A93-46934

PREDICTION OF THREE-DIMENSIONAL LOW FREQUENCY UNSTEADY TRANSONIC FLOW AND FORCED VIBRATION IN AXIAL TURBINE STAGES

J. F. MAYER, V. SCHABER, and H. STETTER (Stuttgart Univ., Germany) Revue Francaise de Mecanique (ISSN 0373-6601) no. 3 1992 p. 279-286. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 Research sponsored by Forschungsvereinigung Verbrennungskraftmaschinen and Arbeitsgemeinschaft Industrieller Forschungsvereinigungen refs

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To determine the dynamic strain amplitudes of turbomachinery blades a finite element code for structural analysis was combined with a three-dimensional CFD finite volume method that has been developed. The CFD code enables computation of unsteady inviscid flow at low frequencies in the rotor of an axial turbine stage. The circumferentially varying flow properties are modelled as time-dependent boundary conditions referring to the rotating frame of the rotor. The calculated pressure distributions on the surface of the rotor blade over one revolution serve as input data for the vibrational analysis using finite elements. Two test cases of the last stage of a steam turbine are presented and compared to measurements.

A93-46936
3D/QUASI-3D TRANS- AND SUPERSONIC FLOW CALCULATION IN ADVANCED CENTRIFUGAL/AXIAL COMPRESSOR STAGES
V. V. ZHURAVLEV, A. N. KRAJKO, V. I. MILESHIN, I. K. OREKHOV, S. K. SHCHIPIN, and A. N. STARTSEV Revue Francaise de Mecanique (ISSN 0373-6601) no. 4 1992 p. 319-339. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07
Copyright
To improve the STFFE fan effectiveness and design the 3D flow structure in the wheel and guide vanes was calculated using a stationary analog of the increased accuracy order Godunov's scheme. An inviscid 3D supersonic flow was calculated simultaneously in the whole stage for 10 min using PC/AT-386. The non-stationary stator-rotor interaction was not taken into account and the flow behind the wheel is averaged in circumferential direction when meeting the appropriate laws of conservation. AIAA

A93-46938
DIRECT AND INVERSE PROBLEMS OF CALCULATING THE AXISYMMETRIC AND 3D FLOW IN AXIAL COMPRESSOR BLADE ROWS
A. B. BOGOD, YU. I. KIMASOV, V. T. MITROKHIN, S. V. PANKOV, and N. M. SAVIN Revue Francaise de Mecanique (ISSN 0373-6601) no. 4 1992 p. 351-359. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 refs
Copyright
A method for solving the inverse problem to determine the blade row shape using the given blade pressure differential under the assumption that the flow is axisymmetric is presented. The change of the blade profile shape in tip sections affects the development of the secondary flows. The effect of overflows in the tip clearance between the rotating blade row and case is studied using a model which account for the discontinuity decay in the clearance zone caused by the differential blade pressure and friction on a wall moving relative to the blade row. Results obtained with the model show that the 'broken scheme' made a major contribution to overflows in the clearance. AIAA

A93-46940
3D VISCOUS FLOW ANALYSIS IN AXIAL TURBINE INCLUDING TIP LEAKAGE PHENOMENA
G. BILLONNET, V. COUAILLIER (ONERA, Chatillon, France), R. HEIDER (SNECMA, Centre de Villaroche, Moissy-Cramayel, France), and A. M. VUILLOT (ONERA, Chatillon, France) Revue Francaise de Mecanique (ISSN 0373-6601) no. 4 1992 p. 373-384. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 refs
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Three-dimensional viscous flows around turbine bladings are analyzed using a CANARI code based on 3D Navier-Stokes equations and a multidomain finite volume method with structured grids. The computation is performed for a subsonic flow around a linear turbine cascade with a tip clearance of about 1 percent of blade height. The mass-averaged flow angle at the exit of the blade, emphasizes the flow underturning near the endwall which is caused by the tip leakage flow between the pressure side and the suction side producing a tip vortex along the suction side. AIAA

A93-46941
NAVIER-STOKES FLOW SIMULATION IN A 2D HIGH PRESSURE TURBINE CASCADE WITH A COOLED SLOT TRAILING EDGE
C. JOURDREN (ONERA, Chatillon, France) and P. CHANEZ (SNECMA, Centre de Villaroche, Moissy-Cramayel, France) Revue Francaise de Mecanique (ISSN 0373-6601) no. 4 1992 p. 385-391. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 refs
Copyright
Preliminary results of the flow field simulation in a cooled turbine stator cascade with a blade cooled by internal cold fluid circulation are presented. The simulation is based on a quasi-3D Navier-Stokes code COLIBRI developed at ONERA and a multidomain structured grid. A Prandtl mixing length model takes into account turbulence effects. AIAA

A93-46944
NUMERICAL ANALYSIS OF AIRFOIL CASCADES SUBJECTED TO UNSTEADY FLOW
P. PSARUDAKIS (Pisa Univ., Italy) Revue Francaise de Mecanique (ISSN 0373-6601) no. 4 1992 p. 409-414. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 refs
Copyright
The paper presents a simple but efficient computational model for the study of incompressible and inviscid flow through 2D airfoil cascades under unsteady conditions. This model is based on the continuous linear vortex distribution over the airfoil contours, to assure that the airfoil contours are stream lines, and on the point vortex distribution in the wake of the airfoils, to guarantee the Thomson theorem. At the trailing edge of the airfoils, the Kutta-Joukowsky condition, as normally used, is applied. A number of numerical experiments are illustrated to show the usefulness of the presented model to predict and to analyze the effects of some typical unsteady operating situations of airfoil cascades.

A93-46946
ON THE SHOCK-FITTING SCHEME OF HALL-CRAWLEY FOR TIME-LINEARIZED TIME-HARMONIC FLOWS USING EULER EQUATIONS
G. A. GEROLYMOS (Paris VI, Univ., France) Revue Francaise de Mecanique (ISSN 0373-6601) no. 4 1992 p. 423-435. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 Research supported by SNECMA refs
Copyright
The Hall-Crawley shock-fitting scheme for computing time-harmonic time-linearized 1.5D flows is analyzed. Topics discussed include the theory and computer implementation of the method, results obtained for subsonic and transonic flows in Laval nozzles, and a comparison of the time-linearized approach with time-nonlinear methods. AIAA

A93-46975
HEAT TRANSFER ON BLUNT CONES IN NONUNIFORM SUPERSONIC FLOW IN THE PRESENCE OF GAS INJECTION FROM THE SURFACE [TEPLOOBMEN NA ZATUPLENNYKH KONUSAKH PRI SVERKHZVUKOVOM NERAVNOMERNOM OBTEKANII I NALICHII VDUVA S POVERKHNOSTI]
N. N. PILYUGIN and R. F. TALIPOV (Moskovskij Gosudarstvennyj Univ., Moscow, Russia) Teplofizika Vysokikh Temperatur (ISSN 0040-3644) vol. 31, no. 1 Feb. 1993 p. 97-104. In RUSSIAN refs
Copyright

The parameters of laminar flow and heat transfer on a blunt cone in a nonuniform supersonic flow are calculated using the equations of the total viscous shock layer (TVSL) model, with particular consideration given to the characteristics of the oncoming wake-type flow and to the effect of gas injection from the surface. The results of TVSL calculations of the flow and heat-transfer parameters are compared with other numerical and asymptotic solutions. It is shown that the efficiency of gas injection at the critical point of the model for the purpose of lowering the heat flow intensity can be significantly increased by using the nonuniformity of the oncoming flow. AIAA

A93-46980
NUMERICAL SIMULATION OF TRANSITION IN TWO- AND THREE-DIMENSIONAL BOUNDARY LAYERS
M. WAGNER and L. KLEISER (DLR, Inst. fuer Theoretische Stroemungsmechanik, Goettingen, Germany) Zeitschrift fuer Angewandte Mathematik und Mechanik (ISSN 0044-2267) vol. 73, no. 6 1993 p. T 524-T 527. Research supported by EEC refs
Copyright
Transition in 2D boundary layers is simulated here using a model in which the frame of reference moves downstream at the group velocity of the dominant Tollmien-Schlichting wave. The spatial dependence of the laminar boundary layer and local Re is taken into account within this temporal model. For both high- and low-resolution simulations, the shape factor and local friction coefficient evolve to their turbulent levels in good agreement with various experimental results. AIAA

A93-46984
MULTIGRID METHODS FOR CALCULATING 3D FLOWS IN COMPLEX GEOMETRIES [MULTIGRIDVERFAHREN ZUR BERECHNUNG VON 3D STROEMUNGEN IN KOMPLEXEN GEOMETRIEN]
L. BAI, M. FIEBIG, N. K. MITRA, and A. KOST (Bochum Ruhr-Univ., Germany) Zeitschrift fuer Angewandte Mathematik und Mechanik (ISSN 0044-2267) vol. 73, no. 6 1993 p. T 554-T 556. In GERMAN refs
Copyright
A multigrid method in a finite-volume procedure is used here to solve the 3D incompressible steady laminar Navier-Stokes equations in body-fitted coordinates. The performance of the method is demonstrated using two test cases. AIAA

A93-46987
INSTABILITY OF THREE-DIMENSIONAL SUPERSONIC BOUNDARY LAYER
EWA SZNITKO (Poznan Technical Univ., Poland) Zeitschrift fuer Angewandte Mathematik und Mechanik (ISSN 0044-2267) vol. 73, no. 6 1993 p. T 589-T 592. refs
Copyright
The flow over a cone rotating in a supersonic free-stream is used to investigate the stability of 3D supersonic boundary layer. The stability characteristics for stationary vortex disturbances are computed. The variations of the stability characteristics with cross-flow Reynolds number calculations at different rotational speeds of the cone are studied. The critical Reynolds number is found to increase with increasing crossflow Reynolds number. AIAA

A93-46988
NUMERICAL SOLUTION OF STEADY AND UNSTEADY EULER EQUATIONS
J. FORT, KAREL KOZEL, and M. VAVRINCOVA (Prague Technical Univ., Czech Republic) Zeitschrift fuer Angewandte Mathematik und Mechanik (ISSN 0044-2267) vol. 73, no. 6 1993 p. T 595-T 599. refs
Copyright
Two methods for the numerical solution of an unsteady system of Euler equations are presented. A steady solution is achieved by a time marching method, and two finite volume methods are used to solve steady and unsteady transonic flows through a 2D cascade: the MacCormack cell-centered and the Ron-Ho-Ni cell vertex finite volume scheme. The results from the methods are compared to experimental results, and several cases of unsteady transonic flows are given as examples. AIAA

A93-46989
THE THREE-DIMENSIONAL REPRESENTATION OF THE PRESSURE DISTRIBUTION ON WEDGED DELTA WINGS WITH SUPERSONIC LEADING EDGES IN SUPERSONIC-HYPERSONIC FLOW
ADRIANA NASTASE and ANDREAS HONERMANN (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) Zeitschrift fuer Angewandte Mathematik und Mechanik (ISSN 0044-2267) vol. 73, no. 6 1993 p. T 603-T 607. refs
Copyright
The pressure coefficient Cp on the surface of a given wing is a 4D entity which depends on the position of the point in the plan-projection of the wing, on the Mach number M(infinity) of the undisturbed flow, and on the angle of attack alpha of the wing. Here the 3D representation of Cp is applied to surfaces for the first time, using several given M(infinity) and alpha in a unified form. This representation is also suitable for analyzing the behavior of the pressure coefficient. AIAA

A93-46990
THE THREE-DIMENSIONAL REPRESENTATION OF THE LIFT AND PITCHING MOMENT COEFFICIENTS ON WEDGED RECTANGULAR WINGS IN SUPERSONIC FLOW
ADRIANA NASTASE and ROGER JAKOBS (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) Zeitschrift fuer Angewandte Mathematik und Mechanik (ISSN 0044-2267) vol. 73, no. 6 1993 p. T 607-T 611. refs
Copyright
It is shown how the lift and pitching moment coefficients of a wedged rectangular wing are well suited for a 3D representation of lift and pitching moment surfaces. The software involved in this representation is discussed. AIAA

A93-46991
TWO DIMENSIONAL INCOMPRESSIBLE FLOW THROUGH A VIBRATING BLADED DISC - THEORETICAL MODEL
R. RZADKOWSKI (Polish Academy of Sciences, Inst. of Fluid-Flow Machinery, Gdansk, Poland) Zeitschrift fuer Angewandte Mathematik und Mechanik (ISSN 0044-2267) vol. 73, no. 6 1993 p. T 611-T 613. refs
Copyright
A procedure for calculating the conditions under which a cascade of unstalled blades around a disk will flutter is presented. The potential incompressible and inviscid 2D flow past thin blades modeled by arcs can be presented as due to a distribution of vortices placed on the arcs. Wakes are not included in the model. The impermeability of conditions on the profile leads to singular integral equations of the first kind. Forces and moments acting on the blades are substituted for the Hamilton principle governing the forced vibration of a bladed disk. No restriction is imposed on the motion of the blade. The structural coupling between blades through the disk is presented. AIAA

A93-47189 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A NEW FLUX SPLITTING SCHEME
MENG-SING LIOU and CHRISTOPHER J. STEFFEN, JR. (NASA, Lewis Research Center, Cleveland, OH) Journal of Computational Physics (ISSN 0021-9991) vol. 107, no. 1 July 1993 p. 23-39. Previously announced in STAR as N91-22814 refs
(Contract RTOP 505-61-52)
Copyright
A new flux splitting scheme is proposed. The scheme is remarkably simple and yet its accuracy rivals and in some cases surpasses that of Roe's solver in the Euler and Navier-Stokes solutions performed in this study. The scheme is robust and converges as fast as the Roe splitting. An approximately defined cell-face advection Mach number is proposed using values from

the two straddling cells via associated characteristic speeds. This interface Mach number is then used to determine the upwind extrapolation for the convective quantities. Accordingly, the name of the scheme is coined as Advection Upstream Splitting Method (AUSM). A new pressure splitting is introduced which is shown to behave successfully, yielding much smoother results than other existing pressure splittings. Of particular interest is the supersonic blunt body problem in which the Roe scheme gives anomalous solutions. The AUSM produces correct solutions without difficulty for a wide range of flow conditions as well as grids.

A93-47196
FINITE ELEMENT SOLUTION OF THE 3D COMPRESSIBLE NAVIER-STOKES EQUATIONS BY A VELOCITY-VORTICITY METHOD
G. GUEVREMONT, W. G. HABASHI, P. L. KOTIUGA (Concordia Univ., Montreal, Canada), and M. M. HAFEZ (California Univ., Davis) Journal of Computational Physics (ISSN 0021-9991) vol. 107, no. 1 July 1993 p. 176-187. refs
(Contract NSERC-OGPIN-013; NSERC-G-1613; NSERC-STREQ-040)
Copyright
This alternative formulation to the Navier-Stokes equations' primitive variable form uses the velocity and vorticity variables as a logical extension of the streamfunction-vorticity method for 2D flows. A weak-Galerkin FEM discretization, followed by Newton linearization, is followed by direct and simultaneous solution of the velocity and vorticity components. Attention is given to the illustrative cases of 2D and 3D imcompressible and subsonic internal-enclosed problems. AIAA

A93-47201
AIAA APPLIED AERODYNAMICS CONFERENCE, 11TH, MONTEREY, CA, AUG. 9-11, 1993, TECHNICAL PAPERS. PTS. 1 & 2
Washington American Institute of Aeronautics and Astronautics 1993 p. Pt. 1, 595 p.; pt. 2, 595 p. For individual items see A93-47202 to A93-47292
Copyright
The present conference discusses such topics as the status of forebody vortex control, the effect of ground and ceiling planes on shape-energized wakes, UH-60 main rotor blade airfoil data, CFD drag predictions for a wide body transport fuselage, a method for the prediction of induced drag for planar and nonplanar wings, the scaling of incipient separation in high-speed laminar flows, streamline visualization around hypersonic vehicles, and waverider configurations with finlets. Also discussed are forebody vortex control with jet and slot blowing, the current status of numerical grid generation, air data estimation for control of guided munitions, a natural laminar flow wing concept for high-speed civil transports, nonslender waveriders, high-alpha aerodynamics of delta planforms using 'pop-up' vortex generators, a deformable leading edge for high performance helicopter rotors, V/STOL aircraft aerodynamics with deflected jets in ground effect, and external store carriage aerodynamics. AIAA

A93-47202*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADAPTIVE COMPUTATIONS OF FLOW AROUND A DELTA WING WITH VORTEX BREAKDOWN
DAVID L. MODIANO (MIT, Cambridge, MA; NASA, Lewis Research Center, Cleveland, OH) and EARLL M. MURMAN (MIT, Cambridge, MA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 1-9. Research supported by McDonnell Aircraft Co. refs
(Contract AF-AFOSR-89-0395A)
(AIAA PAPER 93-3400) Copyright
An adaptive unstructured mesh solution method for the three-dimensional Euler equations was used to simulate the flow around a sharp edged delta wing. Emphasis was on the breakdown of the leading edge vortex at high angle of attack. Large values of entropy, which indicate vortical regions of the flow, specified the region in which adaptation was performed. The aerodynamic normal force coefficients show excellent agreement with wind tunnel data measured by Jarrah, and demonstrate the importance of adaptation in obtaining an accurate solution. The pitching moment coefficient and the location of vortex breakdown are compared with experimental data measured by Hummel and Srinivasan, showing good agreement in cases in which vortex breakdown is located over the wing.

A93-47203#
NUMERICAL SIMULATION OF WING-WALL JUNCTURE FLOW FOR A PITCHING WING
RICHARD W. NEWSOME (USAF, Frank J. Seiler Research Lab., Colorado Springs, CO) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 10-23. refs
(AIAA PAPER 93-3401)
The 3D Navier-Stokes equations were solved for the unsteady flow about a generic wing-wall configuration for constant rate pitching at a nondimensional pitch rate of 0.2 from 0 to 56 deg angle of attack. The configuration consisted of a straight wing with an aspect ratio of two, a rectangular planform, and a NACA 0015 cross section, orthogonally attached to a flat splitter plate. The configuration corresponds to recent experimental tests with the exception that the wing tip vortex was not modeled computationally. A comparison of the computed juncture flow with data for the experimental configuration indicates general agreement in the juncture region. A detailed examination of the sequence of instantaneous limiting streamlines provides a clear view of the temporal evolution of the complex, 3D, unsteady, separated flow in the juncture region. Author (revised)

A93-47204#
UNSTEADY FLOW COMPUTATIONS FOR A THREE-DIMENSIONAL CAVITY WITH AND WITHOUT AN ACOUSTIC SUPPRESSION DEVICE
N. E. SUHS (Calspan Corp., Arnold AFB, TN) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 24-33. Research supported by USAF refs
(AIAA PAPER 93-3402)
A computational capability has been developed for predicting the flow field in a three-dimensional cavity with and without an acoustic suppression device, a solid spoiler. The chimera overset grid methodology is used to simplify grid generation. An implicit Navier-Stokes code with a thin-layer approximation is used to compute the flow for a three-dimensional rectangular cavity with and without the solid spoiler at a free-stream Mach number of 1.2. The computational results are compared to experimental results for time-averaged pressure coefficients, overall sound pressure levels, and the frequency spectra of the sound pressure levels.

A93-47207*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EFFECT OF GROUND AND CEILING PLANES ON SHAPE OF ENERGIZED WAKES
VERNON J. ROSSOW (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 64-76. refs
(AIAA PAPER 93-3410) Copyright
Energized wakes expelled by devices like thrust augmentors, propellers and rotors are studied theoretically in order to explore how their shape changes as they interact with ground and ceiling planes. It is found that when the airstream is stationary and the vehicle in hover, the presence of a ceiling plane causes an energized wake to constrict even more than when in an unbounded medium. The presence of a ground plane is found to cause the wake to constrict less than in free space. The computations also show that the vortex sheets first move inward before moving

downward. Along their trajectory, the vortex sheets that separate the energized fluid from the ambient fluid have a nearly constant strength and velocity which indicates that the velocity just inside the wake is approximately constant. When a velocity is given to the wind tunnel airstream, the forward edge of the wake first rises and then descends so that it spends more time in the vicinity of the actuator disk. Implications of these results on measurements obtained in wind tunnels are discussed.

A93-47209*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
LOW-SPEED WIND TUNNEL TEST RESULTS OF THE CANARD ROTOR/WING CONCEPT
STEVEN M. BASS, THOMAS L. THOMPSON, JOHN W. RUTHERFORD (McDonnell Douglas Helicopter Co., Mesa, AZ), and STEPHEN SWANSON (Sterling Software, Inc.; NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 92-104. refs
(AIAA PAPER 93-3412) Copyright

The Canard Rotor/Wing (CRW), a high-speed rotorcraft concept, was tested at the National Aeronautics and Space Administration (NASA) Ames Research Center's 40- by 80-Foot Wind Tunnel in Mountain View, California. The 1/5-scale model was tested to identify certain low-speed, fixed-wing, aerodynamic characteristics of the configuration and investigate the effectiveness of two empennages, an H-Tail and a T-Tail. The paper addresses the principal test objectives and the results achieved in the wind tunnel test. These are summarized as: i) drag build-up and differences between the H-Tail and T-Tail configuration, ii) longitudinal stability of the H-Tail and T-Tail configurations in the conversion and cruise modes, iii) control derivatives for the canard and elevator in the conversion and cruise modes, iv) aerodynamic characteristics of varying the rotor/wing azimuth position, and v) canard and tail lift/trim capability for conversion conditions.

A93-47210*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A CRITICAL ASSESSMENT OF UH-60 MAIN ROTOR BLADE AIRFOIL DATA
JOSEPH TOTAH (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 105-125. refs
(AIAA PAPER 93-3413) Copyright

Many current comprehensive rotorcraft analyses employ lifting-line methods that require main rotor blade airfoil data, typically obtained from wind tunnel tests. In order to effectively evaluate these lifting-line methods, it is of the utmost importance to ensure that the airfoil section data are free of inaccuracies. A critical assessment of the SC1095 and SC1094R8 airfoil data used on the UH-60 main rotor blade was performed for that reason. Nine sources of wind tunnel data were examined, all of which contain SC1095 data and four of which also contain SC1094R8 data. Findings indicate that the most accurate data were generated in 1982 at the 11-Foot Wind Tunnel Facility at NASA Ames Research Center and in 1985 at the 6-inch-by-22-inch transonic wind tunnel facility at Ohio State University. It has not been determined if data from these two sources are sufficiently accurate for their use in comprehensive rotorcraft analytical models of the UH-60. It is recommended that new airfoil tables be created for both airfoils using the existing data. Additional wind tunnel experimentation is also recommended to provide high quality data for correlation with these new airfoil tables.

A93-47211*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PERFORMANCE RESULTS FROM A TEST OF AN S-76 ROTOR IN THE NASA AMES 80- BY 120-FOOT WIND TUNNEL
PATRICK M. SHINODA (U.S. Army, Aeroflightdynamics Directorate; NASA, Ames Research Center, Moffett Field, CA) and WAYNE JOHNSON (Johnson Aeronautics, Palo Alto, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 126-144. refs
(AIAA PAPER 93-3414) Copyright

A full-scale helicopter rotor wind tunnel test has been conducted which covers a wide range of rotor-shaft angles-of-attack and 0-100 kt thrust conditions. The hover performance data thus obtained were compared with the results of momentum theory calculations; forward flight rotor-performance data were compared with calculations from a comprehensive rotorcraft analysis. These comparisons suggest that hover testing at an outdoor facility in the absence of ground effect is required to make a final determination of the absolute accuracy of the wind tunnel hover data. AIAA

A93-47212#
COMPUTATIONS OF AERODYNAMIC DRAG FOR TURBULENT TRANSONIC PROJECTILES WITH AND WITHOUT SPIN
JAN-KAUNG FU (Chinese Air Force Academy, Kaohsiung, Taiwan) and SHEN-MIN LIANG (National Cheng Kung Univ., Tainan, Taiwan) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 145-153. refs
(AIAA PAPER 93-3416) Copyright

A numerical study is made to analyze the performance of a spinning secant-ogive-cylinder-boattail projectile in the transonic regime in terms of aerodynamic drag. In order to obtain an accurate prediction of the spinning effect on the total drag of the projectile for the shell design, the implicit, diagonalized, symmetric TVD scheme, accompanied by a suitable grid, is employed to solve the thin-layer axisymmetric Navier-Stokes equations associated with the Baldwin-Lomax turbulence model. The computed results show that, in comparison with the nonspinning case, to increase the spin rate can result in increases in viscous drag and nose pressure drag, but can cause decreases in boattail drag and base drag. The variations of drag components only result a small (less than 5 percent) increase in total drag. The performance of the transonic projectiles is found to be insensitive to the spin rate.
Author (revised)

A93-47213*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN IMPROVED FAR FIELD DRAG CALCULATION METHOD FOR NONLINEAR CFD CODES
JAMES R. SIRBAUGH (Sverdrup Technology, Inc., Brook Park, OH) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 154-161. refs
(Contract NAS3-25266)
(AIAA PAPER 93-3417)

An improved method to calculate drag based on far field conditions is presented and demonstrated. The method is illustrated using two CFD codes, PARC and CFL3D, and examining their ability to preserve lift and drag coefficients along grid line defined integration paths. The flow fields were generated by solving the Euler equations for a NACA 0012 airfoil at a free stream Mach number of 0.8 and angle of attack of 1.25 degrees. In comparison to force coefficients obtained by surface pressure integration, neither code acceptably preserved both force coefficients throughout the near and far fields. An investigation into the relationship between numerical prediction error and calculated force coefficients revealed a direct connection between solution mass conservation error and force coefficients error. A method to correct the predicted force coefficients based on integrated mass conservation error is described and demonstrated. The corrected force coefficients for both codes are shown to be more accurate than the uncorrected values. The correction method is applicable to both two and three dimensions and is independent of the algorithm used to generate the flow field.

A93-47214#

CFD DRAG PREDICTIONS FOR A WIDE BODY TRANSPORT FUSELAGE WITH FLIGHT TEST VERIFICATION

J. A. RHODES (McDonnell Douglas Corp., Saint Louis, MO), K. RAVINDRA (Parks College, Cahokia, IL), and D. M. FRIEDMAN (Douglas Aircraft Co., Long Beach, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 162-169. refs

(AIAA PAPER 93-3418) Copyright

A computational fluid dynamics code was used to predict drag increments for three proposed commercial aircraft fuselage nose configurations. The CFD results showed that a significant drag reduction could be achieved by eliminating a windshield wiper recess. The predicted drag reduction was of sufficient magnitude to warrant a flight test by Douglas Aircraft Company on an MD-11 airplane. The flight test results confirmed that drag reduction was possible.

A93-47215#

COMPUTATIONAL ANALYSIS OF DRAG REDUCTION AND BUFFET ALLEVIATION IN VISCOUS TRANSONIC FLOW OVER POROUS AIRFOILS

MARK A. GILLAN (Belfast, Queen's Univ., United Kingdom) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 170-178. refs

(AIAA PAPER 93-3419) Copyright

Boundary layer control over an airfoil may be performed using a mass-transfer technique known as passive control. This paper presents a computational investigation into the effects of passive control over a range of transonic viscous flow conditions. To perform this analysis an explicit finite volume cell-vertex-centered Navier-Stokes solver has been developed, in conjunction with a boundary conforming hyperbolic grid generator. Turbulence closure is accomplished using either the algebraic Baldwin-Lomax turbulence model or a modified version of the nonequilibrium Johnson-King model. Employing Darcy's high transonic free stream Mach numbers, with substantial drag increases, of up to 30 percent, for lower Mach numbers. Finally, for the first time, the Navier-Stokes computational analysis demonstrates the ability of passive control to suppress transonic self-excited shock-induced oscillations on an 18 percent thick circular-arc airfoil, thus alleviating buffet.

Author (revised)

A93-47216*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A METHOD FOR THE PREDICTION OF INDUCED DRAG FOR PLANAR AND NONPLANAR WINGS

KARL W. MORTARA and MARK D. MAUGHMER (Pennsylvania State Univ., University Park) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 179-189. refs

(Contract NAG1-1198)

(AIAA PAPER 93-3420) Copyright

A new method for the prediction of induced drag of planar and nonplanar wings is presented. This method is based on the application of the Kutta-Joukowski law at the trailing edge. Until recently, the use of the Kutta-Joukowski law for this purpose has not been fully explored and pressure integration and Trefftz-plane calculations favored. It is shown, however, that this method is able to give better results for a given amount of effort than the more commonly used techniques, particularly when relaxed wakes and nonplanar wing geometries are considered. When the induced drag prediction procedure is coupled with a panel method, it results in a methodology that is fast enough and sufficiently accurate to be useful for design purposes. It is demonstrated that reductions in induced drag can be achieved, particularly through the use of nonplanar wing geometries. To obtain overall drag reductions, the induced drag reduction must be traded-off against increased profile drag due to increased wetted area. With the design methodology that is described herein, such trade studies can be performed in which the non-linear effects of the free wake are taken into account.

A93-47217#

SEPARATED FLOWFIELD AND LIFT ON AN AIRFOIL WITH AN OSCILLATING LEADING-EDGE FLAP

KURT B. LAURIE and SAEED FAROKHI (Kansas Univ., Lawrence) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 190-199. refs

(AIAA PAPER 93-3422) Copyright

A vortex method approach is applied to a 2D airfoil with an oscillating leading edge flap. The method is a Lagrangian-based vortex blob tracing algorithm that simulates 2D, incompressible flow. The tested configuration is a NACA 0012 airfoil modified with a sharp nosed leading edge flap. With the airfoil at 15 deg angle of attack and the flap initially aligned with the freestream, various flap motions are executed. Velocity vector diagrams are utilized as a means of flow visualization. Generally, the flap motion generates a coherent large scale vortical structure (LSV) that convects along the upper surface of the airfoil. Secondary and tertiary vortical structures that interact with the primary LSV are also identified. The generation and convection of the primary LSV are accompanied by enhanced lift relative to that of the steady initial configuration. Complex, nonsinusoidal flap oscillations are shown to be capable of generating lift coefficients on the order of double the steady value with only small lift degradations following the high lift peaks. Based on our computational results, the application of leading-edge, oscillating flaps to achieve post-stall aerodynamic capability is very promising. Author (revised)

A93-47218#

UNSTEADY GROUND EFFECTS ON AERODYNAMIC COEFFICIENTS OF FINITE WINGS WITH CAMBER

A. O. NUHAIT (King Saud Univ., Riyadh, Saudi Arabia) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 200-207. refs

(AIAA PAPER 93-3423) Copyright

A numerical investigation on finite thin cambered wings moving near ground in unsteady flow was conducted. The numerical model is based on the general 3 - D vortex-lattice method in which the wake is computed as part of the solution. The image technique is used to simulate the ground effects. The computed results indicate that the percentage changes in the aerodynamic coefficients (CL and CM) increase with proximity to the ground. The greater the sink rate is the weaker the increase which is consistent with the trend shown by other experimental investigators for flat wings. Increasing the aspect ratio increases the ground effect causing wings to start feeling the ground at higher positions. The ground effects are weaker as the camber ratio increases consistent with the results of 2 - D plates. Moving the position of maximum camber backward has similar effect. Meanlines of NACA 5-digit series showed bigger increase in CL and CM compared to NACA 4-digit and 6-digit series meanlines. Increasing the angle of attack increases the ground effects in conflict with the results of 2 - D plates.

A93-47220#

A VISUALIZATION STUDY OF THE VORTICAL FLOW OVER A DOUBLE-DELTA WING IN DYNAMIC MOTION

SHESHAGIRI K. HEBBAR, MAX F. PLATZER, and FENG-HSI LI (U.S. Naval Postgraduate School, Monterey, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 217-226. Research supported by U.S. Navy refs

(AIAA PAPER 93-3425)

The vortex interaction and bursting phenomena on a basic double-delta wing model with sharp leading edges was investigated in the Naval Postgraduate School Water Tunnel using the dye-injection technique. The investigation focussed primarily on the effects of pitch on the interaction and breakdown characteristics of strake and wing vortices for both static and dynamic conditions of the model at zero sideslip angle. The main results of this first of a kind flow visualization data indicate that, for the static conditions of the model, the mutual induction effect of strake and wing vortex cores on each other leads to their intertwining. This interaction point moves upstream with increasing angle of attack (AOA) but at higher AOAs the strake vortex bursts even before the interaction. The AOA range for coiling-up of the vortices is 10-25 deg. The dynamic tests indicate that, compared to the static case, the strake vortex bursting is delayed during pitch-up motion but advanced during pitch-down motion, with the lag effects increasing with the pitch rate. Furthermore, these lag effects on the vortex interaction lead to delay in the coiling up of the vortices. Author (revised)

A93-47221#

NEURAL NETWORK PREDICTION OF THREE-DIMENSIONAL UNSTEADY SEPARATED FLOW FIELDS

SCOTT J. SCHRECK, WILLIAM E. FALLER (USAF, Frank J. Seiler Research Lab., Colorado Springs, CO), and MARVIN W. LUTTGES (Colorado Univ., Boulder) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 227-240. refs
(AIAA PAPER 93-3426)

If suitably controlled, unsteady separated flow fields could confer dramatically enhanced agility upon aircraft. Understanding and real-time prediction of these flow fields over a broad parameter range are crucial prerequisites to control. Characteristics inherent to neural networks render them powerful tools for addressing issues of understanding and real-time prediction. Unsteady surface pressures were measured on a wing pitching at constant rate beyond static stall. Unsteady surface pressure data confirmed that the pitching wing generates a rapidly evolving, three-dimensional surface pressure field. Using these data, both linear and nonlinear neural networks were developed. A novel quasi-linear activation function enabled extraction of a linear equation system from the weight matrices of the linear network. This equation set was used to predict unsteady surface pressures, and predictions were compared to measured data. The neural network accurately predicted both temporal and spatial variations in the unsteady separated flow field. Consistent results were obtained using either the linear or nonlinear neural network. In addition, fluid mechanics modeled by the linear equation set were consistent with established vorticity dynamics principles.

A93-47223*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

NEAR-FIELD SUPERSONIC FLOW PREDICTIONS BY AN ADAPTIVE UNSTRUCTURED TETRAHEDRAL GRID SOLVER

M. J. DJOMEHRI and LARRY L. ERICKSON (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 251-268. refs
(AIAA PAPER 93-3430) Copyright

Applicability of a three-dimensional solution adaptive unstructured tetrahedral Euler flow solver about generic models for near-field sonic boom pressure signature predictions is evaluated. Comparisons of computational and experimental data demonstrates the capability of the method for predicting inviscid solutions useful for high speed calculations about simple 3-D geometries. The approach has promising features and results indicate potential for application to more complex configurations. The mesh generation is based on the advancing front technique, and steady state solutions of the Euler equations are achieved by explicit time integration. Spatial discretization uses the Taylor-Galerkin approach; an alternate time integration, based on the Runge-Kutta method, is also included. The solution-adaptive grid procedure is based on either remeshing or mesh refinement techniques. An alternative geometry-adaptive grid procedure has also been incorporated.

A93-47224#

CALCULATIONS ON A DOUBLE-FIN TURBULENT INTERACTION AT HIGH SPEED

DATTA GAITONDE and J. S. SHANG (USAF, Wright Lab., Wright-Patterson AFB, OH) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 269-281. refs
(AIAA PAPER 93-3432)

The full 3D mean compressible Navier-Stokes equations are presently solved with a high-resolution implicit finite-volume scheme for the case of the interaction of a Mach 8.3, 3.25-cm thick turbulent boundary layer with intersecting oblique shock waves generated by 15-deg sharp fins that are mounted symmetrically on a flat plate. While excellent agreement with experimental data is obtained for plate-surface pressures, accurate heat-transfer rates are achieved only near the plane of symmetry. The region beneath the separated boundary layer is occupied by a spanwise movement of fluid attaching near the 3D corner. AIAA

A93-47225*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A ZONAL CFD METHOD FOR THREE-DIMENSIONAL WING SIMULATIONS

J. M. SUMMA, D. J. STRASH, and S. YOO (Analytical Methods, Inc., Redmond, WA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 282-289. refs
(Contract NAS2-12961; NAS2-13194)
(AIAA PAPER 93-3433) Copyright

The primary objective of this work is to demonstrate the feasibility of a 3D potential/viscous flow coupling procedure for reducing computational effort while maintaining solution accuracy. The closed-loop, overlapped, velocity-coupling concept has been developed in a new code, ZAP3D, that couples a potential flow panel code with a Navier-Stokes method. The current ZAP3D calculation for an aspect ratio 5 wing with an outer domain radius of about 1.2 chords represents a speed-up in CPU time over the ARC3D large domain calculation by about a factor of 2.5. This improvement is achieved for less than a 0.5 percent deviation in C(L), 10 counts change in C(D), and 0.0015 variation in C(My). Additional reductions in the required computational domain for ZAP3D are expected as the method is further developed and refined. Author (revised)

A93-47226*# National Aeronautics and Space Administration, Washington, DC.

FLOW FIELD MEASUREMENTS IN A CROSSING SHOCKWAVE TURBULENT BOUNDARY LAYER INTERACTION AT MACH 3

JASON T. LACHOWICZ and NDAONA CHOKANI (North Carolina State Univ., Raleigh) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 290-300. Research supported by U.S. Navy and USAF refs
(Contract NAGW-1072)
(AIAA PAPER 93-3434) Copyright

An experimental study has been conducted to examine the flow field of the 3D crossing shock wave/turbulent boundary layer interaction. A symmetric pair of 9-deg fins were used to generate the crossing shocks. The incoming boundary layer was developed on the tunnel sidewall and thus was relatively thick, 0.49 arcsec, and suited for pitot probe surveys. The test conditions were a nominal Mach number of 3 and unit Reynolds number of 1.2 x 10 exp 7/ft. The measurements obtained included surface oil flow visualizations, surface static pressures, and boundary layer pitot pressure profiles. The results showed that downstream of the crossing shock intersection, the stagnation pressure losses were significant and the stagnation pressure profiles were highly nonuniform. Despite the severe shock disturbances, the law of the wall and the law of the wake were found to give relatively good agreement with the experimental data. Author (revised)

A93-47227#
SCALING OF INCIPIENT SEPARATION IN HIGH SPEED LAMINAR FLOWS
GEORGE R. INGER (Cranfield Inst. of Technology, United Kingdom) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 301-308. refs
(Contract SERC-GR/H/26390)
(AIAA PAPER 93-3435) Copyright
This study provides a sound theoretical foundation for a well-established but heretofore-empirical criterion for incipient separation in moderately-hypersonic shock/boundary layer interactions. It is based on an examination of the leading high Reynolds number approximation to triple deck theory combined with its reformulation in terms of the Reference Temperature concept. The analysis further provides extensions giving the effects of both low supersonic Mach numbers and non-adiabatic wall temperatures on incipient separation.

A93-47228#
THE EFFECT OF A HIGH THRUST PUSHER PROPELLER ON THE FLOW OVER A STRAIGHT WING
F. M. CATALANO and J. L. STOLLERY (Cranfield Inst. of Technology, United Kingdom) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 309-319. refs
(AIAA PAPER 93-3436) Copyright
An experimental and theoretical study was carried out in order to investigate the effects of a high thrust pusher propeller on the aerodynamic characteristics of a two-dimensional wing. The scope of the experimental study was to test several different positions of propeller and wing and to measure the effects on the wing characteristics. Measurements included surface pressure distributions, lift, drag, pitching moment, and boundary layer behavior by flow visualization. A semi-inverse viscous computer program which includes the propeller inflow velocities was developed in order to predict the propeller effects on the wing. It is shown that the inflow suction from the propeller affects a large part of the wing and it is clearly dependent on the wing/propeller position. When testing a smooth wing, transition was moved downstream with a related increase of the laminar part of the boundary layer and a decrease of the drag coefficient. Theoretical predictions showed good agreement with the experimental results through the range of incidence tested.

A93-47229#
ANALYSIS OF THE EFFECT OF SURFACE HEATING ON BOUNDARY LAYER DEVELOPMENT OVER AN NLS-0215 AIRFOIL
SCOTT J. SCHMID and BRUCE P. SELBERG (Missouri-Rolla Univ., Rolla) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 320-331. refs
(AIAA PAPER 93-3437) Copyright
Flows over a NLS-0215 airfoil with and without flush mounted surface heating were analyzed with a two dimensional fourth order boundary layer code. Constant wall temperature and decreasing wall temperature heating cases were studied for different surface heating lengths. Boundary layer properties: tangential velocity, normal velocity, vorticity, transition location and separation location were presented for these temperature distributions. Modified boundary layer properties, due to heating are shown to persist well after heating is stopped, even when the flow is turbulent. These boundary layer results also indicate that with the proper selection of surface temperature variation and length transition can be delayed.

A93-47231#
WAVERIDERS WITH FINLETS
X. HE, M. L. RASMUSSEN, and R. A. COX (Oklahoma Univ., Norman) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 350-359. Research supported by Rockwell International Corp refs
(AIAA PAPER 93-3442) Copyright
A generalized analytical method for designing waverider shapes is presented. Waverider configurations that incorporate finlets are of primary interest. These finlets resemble fins on conventional aircraft and might imaginably be used as control surfaces. The design methodology determines the waverider shape by alternatively specifying the planform shape, the freestream-surface trailing-edge shape, the compression-surface trailing-edge shape, or various combinations of the three. A wide variety of shapes is presented, and their aerodynamic properties are calculated by means of hypersonic small-disturbance theory. The results are novel, and the analysis is readily usable for a variety of design studies.

A93-47232#
AERODYNAMIC DESIGN OF A HYPERSONIC BODY WITH A CONSTANT FAVORABLE PRESSURE GRADIENT
F. L. SHOPE and R. L. SPINETTI (Calspan Corp., Arnold AFB, TN) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 360-367. Research supported by USAF refs
(AIAA PAPER 93-3444)
This paper describes the techniques used to design two wind tunnel models for a hypersonic wind tunnel test intended to measure the effect of a favorable pressure gradient upon boundary-layer stability. The forebody of each model is a sharp cone with a 7-deg half-angle and the aftbody is an ogive based on a 3/2-power law (radius versus centerline distance), which was derived previously from Modified Newtonian theory and validated with data. The design is for a free-stream Mach number of 8. Designs have been developed for 50-percent and 95-percent pressure-coefficient decreases over the ogives. The Newtonian-rigorous design was adequate for the 50-percent ogive. However, for the 95-percent ogive, the 3/2 power was altered to 1.595 to obtain a more nearly constant gradient. The altered exponent was selected by minimizing the standard deviation of the static pressure on the ogive from a linear regression line. The static pressure was computed using the parabolized Navier-Stokes program developed by Molvik and Merkle. Theoretical results are compared with data from AEDC Hypersonic Wind Tunnel B at Mach number 8.

A93-47233#
AERODYNAMIC CHARACTERISTICS OF A DELTA WING WITH A BODY-HINGED LEADING-EDGE EXTENSION
ELISABET SYVERUD, SAEED FAROKHI, RAY TAGHAVI (Kansas Univ., Lawrence), and DAN H. NEUHART (Lockheed Engineering and Sciences Co., Hampton, VA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 368-375. refs
(AIAA PAPER 93-3446) Copyright
A 70-deg-swept delta wing is integrated with an 80-deg leading-edge extension (LEX). Two geometric features distinguish the current wing design from the conventional approach. First, the LEX is body-hinged and acts as a vortex flap in a roll direction. Second, the interface between the main wing and the LEX is swept forward, placing the main wing apex off the fuselage. The wing/LEX system is then integrated in a cylindrical fuselage with a generic nose cone. An extensive flow visualization study in a water tunnel has been performed at NASA-Langley Research Center 16 x 24 inch facility. Dye injection and laser light sheet techniques were employed for the flow visualization purposes. Helium bubble investigations were also performed in the University

of Kansas 3 x 4 wind tunnel. The phenomena of vortex-vortex interaction and vortex breakdown are qualitatively investigated. Based on the flow visualization studies, a dihedral LEX deflection stabilizes the entire vortex system. Anhedral deflection has the opposite effect and leads to a rapid vortex breakdown.

Author (revised)

A93-47234*# National Aeronautics and Space Administration, Washington, DC.

ON THE AERODYNAMICS AND PERFORMANCE OF ACTIVE VORTEX GENERATORS

RON BARRETT and SAEED FAROKHI (Kansas Univ., Lawrence) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 376-386. Research supported by Kansas Technology Enterprise Corp. and NASA refs

(AIAA PAPER 93-3447) Copyright

As a building block in the development of smart lift-enhancement devices, a new concept for flow control using active vortex generators (AVGs) is presented. Ramp, wedge, and doublet wedge (Wheeler) VG configurations are investigated. The AVGs are designed to conform to the surface of the wing section at low alpha. As the section approaches the stall, they are deployed and accordingly, alpha(stall) and C(lmax) are increased. A qualitative analysis of the flow around the various VG configurations was conducted in a low speed wind tunnel at 1.6 ft/s and a Reynolds number of approximately 3400. The results demonstrate that ramp VGs produce vortices that have the longest distance at breakdown. The VGs were also applied to a 25-in. span, 8-in. chord NACA 4415 wing section. Optimization studies were conducted on the spanwise spacing, chordwise position, and size of statically deployed VGs. The test results demonstrate a 14-percent increase in C(lmax) while increasing alpha (stall) by up to 3.

Author (revised)

A93-47238*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

UNSTRUCTURED VISCOUS GRID GENERATION BY ADVANCING-LAYERS METHOD

SHAHYAR PIRZADEH (Vigyan, Inc., Hampton, VA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 420-434. Previously announced in STAR as N93-27067 refs

(Contract NAS1-19672)

(AIAA PAPER 93-3453) Copyright

A new method of generating unstructured triangular/tetrahedral grids with high-aspect-ratio cells is proposed. The method is based on new grid-marching strategy referred to as 'advancing-layers' for construction of highly stretched cells in the boundary layer and the conventional advancing-front technique for generation of regular, equilateral cells in the inviscid-flow region. Unlike the existing semi-structured viscous grid generation techniques, the new procedure relies on a totally unstructured advancing-front grid strategy resulting in a substantially enhanced grid flexibility and efficiency. The method is conceptually simple but powerful, capable of producing high quality viscous grids for complex configurations with ease. A number of two-dimensional, triangular grids are presented to demonstrate the methodology. The basic elements of the method, however, have been primarily designed with three-dimensional problems in mind, making it extendible for tetrahedral, viscous grid generation.

A93-47239#

WIND-TUNNEL TESTS OF AN INCLINED CYLINDER HAVING HELICAL GROOVES

THOMAS D. STUART (U.S. Navy, Arlington, VA), JAMES M. CLIFTON (U.S. Navy, Patuxent River, MD), and LOUIS V. SCHMIDT (U.S. Naval Postgraduate School, Monterey, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 446-454. refs

(AIAA PAPER 93-3456)

A series of low-speed, wind-tunnel investigations were conducted to determine the aerodynamic behavior of a grooved inclined cylinder representing a long trailing wire antenna towed from an airplane. The large test angle of attack range of the wire required two model configurations. For higher angles of attack, full scale wire lengths were tested. For lower angles of attack, a 15-scale grooved, cylindrical model with an ogive nose was constructed. Data were integrated, and empirical relationships for the normal and axial force coefficients verified with historical references for tested clean circular cylinders and extended for the grooved configurations. Existence of a side force coefficient due to circulation caused by the helical grooves was discovered, expressed analytically, and verified with flow-visualization techniques. The experimental coefficients were used to improve an existing simulation model describing the static equilibrium conditions of a cable towed by an airplane. Inclusion of the side force influence in the static model proved consistent with the lateral skew angle and direction observed during flight test.

A93-47242#

CALCULATING CROSSFLOW SEPARATION USING BOUNDARY LAYER COMPUTATIONS COUPLED WITH AN INVISCID METHOD

DAN ALMOSNINO (Analytical Methods, Inc., Redmond, WA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 472-482. refs

(Contract N00014-90-C-0047)

(AIAA PAPER 93-3459) Copyright

A method that provides an initial prediction for the occurrence and location of crossflow separation on smooth surface bodies is presented. The method uses readily available flow quantities along streamlines and streamline following boundary layers. It is shown that crossflow separation occurrence is closely related to a maximum in the shear stress derivative in a direction normal to the wall. The criterion for crossflow separation can be applied to either separated or initially attached flow conditions and it is useful for viscous-inviscid calculations in particular. The present stage of the study involves only the turbulent part of the boundary layer and the initial prediction for crossflow separation in attached flow calculations. Results for several body shapes and flow conditions are presented to demonstrate the usefulness of the method.

A93-47244#

A LAPLACE INTERACTION LAW FOR THE COMPUTATION OF VISCOUS AIRFOIL FLOW IN LOW AND HIGH SPEED AERODYNAMICS

F. ARNOLD (Deutsche Aerospace Airbus GmbH, Bremen, Germany) and F. THIELE (Berlin Technical Univ., Germany) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 490-498. refs

(AIAA PAPER 93-3462) Copyright

A new interaction law which simplifies the numerical coupling of inviscid and boundary layer methods is presented. It is derived from the Laplace equation and considers the outblow and Kutta condition for airfoil flows. For incompressible flows the application of the Laplace interaction law leads to a local-simultaneous coupling technique. A highly efficient computer code for high lift multielement airfoil flows was developed for industrial application at Deutsche Aerospace Airbus. The Laplace interaction law and suitable closure relations for the boundary layer equations make the code fast and robust for flows with partial separation as well. The efficiency of the code is demonstrated by the presentation of the convergence behavior and the comparison of results from computations and wind-tunnel experiments for a reasonable range of high lift configurations. For compressible flows, the application of the Laplace interaction law leads to a quasi-simultaneous coupling technique. It is shown that the higher accuracy of the Laplace interaction law gives faster convergence than the use of the well known thin airfoil interaction laws.

A93-47245#

BOUNDARY LAYER EFFECTS ON THE FLOW OF A LEADING EDGE VORTEX

N. G. VERHAAGEN, J. P. MEEDER, and J. M. VERHELST (Delft Univ. of Technology, Netherlands) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 499-509. refs

(AIAA PAPER 93-3463) Copyright

An experimental study is described that has been carried out in a low-speed wind tunnel on a large 76-deg swept semispan delta wing mounted to a reflection plate. The study has been conducted to investigate the effect of the reflection-plate boundary layer on the leading edge vortex flow over the delta wing. To investigate this effect, on the reflection plate four boundary layers were created of different thickness. The boundary layers and vortex flowfield were surveyed using miniature pressure and cross-wire probes. The test results indicate that near the apex of the delta wing the vortex flow is strongly affected by the boundary layer on the reflection plate. More downstream, boundary layer effects are observed only in the vortex core.

A93-47247#

DEVELOPMENT OF AN INNOVATIVE NATURAL LAMINAR FLOW WING CONCEPT FOR HIGH-SPEED CIVIL TRANSPORTS

BERRY T. GIBSON and HEINZ A. GERHARDT (Northrop Advanced Technology and Design Center, Pico Rivera, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 524-535. refs

(AIAA PAPER 93-3466) Copyright

A wing concept has been developed which may substantially increase the cruise performance of supersonic aircraft. The data presented in this paper suggest that a 'reverse' delta wing having a straight leading edge and forward swept trailing edges is intrinsically suitable for the maintenance of natural laminar boundary layer flow during supersonic flight. Euler calculations were performed to assess and compare the aerodynamic characteristics of reverse delta and conventional delta wings at subsonic and supersonic Mach number. Inviscid results indicate that at supersonic cruise conditions, spanwise flow over the reverse delta wing is virtually absent, in contrast to delta wing flow which exhibits large crossflow gradients, particularly in the 'transition-sensitive' region near the leading edge. In comparison to the conventional delta wing, force calculations from supersonic Euler solutions give a higher lift curve slope for the reverse delta wing and a somewhat higher wave drag. This is a departure from the principles of reciprocal flow theory. Comparisons of the low-speed Euler results with wind tunnel data show good to excellent prediction of longitudinal force and moment coefficients. Subsonic wind tunnel tests were conducted to assess general longitudinal stability characteristics of a reverse delta wing. Emphasis was placed on the effectiveness of a variety of leading and trailing edge flap planforms.

A93-47249#

A WIND TUNNEL INVESTIGATION OF THE PRESSURE DISTRIBUTION ON AN F/A-18 WING

B. H. K. LEE, N. R. VALERIO, and F. C. TANG (National Research Council, Inst. for Aerospace Research, Ottawa, Canada) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 549-558. Research supported by National Research Council of Canada and DND refs

(AIAA PAPER 93-3468) Copyright

A wind tunnel investigation of the pressure field on the wing upper surface of a rigid 6 percent scale model of the F/A-18 was conducted in the Institute for Aerospace Research (IAR) 1.5m trisonic blowdown wind tunnel. The starboard wing and leading-edge extension were instrumented with 168 transducers for unsteady pressure measurements. The investigation was carried out for various Mach numbers and angles of attack. In this paper, detailed results at M = 0.6 and alpha = 30 deg with a clean wing configuration are presented. The emphasis of this study is on the structure of the flowfield on the wing upper surface at high angles of attack. Time-averaged and rms pressure distributions were determined and the normal force on the wing was computed for different angles of attack. Spectral analyses of the pressures at different locations on the wing were carried out. Broadband spacetime correlation of the pressure transducer signals was performed and the convection pattern of the pressure field was compared to the direction of the skin friction lines obtained from flow visualization studies using oil dots deposited on the wing surface.

A93-47250#

SECONDARY FLOW CONTROL ON SLENDER, SHARP-EDGED CONFIGURATIONS

T. TERRY and D. GANGULEE (Toledo Univ., OH) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 559-569. Research supported by Ohio Board of Regents and Univ. of Toledo refs

(AIAA PAPER 93-3470) Copyright

An experimental study of controlling the flow over highly slender sharp-edged configurations at high angles of attack is being conducted. This report focuses on the results of an 80-degree delta wing planform. Small flow deflectors on the leeward side were found to be highly effective in controlling the vortices. Controlled forces and moments were produced with small deflectors. The fluid mechanism of the control method was revealed by flow visualization and forces and moment measurements.

A93-47251*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SUPERSONIC VORTEX BREAKDOWN OVER A DELTA WING IN TRANSONIC FLOW

HAMDY A. KANDIL, OSAMA A. KANDIL (Old Dominion Univ., Norfolk, VA), and C. H. LIU (NASA, Langley Research Center, Hampton, VA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 582-596. Research supported by USAF refs

(Contract NAG1-994)

(AIAA PAPER 93-3472) Copyright

The effects of freestream Mach number and angle of attack on the leading-edge vortex breakdown due to the terminating shock on a 65-degree, sharp-edged, cropped delta wing are investigated computationally, using the time-accurate solution of the laminar unsteady compressible full Navier-Stokes equations with the implicit upwind flux-difference splitting, finite-volume scheme. A fine O-H grid consisting of 125 x 85 x 84 points in the wrap-around, normal, and axial directions, respectively, is used for all the flow cases. Keeping the Reynolds number fixed at 3.23 x 10 exp 6, the Mach number is varied from 0.85 to 0.9 and the angle of attack is varied from 20 to 24 deg. The results show that, at 20-deg angle of attack, the increase of the Mach number from 0.85 to 0.9 results in moving the location of the terminating shock downstream. The results also show that, at 0.85 Mach number, the increase of the angle of attack from 20 to 24 deg results in moving the location of the terminating shock upstream. The results are in good agreement with the experimental data. Author (revised)

A93-47252#

ON DYNAMICS OF THE JUNCTURE VORTEX

M. J. KHAN, J. R. TROSPER, and A. AHMED (Texas A & M Univ., College Station) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics

1993 p. 597-604. refs
(AIAA PAPER 93-3473) Copyright

Detailed characteristics of a horseshoe vortex formed at the juncture of a wing and flat plate have been studied using flow visualization and image analysis techniques. With increasing Reynolds number the flow field exhibited three distinct modes consisting of: (1) steady vortex system; (2) oscillatory vortex motion; and (3) vortex shedding followed by dissipation. Different trends in the variation of Strouhal number were observed when the flow switched from second mode to the third mode. Vortex splitting and subsequent re-connection phenomena was also observed.

A93-47253#
COMPUTATION OF PASSIVELY CONTROLLED TRANSONIC WING
I. KIM and B. SUNG (Korea Aerospace Research Inst., Taejon, Republic of Korea) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 605-613. Research supported by Cray Research, Inc refs
(AIAA PAPER 93-3474) Copyright

A computational investigation has been conducted to examine the effect of passive control on the transonic wing flowfield. The passive control, where part of the solid surface of a wing is replaced by a porous surface over a cavity, was implemented through the use of a simple linear pressure-velocity law over the porous surface. The solutions of the three dimensional Euler equations were generated using the explicit multistage Runge-Kutta time-stepping scheme. The computed results demonstrated that the fundamental behavior of passive control is predominantly two dimensional in nature.

A93-47254*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
GRID AND AERODYNAMIC SENSITIVITY ANALYSES OF AIRPLANE COMPONENTS
IDEEN SADREHAGHIGHI (Old Dominion Univ., Norfolk, VA), ROBERT E. SMITH (NASA, Langley Research Center, Hampton, VA), and SURENDRA N. TIWARI (Old Dominion Univ., Norfolk, VA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 614-624. refs
(Contract NCC1-68)
(AIAA PAPER 93-3475) Copyright

An algorithm is developed to obtain the grid sensitivity with respect to design parameters for aerodynamic optimization. The procedure is advocating a novel (geometrical) parameterization using spline functions such as NURBS (Non-Uniform Rational B-Splines) for defining the wing-section geometry. An interactive algebraic grid generation technique, known as Two-Boundary Grid Generation (TBGG) is employed to generate C-type grids around wing-sections. The grid sensitivity of the domain with respect to geometric design parameters has been obtained by direct differentiation of the grid equations. A hybrid approach is proposed for more geometrically complex configurations such as a wing or fuselage. The aerodynamic sensitivity coefficients are obtained by direct differentiation of the compressible two-dimensional thin-layer Navier-Stokes equations. An optimization package has been introduced into the algorithm in order to optimize the wing-section surface. Results demonstrate a substantially improved design due to maximized lift/drag ratio of the wing-section.

A93-47255*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CALCULATION OF AGARD WING 445.6 FLUTTER USING NAVIER-STOKES AERODYNAMICS
ELIZABETH M. LEE-RAUSCH and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 625-639. refs
(AIAA PAPER 93-3476) Copyright

An unsteady, 3D, implicit upwind Euler/Navier-Stokes algorithm is here used to compute the flutter characteristics of Wing 445.6, the AGARD standard aeroelastic configuration for dynamic response, with a view to the discrepancy between Euler characteristics and experimental data. Attention is given to effects of fluid viscosity, structural damping, and number of structural model nodes. The flutter characteristics of the wing are determined using these unsteady generalized aerodynamic forces in a traditional V-g analysis. The V-g analysis indicates that fluid viscosity has a significant effect on the supersonic flutter boundary for this wing.
AIAA

A93-47256#
HIGH LIFT MULTIPLE ELEMENT AIRFOIL ANALYSIS WITH UNSTRUCTURED GRIDS
WARREN H. DAVIS (Grumman Corp., Bethpage, NY) and RICHARD J. MATUS (Fluent, Inc., Lebanon, NH) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 640-650. refs
(AIAA PAPER 93-3478) Copyright

The viscous, unstructured mesh-based CFD code RAMPANT is here used to explore (1) a standard test case for a single-element airfoil in transonic flow, (2) the low-speed high angle-of-attack flow around a three-element slotted airfoil, and (3) a 23-percent chord-blown trailing-edge flap configuration that uses a drooped leading-edge slat, for both nonblowing and various blowing mass coefficients. All computational results are compared with experimental values of surface pressure and lift characteristics.
AIAA

A93-47257#
ON THE MODELLING OF SEPARATED FLOWS ABOUT AIRFOILS
P. DE MATTEIS and C. DIMA (Centro Italiano Ricerche Aerospaziali, Capua, Italy) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 651-658. refs
(AIAA PAPER 93-3479) Copyright

The modeling of separated flows about airfoils in the framework of a viscous/inviscid coupling approach is considered. Some reliable models are proposed and critically discussed in the light of numerical investigation on single airfoils. Results show that the proposed methods can accurately predict the aerodynamic characteristics of airfoils at high incidence up to stall. In post-stall conditions results indicate that a steady approach is not accurate.

A93-47258#
CURVATURE AND LEADING EDGE SWEEP BACK EFFECTS ON GRID FIN AERODYNAMIC CHARACTERISTICS
WM. D. WASHINGTON, PAMELA F. BOOTH (U.S. Army, Missile Command, Redstone Arsenal, AL), and MARK S. MILLER (Dynetics, Inc., Huntsville, AL) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 659-667. refs
(AIAA PAPER 93-3480)

The aerodynamic characteristics of a curved grid fin configuration have been investigated experimentally. The fins were mounted near the aft end of a body-of-revolution consisting of a 3.0 caliber ogive nose with a 7.4 caliber cylindrical afterbody. The fin radius-of-curvature was chosen to be equivalent to the model body radius to take full advantage of curved grid fins' packaging potential. The grid fin is examined as a deployable, stabilizing device and can also be used as a drag brake device. Test parameters include: grid fin leading edge profile (flat, convex, concave) relative to the freestream direction, sweep back/forward angle (-75 to +75 degrees), angle of attack (-10 to 20 degrees) and Mach number (0.5 to 3.5). Fin balance and main balance data were obtained. Results indicate that the effects of curvature on grid fin aerodynamic characteristics are small. Grid fin sweep back/forward angles are shown to cause a sharp increase in drag and a corresponding decrease in lift indicating their potential as drag stabilizing devices.

A93-47259#

APPLICATION OF COMPUTATIONAL FLUID DYNAMICS IN TRANSONIC AERODYNAMIC DESIGN

K. D. LEE (Illinois Univ., Urbana) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 668-679. refs

(AIAA PAPER 93-3481) Copyright

Various CFD-based transonic vehicle design methodologies are compared in order to determine the quality of the design result and associated design costs. Attention is given to the tools used by both inverse and constrained designs and multipoint designs. Design performance and cost are found to be controllable through proper selection of the number and type of base functions, as well as the number of tolerance constraints. AIAA

A93-47260#

A COMPUTATIONAL METHOD FOR INVERSE DESIGN OF TRANSONIC AIRFOIL AND WING

Z. X. XIA (Changsha Inst. of Technology, China), Z. Q. ZHU, and L. Y. WU (Beijing Univ. of Aeronautics and Astronautics, China) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 680-687. refs

(AIAA PAPER 93-3482) Copyright

A computational method for transonic airfoil and wing design is presented. The method is similar in spirit to the approach of Takanashi (1985). Improvements aimed at increasing abilities of the method and computational efficiency are introduced. For example, a Riegels-type leading edge correction is introduced, an artificial viscosity term is added to the integral equation method, and a smoothing relaxation procedure is proposed. In the 2D transonic flow case, a regularity condition in closed form to be satisfied by the target pressure distribution is used. A few given design results illustrate that present method is an efficient tool for transonic airfoil and wing design. Author (revised)

A93-47261#

NONSLENDER WAVERIDERS

X. HE and G. EMANUEL (Oklahoma Univ., Norman) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 699-706. refs

(AIAA PAPER 93-3487) Copyright

A new body-oriented procedure for generating nonslender waverider shapes is described. These shapes are more practical than conventional waveriders that are relatively slender. Aside from slenderness, the method provides control over the included angle at the leading edge of the waverider, which is structurally important. A new procedure for rounding the leading edge is also presented. Although the lift-to-drag ratio is less for a nonslender waverider, relative to a slender one, it is still quite large. Lift-to-drag is thus traded for improved volumetric effectiveness, thicker winglets, and easier matching with the aft portion of a waverider-based vehicle. By means of hypersonic small-disturbance theory, an on-design parametric study is performed. Off-design performance is provided by solutions of an Euler space-marching code. Both studies verify the feasibility for developing nonslender waveriders.

A93-47262*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

COMPUTATIONAL ANALYSIS OF OFF-DESIGN WAVERIDERS

X. HE and M. L. RASMUSSEN (Oklahoma Univ., Norman) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 707-718. refs

(Contract NAG1-886)

(AIAA PAPER 93-3488) Copyright

Comprehensive inviscid and viscous numerical simulations of hypersonic flow past nonconical rounded-nose waveriders are presented. The flow fields and aerodynamic forces at off-design conditions are determined inviscidly by a space-marching CFD code with the initial-data plane provided by a time-marching Navier-Stokes CFD code. Off-design conditions include off-design Mach numbers, angles of attack, and rounded leading edges. A wide range of waverider configurations is investigated and compared. These calculations show the effects of viscous interactions, which are influential near the leading edges, and determine the viscous drag. The inviscid calculations show that L/D decreases as freestream M increases (with alpha = 0). At the on-design Mach numbers, the maximum L/D may occur at slight positive or negative alpha, depending on the shape of the waverider, and zero lift occurs at a negative alpha approximately equal to half of the body thickness. The effects of slight leading-edge blunting produce only local effects in the flow field and small losses in L/D. Author (revised)

A93-47263#

PRELIMINARY DESIGN ESTIMATES OF HIGH-SPEED STREAMLINES ON ARBITRARY SHAPED VEHICLES DEFINED BY QUADRILATERAL ELEMENTS

K. J. DETERS (McDonnell Douglas Aerospace, Saint Louis, MO) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 719-729. refs

(Contract F33615-89-C-3003)

(AIAA PAPER 93-3491)

A computer program (QUADSTREAM) has been developed to calculate the boundary layer edge streamlines on arbitrary geometries defined by quadrilateral elements. The program is based on the Newtonian steepest descent concept which is valid at high speeds over a wide range of angles of attack. This paper discusses the computer program and the methods used to calculate the streamline traces. In addition, several peculiarities that are associated with tracing streamlines on quadrilateral geometries are presented. Finally, several comparisons between QUADSTREAM and a surface-based streamline code are included. The results from QUADSTREAM show good agreement with the surfaced based code for arbitrary shaped vehicles. QUADSTREAM is capable of tracing streamlines on complex arbitrary shaped vehicles with the limitations discussed in this paper.

A93-47264#

EFFECT OF LEEWARD FLOW DIVIDERS ON THE WING ROCK OF A DELTA WING

T. T. NG, TONY SKAFF, and JOHN KOUNTZ (Toledo Univ., OH) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 730-740. Research supported by Ohio Board of Regents and Univ. of Toledo refs

(AIAA PAPER 93-3492) Copyright

The effect of a leeward flow divider on the wing rock of a 80-degree sharp-edged delta wing was studied in a wind tunnel experiment. Force and moment measurements and flow visualizations were performed to investigate the effect of divider geometry, size, and placement on wing rock. It was found that the divider can suppress wing rock over a wide range of angle of attack, but can also be destabilizing under certain conditions. A fluid mechanism explaining the effects of the divider on wing rock was proposed.

A93-47265#

AERODYNAMIC CHARACTERISTICS OF THE MMPT ATD VEHICLE AT HIGH ANGLES OF ATTACK

EDMUND H. SMITH, MICHAEL E. SALAZAR (U.S. Navy, Naval Air Warfare Center, China Lake, CA), S. K. HEBBAR, and M.

PLATZER (U.S. Naval Postgraduate School, Monterey, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 741-753. refs
(AIAA PAPER 93-3493)

The Multi-Mission Propulsion Technology Advanced Technology Demonstration (ATD) vehicle will after vertical launch 'pitch-over' into a near-horizontal trajectory, encountering a high angle-of-attack at low Mach number that places a premium on the maintenance of stability. Six-component force data have been obtained for angles-of-attack of up to 50 deg at Mach 0.2 for a 0.25-scale model of the ATD; also measured were seven fin-pitch control deflections, three missile roll angles, and roll control authority. General agreement between actual and predicted aerodynamic characteristics is satisfactory, indicating that the vehicle will be controllable and stable. AIAA

A93-47266#
FLOW CONTROL OVER DELTA WINGS AT HIGH ANGLES OF ATTACK
SANDRA M. KLUTE, ROBERT A. MARTIN, OTHON K. REDINIOTIS, and DEMETRI P. TELIONIS (Virginia Polytechnic Inst. and State Univ., Blacksburg) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 754-764. refs
(Contract AF-AFOSR-91-0310)
(AIAA PAPER 93-3494) Copyright

The possibility of delaying vortex breakdown to higher angles of attack by employing control surfaces is studied experimentally. The effect of control surfaces is tested for fixed and dynamically pitching delta wings. Flow visualization, surface pressure measurements, and laser-Doppler velocimetry are employed to map out pressure, velocity, and vorticity fields. It is found that a drooping apex flap can delay vortex breakdown by an angle of 8 deg beyond the steady flow breakdown angle. The apex flap effect is equally pronounced in dynamic maneuvers. Author (revised)

A93-47267*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NAVIER-STOKES PREDICTION OF A DELTA WING IN ROLL WITH VORTEX BREAKDOWN
NEAL M. CHADERJIAN and LEWIS B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 765-773. refs
(AIAA PAPER 93-3495) Copyright

The three-dimensional, Reynolds-averaged, Navier-Stokes (RANS) equations are used to numerically simulate vortical flow about a 65 degree sweep delta wing. Subsonic turbulent flow computations are presented for this delta wing at 30 degrees angle of attack and static roll angles up to 42 degrees. This work is part of an on going effort to validate the RANS approach for predicting high-incidence vortical flows, with the eventual application to wing rock. The flow is unsteady and includes spiral-type vortex breakdown. The breakdown positions, mean surface pressures, rolling moments, normal forces, and streamwise center-of-pressure locations compare reasonably well with experiment. In some cases, the primary vortex suction peaks are significantly underpredicted due to grid coarseness. Nevertheless, the computations are able to predict the same nonlinear variation of rolling moment with roll angle that appeared in the experiment. This nonlinearity includes regions of local static roll instability, which is attributed to vortex breakdown.

A93-47268#
AN EXPERIMENTAL STUDY OF DROOP LEADING EDGE MODIFICATIONS ON HIGH AND LOW ASPECT RATIO WINGS UP TO 50 DEG ANGLE OF ATTACK
HUGO A. GONZALEZ and ALLEN E. WINKELMANN (Maryland Univ., College Park) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 774-786. refs
(AIAA PAPER 93-3496) Copyright

Experimental studies were conducted to determine the effect of drooped leading edge modifications on high aspect ratio wings. Wind tunnel tests were conducted on effective aspect ratio 6, 9, and 12 wings with a NACA 64(2) - 415 (Modified) airfoil. Lift, drag, and pitching moment were measured with a three-component sidewall pyramidal balance. In addition to force and moment measurements, a complete series of surface flow visualization tests were conducted using fluorescent oil. The results obtained give a better understanding of stall/spin prevention through the use of droop leading edge modifications on general aviation and remotely piloted aircraft. The stall characteristics of a wing were greatly improved by the use of a 3/4 span droop leading edge modification. The wing modification generated a double 'hump' lift curve which recovered and surpassed the lift lost at primary stall. Lift recovery decreased with increasing wing span, since the downwash over the drooped section decreased. A recommended droop configuration and a qualitative flow field model for high aspect ratio drooped wings are presented. Author (revised)

A93-47269#
A FLOWFIELD STUDY OF A CLOSE-COUPLED CANARD CONFIGURATION
RICHARD M. HOWARD and JOHN F. O'LEARY (U.S. Naval Postgraduate School, Monterey, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 787-795. Research supported by U.S. Navy refs
(AIAA PAPER 93-3499)

A wind-tunnel study was completed examining the flowfield behavior of the canard-vortex/wing-vortex interaction for a close-coupled canard configuration in the post-stall regime (stall of wing with no canard present). Three crossplanes were mapped in the lee flowfield using a five-hole pressure probe traversing 200 to 500 grid points per grid. The mappings traced the canard and wing vortices as they moved downstream, and gave clear evidence that the canard vortex provided the mechanism for flow reattachment over the inboard wing section. The previously-separated flow became a coherent wing leading-edge vortex under the canard vortex influence. A secondary vortex at the canard-fuselage juncture was revealed; this vortex may have an impact upon the resulting flow, and would not be evident in studies of bodiless wings with canards. Surface flow visualization aided in revealing the effects of the post-stall behavior.

A93-47270*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PREDICTION OF STALL AND POST-STALL BEHAVIOR OF AIRFOILS AT LOW AND HIGH REYNOLDS NUMBERS
T. CEBECI, F. ROKNALDIN (California State Univ., Long Beach), and L. W. CARR (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 796-804. refs
(AIAA PAPER 93-3502) Copyright

An interactive boundary-layer method, together with the e(super n)-approach to the calculation of transition, has been used to predict the stall and post-stall behavior of airfoils at low and high Reynolds numbers. The turbulence model is based on the Cebeci-Smith algebraic eddy-viscosity formulation with improvements for strong pressure gradient effects and transitional flows at low Reynolds numbers. Comparison of calculated results for incompressible flows indicate good agreement with experiment for a wide range of Reynolds numbers. Preliminary calculations for low Mach number flows with this interactive method with compressibility corrections to the panel method indicate that, at a Mach number of 0.3, the compressibility effect on (C sub Q)max is not negligible. Author (revised)

A93-47271#
NUMERICAL SIMULATION OF INCOMPRESSIBLE VISCOUS FLOW AROUND A PROPELLER
WARN-GYU PARK and LAKSHMI N. SANKAR (Georgia Inst. of Technology, Atlanta) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 805-813. refs
(Contract N00014-89-J-1319)
(AIAA PAPER 93-3503) Copyright

An iterative time marching procedure for solving three-dimensional incompressible viscous flow has been applied to the flow around a propeller. This procedure solves 3-D unsteady incompressible Navier-Stokes equations on a moving, body-fitted, non-orthogonal grid using first-order accurate schemes for the time derivatives and second- and third-order accurate schemes for the spatial derivatives. To accelerate iterative process, a multigrid technique has been applied. This procedure is suitable for efficient execution on the current generation of vector or massively parallel computer architectures. Generally good agreement with published experimental and numerical data has been obtained. It was also found that the multigrid technique was efficient in reducing the CPU time needed for the simulation and improved the solution quality.

A93-47272*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL STUDY OF A CONICAL WING HAVING UNIT ASPECT RATIO AT SUPERSONIC SPEEDS
BRIAN E. MCGRATH (Lockheed Engineering & Sciences Co., Hampton, VA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 814-826. Research supported by NASA refs
(AIAA PAPER 93-3505)

A study was conducted to identify and assess a computational method as a preliminary analysis and design tool for advanced military aircraft designs. The method of choice for this study was the Euler Marching Technique for Accurate Computation (EMTAC). Computational and experimental results were compared for a thick unit aspect ratio delta wing at Mach 2.8 and 4.0. This geometry along with the associated flow physics is representative of advanced aircraft designs. The comparisons of the lift and drag coefficients show that the computations agree with experimentally obtained data at Mach 2.8 and 4.0. Further, comparison between EMTAC and experiment shows that the computations accurately predict the overall shape and levels of the surface pressure distributions at Mach 2.8 and 4.0. Qualitative assessment of the computed flow-field properties shows that EMTAC captures the basic flow-field characteristics representative of advanced aircraft designs. The study further suggests that EMTAC can be successfully used in the preliminary analysis and design of advanced military aircraft.

A93-47274#
EXPERIMENTAL AND COMPUTATIONAL INVESTIGATIONS OF THE FLOWFIELD AROUND THE F117A
SABINE A. VERMEERSCH, DAVID MODIANO, IOANNIS HARIZOPOULOS, EARLL MURMAN (MIT, Cambridge, MA), and JAIME PERAIRE (Imperial College of Science, Technology, and Medicine, London, United Kingdom) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 842-850. Research supported by McDonnell Aircraft Co. and MIT refs
(Contract AF-AFOSR-89-0395)
(AIAA PAPER 93-3508) Copyright

The investigation of the vortical flow around the F117A stealth fighter is presented in order to demonstrate the capability to resolve leading-edge vortices with an adaptive finite element solver for the Euler equations. One goal is to capture vortex breakdown at high angles of attack. This work presents the five main steps involved in a typical study of the flow characteristics of a complete aircraft: the definition of the model geometry, the realization of a suitable grid around the discretized model, the implementation of an Euler solver, the subsequent analysis of the flow field, and the comparison to experimental data sets. The computational data are compared to the lift and moment curves obtained in a subsonic 5 ft x 7 ft wind tunnel. The occurrence of vortex breakdown is determined by performing flow visualization in the tunnel. Five cases are computed for this work. Each case is studied at Mach 0.3, and angles of attack range between 7 and 30 degrees.
Author (revised)

A93-47275#
COMPUTATION OF WAKE ROLL-UP FOR COMPLETE AIRCRAFT CONFIGURATIONS
RENATO S. RIBEIRO and OTTO C. DE RESENDE (Embraer-Empresa Brasileira de Aeronautica, S.A., Sao Jose dos Campos, Brazil) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 851-861. refs
(AIAA PAPER 93-3509) Copyright

This paper describes modifications made to a low-order panel method in order to compute wake roll-up for complete aircraft configurations. A vortex-in-cell method and a new source-in-cell method were coupled with the panel code, computing the velocity field used by a wake relaxation scheme. The use of the 'in-cell' methodology provided substantial savings in computational time when compared with conventional wake roll-up calculations, as well as increased robustness. The hybrid method developed was applied to an isolated wing with double-slotted flaps, and to a complete jet aircraft configuration. The introduction of wake relaxation caused significant changes in the global aerodynamic coefficients for both cases, while downwash at the horizontal tail was less affected.

A93-47276#
THE APPLICATION OF AN EULER METHOD AND A NAVIER STOKES METHOD TO THE VORTICAL FLOW ABOUT A DELTA WING
F. J. BRANDSMA (National Aerospace Lab., Amsterdam, Netherlands), S. BOSSE, H. W. M. HOEIJMAKERS (Delft Univ. of Technology, Netherlands), and J. I. VAN DEN BERG (National Aerospace Lab., Amsterdam, Netherlands) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 862-875. Research supported by Netherlands Agency for Aerospace Programs refs
(AIAA PAPER 93-3510) Copyright

Numerical simulations of the transonic flow about a 65-deg sharp-edged cropped delta wing were carried out using an Euler method as well as a thin-layer Navier-Stokes (TLNS) method, both based on a cell-centered central-difference finite-volume scheme. The Euler and TLNS solutions for the configuration at a transonic Mach number of 0.85 are compared in detail with experimental results available from NLR experiments for two incidences, alpha = 10 deg and alpha = 15 deg. Comparisons of the computed and experimental results indicate that the Euler method captures the global flow features (i.e., separation from the sharp leading edge, and the formation of the leading-edge and trailing edge vortices) reasonably well except for the still substantial discrepancies in the predicted spanwise pressure distributions. The Navier-Stokes results show a much improved correlation with the experimental data on that point because the method yields, in addition to the flow features already captured by the Euler method, also the boundary layer effects and, specifically, the secondary separation induced by the leading edge vortex on the wing upper surface.
Author (revised)

A93-47277#
ATTENUATION OF AIRPLANE WAKE VORTICES BY EXCITATION OF FAR-FIELD INSTABILITY
V. R. NIKOLIC (Rose-Hulman Inst. of Technology, Terre Haute, IN) and E. J. JUMPER (Notre Dame Univ., IN) *In* AIAA Applied

Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 876-884. refs
(AIAA PAPER 93-3511) Copyright

This paper presents the results of a computational study of the injection of discrete vortices at a wake-generating wing and their effect on the development and dynamics of the wing's wake. The study was motivated by the results of an experimental study by Rossow showing that injection of vortices at approximately the mid semispan of an airplane wing greatly reduced the potential hazard to an aircraft penetrating the wake. Our study suggests that the reduction in wake hazard is due to the excitation of the Crow instability in the primary 'wing-tip' vortices due to their interaction with secondary vortices formed around the injected vortices. The computational model used a point-vortex method specifically developed for this study.

A93-47278#
EXPERIMENTAL ANALYSIS OF ROTARY DERIVATIVES ON A MODERN AIRCRAFT CONFIGURATION
G. R. GUGLIERI (CNR, Centro di Studio per la Dinamica dei Fluidi, Turin, Italy) and F. B. QUAGLIOTTI (Torino, Politecnico, Turin, Italy) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 885-893. refs
(AIAA PAPER 93-3514) Copyright

The experimental results presented are representative of a research program concerned with the determination of stability parameters in low speed wind tunnels. Static and oscillating behavior data have been obtained for a calibration model and compared with those measured at other facilities. Attention is given to comparisons with NASA-Ames rotation-behavior data obtained for the same model. AIAA

A93-47279*# National Aeronautics and Space Administration, Washington, DC.
LASER HOLOGRAPHIC INTERFEROMETRIC MEASUREMENTS OF THE FLOW BEHIND A REARWARD FACING STEP
RACHEL LEONARD and NDAONA CHOKANI (North Carolina State Univ., Raleigh) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 894-902. refs
(Contract NAGW-1331)
(AIAA PAPER 93-3515) Copyright

A holographic interferometer has been designed, constructed, and evaluated in an experimental study of the supersonic flow over a rearward facing step. The nominal Mach number at the corner was 2.05 +/- 0.04 and the Reynolds number per inch was 11.9 x 10 exp 6. The holographic interferometric measurements were supplemented by classical measurements of surface pressure, oil flow, and schlieren visualization. The effects of step height and step width were examined. A method to determine the reattachment point from the interferograms was examined and found to be in good agreement with the other measurement techniques. The reattachment point moved closer to the step as the step height was decreased, but its location did not change with varying step width. In addition to providing surface data for the flow over a rearward facing step, this study provides quantitative off-surface density data and Mach number data throughout the flow, obtained from the holographic interferometry measurements, which are suited for code validation. Author (revised)

A93-47282*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SEMI-DISCRETE GALERKIN SOLUTION OF THE COMPRESSIBLE BOUNDARY-LAYER EQUATIONS WITH VISCOUS-INVISCID INTERACTION
BRAD A. DAY and ANDREW J. MEADE, JR. (Rice Univ., Houston, TX) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 939-949. refs
(Contract NAG1-1196)
(AIAA PAPER 93-3520) Copyright

A semi-discrete Galerkin (SDG) method is under development to model attached, turbulent, and compressible boundary layers for transonic airfoil analysis problems. For the boundary-layer formulation the method models the spatial variable normal to the surface with linear finite elements and the time-like variable with finite differences. A Dorodnitsyn transformed system of equations is used to bound the infinite spatial domain thereby providing high resolution near the wall and permitting the use of a uniform finite element grid which automatically follows boundary-layer growth. The second-order accurate Crank-Nicholson scheme is applied along with a linearization method to take advantage of the parabolic nature of the boundary-layer equations and generate a non-iterative marching routine. The SDG code can be applied to any smoothly-connected airfoil shape without modification and can be coupled to any inviscid flow solver. In this analysis, a direct viscous-inviscid interaction is accomplished between the Euler and boundary-layer codes through the application of a transpiration velocity boundary condition. Results are presented for compressible turbulent flow past RAE 2822 and NACA 0012 airfoils at various freestream Mach numbers, Reynolds numbers, and angles of attack.

A93-47283#
A 3D NAVIER-STOKES ANALYSIS OF A GENERIC GROUND VEHICLE SHAPE
M. B. MALONE, W. P. DWYER, and D. CROUSE (Northrop Corp., Pico Rivera, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 950-958. refs
(AIAA PAPER 93-3521) Copyright

Low speed aerodynamics on bluff bodies in ground proximity (i.e., ground vehicles) has many current day applications, including renewed interest in automobile and train aerodynamics. Verification of proven computational aerodynamic methods on these types of complex flows is required before they can be applied generally in a design process. Presented are computational results for flow around Ahmed's family of vehicle-like bodies. A general purpose CFD code was used to solve the Reynolds-averaged, Navier-Stokes equations, together with the Baldwin-Barth one-equation model of turbulence. A 1,000,000 grid point, multiple block, non-orthogonal grid was constructed to model each geometry. Pressure distributions and drag calculations compared well with the experimental data for various base slant angles. The 30-deg slant configuration has both a high and low drag solution, both of which were reproduced in the numerical results. Grid adaptation was also performed to determine grid dependency as well as to resolve finer details of the flow.

A93-47284#
A POINTWISE VERSION OF THE BALDWIN-BARTH TURBULENCE MODEL
URIEL C. GOLDBERG and SEKARIPURAM V. RAMAKRISHNAN (Rockwell International Science Center, Thousand Oaks, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 959-967. refs
(AIAA PAPER 93-3523) Copyright

The present modification of the Baldwin-Barth (1990) nu-R(t) one-equation turbulence model involves replacing the y(exp +)-dependent near-wall formulation with equivalent functions based on the ratio of the large eddy and the Kolmogorov time scales. The resulting model is valid in near-wall regions which do not entail knowledge of local wall resistance, making this approach germane to both unstructured grid frameworks and traditionally structured grids. A number of illustrative flow cases are treated. AIAA

A93-47285*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CHARACTERISTICS OF DEFORMABLE LEADING EDGE FOR HIGH PERFORMANCE HELICOPTER ROTOR
SOOGAB LEE, K. W. MCALISTER, and CHEE TUNG (U.S. Army, Aeroflightdynamics Directorate; NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 968-988. refs
(AIAA PAPER 93-3526) Copyright
The deformable leading edge (DLE) concept to improve the blade capability in lift, drag and pitching moments has been investigated for the purpose of meeting new rotor maneuverability and susceptibility requirements. The advantages and disadvantages of this concept have been carefully examined with limited computational and experimental results. This work showed that this concept achieves a substantial improvement in lift capability and also reduces the drag and pitching moment at the same time. Effects of various parameters, such as Reynolds number, reduced frequency, mean angle of oscillation, and airfoil shape, on the performance of these airfoils were also investigated.

A93-47286#
NAVIER-STOKES CALCULATIONS OF ROTATING BERP PLANFORM BLADE FLOWFIELDS
CHANJIN NAM and DONGHO LEE (Seoul National Univ., Republic of Korea) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 989-998. refs
(AIAA PAPER 93-3527) Copyright
A upwind Navier-Stokes code has been developed and it was used to analyze the hovering and forward flight aerodynamic characteristics of British Experimental Rotor Program (BERP) planform helicopter blade. A finite-volume upwind method and LU-SGS implicit operator are applied with sub-iteration for solving the unsteady Navier-Stokes equations in moving grid domain. Computational results of hovering condition at high tip speed and low angle of attack show that BERP planform blade requires less torque and has much less pitching moment than those of rectangular one. At high angle of attack and low tip speed, the BERP attained high-lift by maintaining attached flow at the tip region. Quasi-steady calculations for both advancing rotor and retreating one in forward flight with blade flapping motion are also calculated. The aerodynamic characteristics of advancing blade are similar to that of high tip speed hovering blade. For retreating side, where angle of attack is high and tip speed low, the BERP blade also shows better performance than rectangular one by delayed stall.

A93-47287#
CALCULATION OF V/STOL AIRCRAFT AERODYNAMICS WITH DEFLECTED JETS IN GROUND EFFECT
PAUL C. LIAW (Engineering Sciences, Inc., Huntsville, AL), C. E. LAN (Kansas Univ., Lawrence), and YEN-SEN CHEN (Engineering Sciences, Inc., Huntsville, AL) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 999-1009. refs
(AIAA PAPER 93-3530) Copyright
The present numerical code, which combines a panel code and a Navier-Stokes code, is used to predict the flowfield around a V/STOL aircraft in ground effect, including the suction force induced by a jet for a wing-body configuration, the ground vortex, and the collision of the freestream with the jet flow. The numerical results thus obtained follow the same trends as the experimental data; with or without freestream effects, the computed flow field exhibits a jet rollup phenomenon resembling that which is theoretically projected. AIAA

A93-47288#
APPLICATION OF A PARABOLIZED NAVIER-STOKES CODE TO AN HSCT CONFIGURATION AND COMPARISON TO WIND TUNNEL TEST DATA
D. M. HOLLENBACK and G. A. BLOM (Boeing Commercial Airplane Group, Seattle, WA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1010-1017. refs
(AIAA PAPER 93-3537) Copyright
A code validation effort was undertaken at Boeing to understand the capabilities of advanced computational fluid dynamics (CFD) codes to predict the flow about high-speed civil transport (HSCT) configurations. A wind tunnel model of this same configuration was built and tested at supersonic Mach numbers to obtain force and moment data and surface pressure data for comparison to the predicted values. A parabolized Navier-Stokes code was used for the predictions. The predicted forces and moments compare very well with the wind tunnel data. The pressure distributions are also very well predicted, with all of the important features, including those near the leading edge, well represented. Oil flow photographs from the wind tunnel testing are compared to particle traces. The code is shown to capture flow features that are due to viscosity.

A93-47289#
LIFT ENHANCEMENT DUE TO UNSTEADY AERODYNAMICS
SAMUEL GREENHALGH (U.S. Navy, Naval Air Warfare Center, Warminster, PA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1018-1028.
(AIAA PAPER 93-3538)
A recent series of tests were conducted in the Princeton University 4 ft x 5 ft Low Speed Wind Tunnel Test Facility on a 36-in. semispan wing with a mechanically driven oscillating trailing edge. The oscillation displacement was essentially sinusoidal. Aerodynamic data were collected over a range of oscillating frequencies, for a range of amplitudes about different neutral positions, and over a range of angles of attack. The results of the experiments show that, under certain conditions, by oscillating the trailing edge, there is a substantial increase in the maximum lift and a mild increase in the lift curve slope. The maximum steady lift on the wing can be increased by as much as 55 percent. The conditions for lift enhancement correlate well with a modified reduced frequency. The results demonstrate that lift enhancement can be obtained by using unsteady aerodynamic effects produced by oscillating the trailing edge of a wing. Author (revised)

A93-47292#
FOREBODY VORTEX CONTROL - A PROGRESS REVIEW
GERALD N. MALCOLM (Eidetics International, Inc., Torrance, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1082-1116. refs
(AIAA PAPER 93-3540) Copyright
Conventional fighter aircraft control surfaces, such as the rudder, become ineffective at high angles of attack resulting in a serious deficiency in lateral-directional controllability in the angle of attack range for maximum lift and in the post stall regime. Development of robust control methods for high angle of attack flight has focused primarily on thrust vector control and forebody vortex control. This paper is an attempt to review the forebody vortex control research that has taken place in the last two to three years. Some earlier research results are also shown to provide a historical perspective and to document the state of our knowledge of this rapidly advancing technology. The techniques that have been investigated include large deployable or hinged strakes, pneumatic techniques using either nozzles or slots, suction through small holes or ports, and miniaturized rotatable nose-tip and nose-boom strakes. Optimized versions of all of these techniques are effective in producing primarily yawing moments at high AOA, with, for some configurations, some interactions in rolling moment.

Mass flow rates required for pneumatic techniques are at levels that can be obtained from today's engine bleed systems. Application of techniques developed for conventional forebodies with rounded cross sections are just beginning to be evaluated for advanced forebodies with chined cross sections.

A93-47331
MULTIPLE SOLUTIONS OF THE TRANSONIC PERTURBATION EQUATION
FASHU SHI, SONGYE DONG, and SHOUZHI YU (MAS, 31st Research Inst., China) Journal of Propulsion Technology (ISSN 1001-4055) no. 3 June 1993 p. 1-7. In CHINESE refs

In the present work, Engquist-Osher scheme was adopted to solve 2D steady potential flow field over NACA0012 airfoil by discrete transonic perturbation equation. The solutions are in agreement with experimental results. In order to investigate the problem of multiple solutions, the nonconservative and conservative forms of the Murman-Cole scheme were used and compared simultaneously. Some useful phenomena have been found as follows. The solutions with E-O scheme are not unique. Under the condition of narrow Mach number region and zero angle of attack, there exist three converged solutions. One is a correct symmetric solution, and others positive and negative nonsymmetric solutions. In other cases, the solution is unique. When circulation strength Gamma is greater than 10 exp -3 in order of magnitude, the symmetric solution cannot be obtained. Only if the zero potential field or almost completely symmetric field is taken as initial field, can the symmetric solution be a solution. The converged solutions and characteristics of M-C conservative scheme are very similar to that of E-O scheme, but its pressure coefficient Cp value jumps sharply near parabolic points. Author (revised)

A93-47341
THE DEVELOPMENT OF SWIRL FIVE-HOLE PROBE
GUOCAI YANG (611th Research Inst., China) Journal of Propulsion Technology (ISSN 1001-4055) no. 3 June 1993 p. 69-75. In CHINESE refs

A 3-mm diameter prismoid-shaped five-hole swirl probe with a square cross section is developed, which can quantitatively measure the parameters of three-dimensional swirl flow for engineering applications. By using the fourth-order polynomials to fit the calibration data set, the standard deviation of flow angles is controlled to under 0.3 deg, and the relative deviations of the total pressure and dynamic pressure are controlled to under 1.2 percent. It was found that, when Mach numbers are within 0.3 to 0.6 and the flow angles are within 0 to +/- 30 deg, the calibration pressure coefficients are independent from Mach number. AIAA

A93-47446
THREE-DIMENSIONAL ANALYSIS OF TURBINE ROTOR FLOW INCLUDING TIP CLEARANCE
R. HEIDER, J. M. DUBOUE, B. PETOT (SNECMA, Moissy-Cramayel, France), G. BILLONNET, V. COUAILLIER, and N. LIAMIS (ONERA, Chatillon, France) ONERA, TP no. 1993-41 1993 17 p. ASME, International Gas Turbine and Aeroengine Congress and Exposition, 38th, Cincinnati, OH, May 24-27, 1993 Research supported by DRET and Service Technique des Programmes Aeronautiques refs
(ASME PAPER 93-GT-111; ONERA, TP NO. 1993-41)

A 3D Navier-Stokes investigation of a high pressure turbine rotor blade including tip clearance effects is presented. The 3D Navier-Stokes code developed at ONERA solves the three-dimensional unsteady set of mass-averaged Navier-Stokes equations by the finite volume technique. A one step Lax-Wendroff type scheme is used in a rotating frame of reference. An implicit residual smoothing technique has been implemented, which accelerates the convergence towards the steady state. A mixing length model adapted to 3D configurations is used. The turbine rotor flow is calculated at transonic operating conditions. The tip clearance effect is taken into account. The gap region is discretized using more than 55,000 points within a multi-domain approach. The solution accounts for the relative motion of the blade and casing surfaces. The total mesh is composed of five sub-domains and counts 710,000 discretization points. The effect of the tip clearance on the main flow is demonstrated. The calculation results are compared to a 3D inviscid calculation, without tip clearance.

A93-47448
AEROELASTIC COMPUTATION FOR A FLEXIBLE AIRFOIL USING THE SMALL PERTURBATION METHOD COMPARISON WITH WIND-TUNNEL RESULTS
J. L. MEURZEC and P. VIGUIER (ONERA, Chatillon, France) ONERA, TP no. 1993-43 1993 15 p. Forum International Aeroelasticite et Dynamique de Structures, Strasbourg, France, May 24-26, 1993 refs
(ONERA, TP NO. 1993-43)

A systematic assessment of a small perturbation method for aeroelastic flutter prediction was performed using steady and unsteady experimental test results obtained in the ONERA S2Ma wind tunnel on a flexible model of a transport aircraft. Computation and test results for steady and unsteady pressure distribution, and global lift coefficients for subsonic and transonic conditions were compared. It is concluded that application of the small perturbation method to transonic flows takes into account certain aerodynamic nonlinearities. The very moderate execution time required makes it possible to compute aeroelastic stability in the transonic domain. AIAA

A93-47522
EXPERIMENTAL STUDY OF THE EFFECT OF EXTERNAL TURBULENCE AND THE SHAPE OF THE SURFACE ON THE CHARACTERISTICS OF LAMINAR AND TRANSITION BOUNDARY LAYERS [EHKSPERIMENTAL'NOE ISSLEDOVANIE VLIYANIYA VNESHNEJ TURBULENTNOSTI I FORMY POVERKHNOSTI NA KHARAKTERISTIKI LAMINARNOGO I PEREKHODNOGO POGRANICHNYKH SLOEV]
A. N. SEKUNDOV and B. I. MINEEV *In* Turbulent flow problems Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya 1991 p. 237-260. In RUSSIAN refs
Copyright

Experimental results are presented on the structure of laminar and transition boundary layers developing in the interaction with large-scale external turbulence. The flow characteristics are shown to be stable to variations of the turbulence characteristics, the conditions of flow around the plate, and the surface shape and relief. Based on hot-wire anemometer measurements and visualization data, an explanation is offered for the formation of the 3D structure of the velocity pulsation field in the stable boundary layer. AIAA

N93-31052# Aeronautical Research Inst. of Sweden, Stockholm.
GARTEUR 3D SHEER LAYER EXPERIMENT Main Model Report
ERNST TOTLAND Oct. 1992 72 p
(FFA-TN-1992-26; GARTEUR-AD(AG07)TP069; ETN-93-94214)
Avail: CASI HC A04/MF A01

The structural design and manufacture of the two main half wing models for the GARTEUR shear layer experiment are described. The models are identical in shape, but different in size. Both models have the same structural design based on a foam and fiberglass sandwich shell with a minimum of internal structure. The geometrical properties of the models are thoroughly documented. The instrumentation of the two models is also documented. This consists of a large number of pressure taps, hot film sensors for skin friction measurements and internally traversable boundary layer probes. The two models contribute to the project GARTEUR AG 07, which concerns the experimental investigation of turbulent shear layers on a swept wing. ESA

N93-31148# National Aerospace Lab., Amsterdam (Netherlands). Aerodynamics Div.
COMPUTATIONAL METHODS FOR AERODYNAMIC DESIGN OF AIRCRAFT COMPONENTS

T. E. LABRUJERE and J. W. SLOOFF 25 Feb. 1992 51 p
Submitted for publication
(NLR-TP-92072-4; ETN-93-94081) Avail: CASI HC A04/MF A01

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. ESA

N93-31171# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany). Gruppe Instationaere Aerodynamik.
TDLM: A TRANSONIC DOUBLET LATTICE METHOD FOR 3D POTENTIAL UNSTEADY TRANSONIC FLOW CALCULATION
SHUQUAN LU (Nanjing Aeronautical Inst., China.) and RALPH VOSS Sep. 1992 44 p
(ISSN 0939-2963)
(DLR-FB-92-25; ETN-93-93956) Avail: CASI HC A03/MF A01; DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany, HC

The develoompent of a Transonic Doublet Lattice Method (TDLM) for calculating unsteady transonic pressure distributions and airloads is reported. The flow around harmonically oscillating surfaces is described by superposition of a steady transonic ocean flow and an unsteady harmonic flow. The unsteady flow component is modeled by acceleration potential doublets in the mean wing surface and a source distribution in the flow field near the wing. The time linearized unsteady transonic small perturbation equation is solved by an integral equation method. Results for a rectangular wing, the Northrop F-5 wing, and the LANN wing in pitching oscillation are presented. Comparisons are made with both experimental and other numerical results. Agreement with the experimental results is very good. The computing time in the IBM 3090 is less than ten minutes for one reduced frequency, and it shows that the TDLM can provide a sufficiently accurate and cost effective procedure for routine transonic flutter calculations. ESA

N93-31189# National Aerospace Lab., Tokyo (Japan).
LOW-SPEED WIND TUNNEL STUDY OF THE DIRECT SIDE-FORCE CHARACTERISTICS OF A JOINED-WING AIRPLANE WITH AN UPPER FIN
T. FUJITA, A. IWASAKI, H. FUJIEDA, and N. TAKIZAWA Mar. 1992 23 p
(DE93-767966; NAL-TM-645) Avail: CASI HC A03/MF A01 (US Sales Only)

Low-speed wind tunnel tests were conducted on a diamond shaped joined-wing airplane with its horizontal tail width linked at a 60%-position of the wing width, fitted with an upper fin having a trailing fin to control side force. Effects of the upper fin were discussed on direct side-force control characteristics. The diamond shaped joined-wing airplane model used in the tests had a wing width of 1.3m and a total fuselage length of 1.6m. The upper fins used in the tests were those having different wing shapes and those having identical wing shapes with different aspect ratios. Their fitting positions were varied along the chord direction. The low-speed wind tunnel tests were carried out with the airplane model fitted on three balance stanchions in the wind tunnel, at a test wind velocity of 30 m/s. Derived for discussions were aerodynamic effect when the fins on the rudders on the wing and the vertical tail were operated independently, and aerodynamic characteristics for direct side-force control when the upper fin fitting position was varied, and the side-force coefficients. It was found that upper fins installed at the front wing leading edge or over-hanging upper fins are effective in controlling the direct side force, and a large aspect ratio is advantageous in gaining the side force. DOE

N93-31320# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Abt. Flugmechanik der Drehfluegelflugzeuge.
THE INFLUENCE OF VARIABLE FLOW VELOCITY ON UNSTEADY AIRFOIL BEHAVIOR M.S. Thesis - Maryland Univ., College Park
BEREND VANDERWALL Feb. 1992 148 p
(ISSN 0939-2963)
(DLR-FB-92-22; UM-AERO-91-46; ETN-93-93739) Avail: CASI HC A07/MF A02; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany, HC

Unsteady aerodynamics of oscillating airfoils in constant freestream velocity are widely used for prediction of rotor dynamics. The additional degrees of freedom, namely the fore-aft motion and the unsteady freestream variation are neglected in virtually all analyses. Since the effect of unsteady freestream results in a stretching and compressing of the shed wake vorticity distribution behind an airfoil, it will have an effect on the airfoil characteristics. A review of the analytic and experimental work done in the area of unsteady freestream and to clarify the limits of the various theories is presented. As far as possible, the theories are compared with experimental data; however, most of the available data are confined to stalled flow conditions and are not useful. In addition to the theories, a semi-empirical mathematical model is used for purposes of comparison based on the aerodynamics of indicial functions. A generalization and closed form solution of the unsteady aerodynamic theory for incompressible two dimensional flow including fore-aft blade motion is derived and presented. With this it can be shown that the available theories are either not at all or only in parts able to correctly predict these effects. ESA

N93-31538# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
PARAMETRIC STUDIES OF SHOCK WAVE/BOUNDARY LAYER INTERACTIONS OVER 2D COMPRESSION CORNERS AT MACH 6
J. P. VERMEULEN and G. SIMEONIDES Sep. 1992 141 p
(VKI-TN-181; ETN-93-94223) Avail: CASI HC A07/MF A02

Results fron a series of experiments performed in the VKI H-3 hypersonic wind tunnel at Mach 6 with flat plate and flat plate/two dimensional (2D) compression ramp configurations simulating deflected control surfaces (rudders, elevons, flaps) of hypersonic vehicles are presented. The study falls within the framework of a more general investigation on shock wave/boundary layer interactions. The main experimental measurement technique was infrared thermography. The technique and data reduction models were improved in order to achieve state of the art accuracy levels. The model configurations considered have involved sharp and moderately blunt leading edges, as well as additional (periodic) leading edge disturbances. The thermal effect and the behavior of streamwise striations, detected in reattaching flow regions and interpreted as the footprint of Goertler vortices developing due to the concave flow curvature in such regions are discussed. Extensive comparisons of heat transfer data in regions of shock wave/boundary layer interaction, from the present work and other investigators, with simple theoretical predictions are presented. These led to the development of a new peak heating correlation, based on the reference temperature method, which was found to apply to two and three dimensional fully laminar, transitional and fully turbulent interactions, and to provide accurate engineering estimates of peak heating even in the presence of severe heat transfer non-uniformities (striations). ESA

N93-31648*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STREAMWISE VORTICITY GENERATION AND MIXING ENHANCEMENT IN FREE JETS BY DELTA-TABS
K. B. M. Q. ZAMAN Jun. 1993 15 p Presented at the AIAA Shear Flow Conference, Orlando, FL, 6-9 Jul. 1993; sponsored by AIAA
(Contract RTOP 505-62-52)
(NASA-TM-106235; E-7955; NAS 1.15:106235; AIAA PAPER 93-3253) Avail: CASI HC A03/MF A01

The effect of triangular tabs, placed at the nozzle exit, on the evolution of free jets is investigated. The effect, a large distortion of the jet cross section and a resultant increase in mixing downstream, has been inferred before to be due to a pair of streamwise vortices originating from each tab. In this paper, the generation mechanism of the stream wise vorticity (omega sub x) is considered first. Two sources are postulated. One is the upstream 'pressure hill', produced by the tab, which appears to be the dominant source. Another is due to vortex filaments shed from the sides of the tab and reoriented downstream by the mean shear of the mixing layer. In the case of a 'delta-tab', a triangular tab with its apex leaning downstream, vorticity from the two sources explain the stronger effect in that configuration. Data on the vorticity evolution for the effect of two delta-tabs are presented, up to twelve jet diameters from the exit, which show that the streamwise vortices persist even at the farthest measurement station. The magnitude of omega sub x-maximum decays continually with distance from the nozzle, its ratio to azimuthal vorticity maximum is found to be about 1/5 everywhere. The relative effect of a delta-tab on jets from an axisymmetric nozzle and a 8:1 rectangular nozzle is also studied. The mixing layer distortion is found to be less pronounced in the rectangular case. The jet mixing, as manifested by the mass flux measured at a downstream station, is increased in the axisymmetric jet but it is decreased in the rectangular jet under consideration by the delta-tab.
Author (revised)

N93-31672*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ENHANCED MIXING OF A RECTANGULAR SUPERSONIC JET BY NATURAL AND INDUCED SCREECH
EDWARD J. RICE and GANESH RAMAN (Sverdrup Technology, Inc., Brook Park, OH.) Jul. 1993 14 p Presented at the AIAA Shear Flow Conference, Orlando, FL, 6-9 Jul. 1993; sponsored by AIAA
(Contract RTOP 505-62-52)
(NASA-TM-106245; E-7964; NAS 1.15:106245; AIAA PAPER 93-3263) Avail: CASI HC A03/MF A01

The influence of shear layer excitation on the mixing of supersonic rectangular jets was studied experimentally. Two methods of excitation were used to control the jet mixing. The first used the natural screech of an underexpanded supersonic jet from a converging nozzle. The level of the screech excitation was controlled by the use of a pair of baffles located to block the acoustic feedback path between the downstream shock structure and the nozzle lip. A screech level variation of over 30 decibels was achieved and the mixing was completely determined by the level of screech attained at the nozzle lip. The second form of self-excitation used the induced screech caused by obstacles or paddles located in the shear layers on either long side of the rectangular jet. With sufficient immersion of the paddles intense jet mixing occurred and large flapping wave motion was observed using a strobed focused Schlieren system. Each paddle was instrumented with a total pressure tap and strain gages to determine the pressure and drag force on the square cross-section paddle. Considerable drag was observed in this initial exploratory study. Future studies using alternate paddle geometries will be conducted to maximize jet mixing with minimum drag. Author

N93-31732*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
REYNOLDS NUMBER INFLUENCES IN AERONAUTICS
DENNIS M. BUSHNELL, LONG P. YIP, CHUNG-SHENG YAO, JOHN C. LIN, PIERCE L. LAWING, JOHN T. BATINA, JAY C. HARDIN, THOMAS J. HORVATH, JAMES W. FENBERT, and CHRISTOPHER S. DOMACK May 1993 172 p
(Contract RTOP 505-60-01-02)
(NASA-TM-107730; NAS 1.15:107730) Avail: CASI HC A08/MF A02

Reynolds number, a measure of the ratio of inertia to viscous forces, is a fundamental similarity parameter for fluid flows and therefore, would be expected to have a major influence in aerodynamics and aeronautics. Reynolds number influences are generally large, but monatomic, for attached laminar (continuum) flow; however, laminar flows are easily separated, inducing even stronger, non-monatomic, Reynolds number sensitivities. Probably the strongest Reynolds number influences occur in connection with transitional flow behavior. Transition can take place over a tremendous Reynolds number range, from the order of 20 x 10(exp 3) for 2-D free shear layers up to the order of 100 x 10(exp 6) for hypersonic boundary layers. This variability in transition behavior is especially important for complex configurations where various vehicle and flow field elements can undergo transition at various Reynolds numbers, causing often surprising changes in aerodynamics characteristics over wide ranges in Reynolds number. This is further compounded by the vast parameterization associated with transition, in that any parameter which influences mean viscous flow development (e.g., pressure gradient, flow curvature, wall temperature, Mach number, sweep, roughness, flow chemistry, shock interactions, etc.), and incident disturbance fields (acoustics, vorticity, particulates, temperature spottiness, even electro static discharges) can alter transition locations to first order. The usual method of dealing with the transition problem is to trip the flow in the generally lower Reynolds number wind tunnel to simulate the flight turbulent behavior. However, this is not wholly satisfactory as it results in incorrectly scaled viscous region thicknesses and cannot be utilized at all for applications such as turbine blades and helicopter rotors, nacelles, leading edge and nose regions, and High Altitude Long Endurance and hypersonic airbreathers where the transitional flow is an innately critical portion of the problem. Author (revised)

N93-31733*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC AERODYNAMIC CHARACTERISTICS OF AN ADVANCED F-16 DERIVATIVE AIRCRAFT CONFIGURATION
MIKE C. FOX (Vigyan Research Associates, Inc., Hampton, VA.) and DANA K. FORREST Washington Jul. 1993 122 p Microfiche as supplement
(Contract NAS1-18585; RTOP 505-59-30-01)
(NASA-TP-3355; L-17143; NAS 1.60:3355) Avail: CASI HC A06/MF A02

A supersonic wind tunnel investigation was conducted in the NASA Langley Unitary Plan Wind Tunnel on an advanced derivative configuration of the United States Air Force F-16 fighter. Longitudinal and lateral directional force and moment data were obtained at Mach numbers of 1.60 to 2.16 to evaluate basic performance parameters and control effectiveness. The aerodynamic characteristics for the F-16 derivative model were compared with the data obtained for the F-16C model and also with a previously tested generic wing model that features an identical plan form shape and similar twist distribution.
Author (revised)

N93-31839*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TURBULENCE MEASUREMENT IN A REACTING AND NON-REACTING SHEAR LAYER AT A HIGH SUBSONIC MACH NUMBER
C. T. CHANG, C. J. MAREK, C. WEY (Sverdrup Technology, Inc., Brook Park, OH.), R. A. JONES (Rensselaer Polytechnic Inst., Troy, NY.), and M. J. SMITH (Purdue Univ., West Lafayette, IN.) Jun. 1993 8 p Prepared for presentation at the Ninth Symposium on Turbulent Shear Flows, Kyoto, Japan, 16-18 Aug. 1993
(Contract RTOP 505-62-52)
(NASA-TM-106186; E-7891; NAS 1.15:106186) Avail: CASI HC A02/MF A01

The results of two component velocity and turbulence measurements are presented which were obtained on a planar reacting shear layer burning hydrogen. Quantitative LDV and temperature measurements are presented with and without chemical reaction within the shear layer at a velocity ratio of 0.34 and a high speed Mach number of 0.7. The comparison showed that the reacting shear layer grew faster than that without reaction. Using a reduced width coordinate, the reacting and non-reacting profiles were very similar. The peak turbulence for both cases was 20 percent. Author

N93-31855*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
EFFECTS OF AN AFT FACING STEP ON THE SURFACE OF A LAMINAR FLOW GLIDER WING Final Report, 1 Jan. 1991 - 30 Jun. 1993
DORAL R. SANDLIN and NEAL SAIKI Jun. 1993 141 p
(Contract NCC2-701)
(NASA-CR-193302; NAS 1.26:193302) Avail: CASI HC A07/MF A02

A motor glider was used to perform a flight test study on the effects of aft facing steps in a laminar boundary layer. This study focuses on two dimensional aft facing steps oriented spanwise to the flow. The size and location of the aft facing steps were varied in order to determine the critical size that will force premature transition. Transition over a step was found to be primarily a function of Reynolds number based on step height. Both of the step height Reynolds numbers for premature and full transition were determined. A hot film anemometry system was used to detect transition. Author

N93-32004# Universal Energy Systems, Inc., Dayton, OH.
CALCULATIONS ON UNSTEADY TYPE 4 INTERACTION AT MACH 8 Final Report, Dec. 1981 - Aug. 1992
DATTA GAITONDE Jan. 1993 40 p
(Contract F33615-90-C-2089)
(AD-A265214; WL-TR-93-3002) Avail: CASI HC A03/MF A01

The viscous unsteady flow due to a type 4 shock-on-shock interaction at Mach 8 is examined with an implicit flux-split scheme. A sequence of grids is utilized to perform a grid resolution study and the results are compared with experimental values. The formulation is finite-volume with higher order accuracy obtained with the MUSCL approach in conjunction with a limiter to prevent oscillations. Viscous terms are centrally differenced. The flow exhibits a limit cycle in aggregate quantities which can be related to the details for the flow structure. The supersonic jet bounded by the two shear layers displays large scale movement at a dominant frequency of 32 kHz. This is accompanied by variation in the angle between the terminating jet bow shock and the surface tangent. Unsteady separation regions are observed both above and below the point of jet impingement. DTIC

N93-32226*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SELECTED EXPERIMENTS IN LAMINAR FLOW: AN ANNOTATED BIBLIOGRAPHY
AARON DRAKE and ROBERT A. KENNELLY, JR. Dec. 1992 30 p
(Contract RTOP 505-59-10)
(NASA-TM-103989; A-93012; NAS 1.15:103989) Avail: CASI HC A03/MF A01

Since the 1930s, there have been attempts to reduce drag on airplanes by delaying laminar to turbulent boundary layer transition. Experiments conducted during the 1940's, while successful in delaying transition, were discouraging because of the careful surface preparation necessary to meet roughness and waviness requirements. The resulting lull in research lasted nearly 30 years. By the late 1970s, airframe construction techniques had advanced sufficiently that the high surface quality required for natural laminar flow (NLF) and laminar flow control (LFC) appeared possible on production aircraft. As a result, NLF and LFC research became widespread. This report is an overview of that research. The experiments summarized herein were selected for their applicability to small transonic aircraft. Both flight and wind tunnel tests are included. The description of each experiment is followed by corresponding references. Part One summarizes NLF experiments; Part Two deals with LFC and hybrid laminar flow control (HLFC) experiments. Author

N93-32357# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
PANEL METHODS FOR AERODYNAMIC ANALYSIS AND DESIGN
H. W. M. HOEIJMAKERS 15 Oct. 1991 54 p Presented at AGARD-FDP/VKI Special Course on Engineering Methods in Aerodynamic Analysis and Design of Aircraft, Ankara, Turkey, 6-10 May 1991; Brussels, Belgium, 13-17 May 1991; and Madrid, Spain, 20-24 May 1991 Sponsored in part by Netherlands Agency for Aerospace Programs, Delft, and Royal Netherlands Air Force
(NLR-TP-91404-U; ETN-93-94074; AD-B168792L) Avail: CASI HC A04/MF A01

Several aspects of panel methods in the aerodynamic analysis and design of aircraft or aircraft components are discussed. Panel methods can provide the flow about complex configurations and are used in the analysis of the aerodynmics of aircraft shapes. Panel methods are based on a mathematical model in which much of the fluid physics is ignored. The capabilities and limitations of panel methods, the basic concepts of panel methods, choices that can be made in the implementation of the basic concepts, as well as possible types of boundary conditions that can be applied to model subsonic and supersonic flow are discussed. Some aspects of the accuracy of the approximations involved, consistent formulations, aspects of low order and higher order panel methods are investigated. Computational aspects of panel methods and possible extensions to nonlinear compressible flows, coupling with viscous flow methods and application to other flow problems are discussed. ESA

N93-32358# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
NLR INVISCID TRANSONIC UNSTEADY LOADS PREDICTION METHODS IN AEROELASTICITY
M. H. L. HOUNJET 15 Dec. 1991 22 p Presented at the AGARD Specialists Meeting on Transonic Unsteady Aerodynamics and Aeroelasticity, San Diego, CA, 9-11 Oct. 1991 Sponsored in part by Royal Netherlands Air Force
(Contract NIVR-01904N)
(NLR-TP-91410-U; ETN-93-94075; AD-B169113L) Avail: CASI HC A03/MF A01

Unsteady inviscid calculation methods developed at the National Aerospace Laboratory (NLR), which are based on the full potential equation for the prediction of airloads in oscillating structures in transonic flow, are presented. Attention is given to experience with entropy/vorticity corrections and to a procedure which removes the frequency barrier associated with time linearized modelings. This procedure has a favorable effect in computer cost such that transonic flutter boundaries can be obtained in accceptable turn around times on current work stations. A method for the transonic aeroelastic analysis of complete aircraft is introduced. Attention is given to its grid generation procedure. The methods are demonstrated by showing results of unsteady loads and pressure coefficients applications in two and three dimensional transonic flow and of an aeroelastic application to a three dimensional AGARD standard aeroelastic case in transonic flow. ESA

03

AIR TRANSPORTATION AND SAFETY

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

A93-45164
BRITISH AIRWAYS ETOPS FLIGHT PLANNING SYSTEM
P. E. MOORE (British Airways, PLC, London, United Kingdom) Journal of Navigation (ISSN 0373-4633) vol. 46, no. 2 May 1993 p. 192-199.
Copyright

An Extended Range Twin Operations (ETOPs) flight planning system is described. Flight crews have to perform several checks at the flight planning stage for an ETOPs flight including the distance, calculated using the still-air single engine speed for the certified time, from the nearest suitable airfield; the ETOPs planning minima attained for each of the suitable fields used; the weather at each of the suitable fields for a period from one hour before to one hour after the expected time of arrival of the aircraft; and the sufficiency of fuel, using the most critical fuel scenario. AIAA

A93-45668
AIRCRAFT MONITORING OF THE PLANENESS OF THE EXISTING AND NEW RUNWAYS [SAMOLETNO-NIVELIRNYJ KONTROL' ROVNOSTI POKRYTIJ EHKSPLUATIRUEMYKH I NOVYKH VZLETNO-POSADOCHNYKH POLOS AEHRODROMOV]
L. G. BRAILKO *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 47-55. In RUSSIAN refs
Copyright

The use of specially instrumented aircraft for monitoring the planeness of runway pavements on a continuous basis is discussed with reference to the results of theoretical and experimental studies conducted over the period 1963-1989. The required instrumentation and test procedures are discussed, and the advantages of the aircraft monitoring of the condition of runway pavements over other methods are demonstrated. AIAA

A93-45675
CALCULATION OF SAFE ALTITUDES [OSOBENNOSTI RASCHETA BEZOPASNYKH VYSOT]
V. YU. PETROV *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 90-94. In RUSSIAN
Copyright

A method for calculating safe altitudes, which is incorporated into a computer-aided flight preparation system, is described. The standard procedures for calculating safe altitudes for civil aircraft are shown to be particular cases of the method presented here. An example of safe altitude calculations for a specific airport is presented. AIAA

A93-45783
THE ALOHA AIRLINES ACCIDENT - A NEW ERA FOR AGING AIRCRAFT
WILLIAM R. HENDRICKS (FAA, Washington) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 153-165.
Copyright

Aloha Airlines Flight 243's B 737-200 airliner, with 95 persons on board, lost much of its upper fuselage while approaching cruise altitude on a scheduled flight on April 28, 1988. The crew were nevertheless able to land safely without loss of life. It was determined by the ensuing investigation that the aircraft had accumulated 35,493 flight hours, associated with a total of 89,090 cabin-pressurization cycles. An overview is presently given of the investigation's other determinations, and the aircraft fatigue-related guidelines that have been based on this experience. AIAA

A93-47023* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ADVANCED CARGO AIRCRAFT MAY OFFER A POTENTIAL RENAISSANCE IN FREIGHT TRANSPORTATION
SHELBY J. MORRIS and WALLACE C. SAWYER (NASA, Langley Research Center, Hampton, VA) Mar. 1993 24 p. International Symposium on the Future of Cargo Transport Aircraft, Strasbourg, France, Mar. 25-27, 1993, Paper refs

The increasing demand for air freight transportation has prompted studies of large, aerodynamically efficient cargo-optimized aircraft capable of carrying intermodal containers, which are typically 8 x 8 x 20 ft. Studies have accordingly been conducted within NASA to ascertain the specifications and projected operating costs of such a vehicle, as well as to identify critical, development-pacing technologies. Attention is here given not only to the rather conventional, 10-turbofan engined configuration thus arrived at, but numerous innovative configurations featuring such concepts as spanloading, removable cargo pods, and ground effect. AIAA

N93-31652# Transportation Research Center of Ohio, East Liberty.
LONGITUDINAL ACCELERATION TEST OF OVERHEAD LUGGAGE BINS IN A TRANSPORT AIRFRAME SECTION Report, Jun. 1990 - Jan. 1991
DARRELL AULT Nov. 1992 311 p
(Contract DTFA03-88-C-00066)
(DOT/FAA/CT-92/9) Avail: CASI HC A14/MF A03

A 10-foot transport airframe section was longitudinally tested at the Transportation Research Center (TRC) Inc. The purpose of the test was to measure the structural responses of and the interaction between the overhead storage bins and fuselage under simulated, potentially survivable, impact conditions. Three tests were conducted using the TRC 24-inch Hyge Shock Tester. The first test attained a peak acceleration of 5.9 g and a velocity change of 30.7 ft/sec. The second test reached 8.8 g and 37.5 ft/sec. The third test resulted in 13.2 g and 42.3 ft/sec. The input acceleration pulses were triangular in shape. The airframe test section was configured with two triple passenger seats in two rows on the left side, four anthropomorphic test dummies (ATD), a 60-inch overhead storage bin (Bin A) on the right side, and a 20- by 20-inch set of overhead storage bins (Bin B) on the left side. Author (revised)

N93-31730 Civil Aviation Authority, London (England).
REPORTABLE ACCIDENTS TO UK REGISTERED AIRCRAFT, AND TO FOREIGN REGISTERED AIRCRAFT IN UK AIRSPACE, 1990
Mar. 1992 149 p
(CAP-600; ISBN-0-86-039500-6; ETN-93-93932) Copyright
Avail: Issuing Activity (Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, England, HC)

A survey providing details of accidents involving UK (United Kingdom) and foreign registered aircraft which occurred during the calendar year 1990 and which were reportable in accordance with the Provisions of the Civil Aviation (Investigation of Accidents) Regulations, 1983, is presented. Descriptive data for each accident and analyses of these accidents are given. Data for accidents to power driven lighter than air aircraft and data for accidents to foreign registered aircraft in UK airspace are provided. The causal factors allocated are listed. Operating statistical and accident rates are given. ESA

N93-32195 National Transportation Safety Board, Washington, DC.
AIRCRAFT ACCIDENT REPORT: TAKEOFF STALL IN ICING CONDITIONS. USAIR FLIGHT 405, FOKKER F-28, N485US, LAGUARDIA AIRPORT, FLUSHING, NEW YORK, 22 MARCH 1992
17 Feb. 1993 130 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(PB93-910402; NTSB/AAR-93/02) Avail: CASI HC A07

The report explains the crash of USAir flight 405, a Fokker 28-4000, after an attempted takeoff from runway 13 at LaGuardia Airport, Flushing, New York, on March 22, 1992. The safety issues in the report focus on the weather. USAir's deicing procedures, industry airframe deicing practices, air traffic control aspects of the flight, USAir's takeoff and preflight procedures, and flightcrew qualifications and training. The airplane's impact with the ground, postaccident survivability, and crash/fire/rescue activities are also discussed. Safety recommendations concerning these issues are addressed to the Federal Aviation Administration, the Port Authority of New York and New Jersey, the Department of Transportation, and the New York City Health and Hospitals Corporation. Author

N93-32196 National Transportation Safety Board, Washington, DC.
AIRCRAFT ACCIDENT REPORT: CONTROLLED COLLISION WITH TERRAIN GP EXPRESS AIRLINES, INC., FLIGHT 861, A BEECHCRAFT C99, N118GP, ANNISTON, ALABAMA, 8 JUNE 1992
2 Mar. 1993 79 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(PB93-910403; NTSB/AAR-93/03) Avail: Issuing Activity (National Technical Information Service (NTIS))
The report explains the controlled collision into terrain of GP Express flight 861, a Beechcraft C99, N118GP, in Anniston, Alabama, on June 8, 1992. The safety issues discussed in the report are, for aircraft operating under 14 CFR Part 135, the importance of adequate preparation and experience of newly hired captains, available approach charts for each pilot, and adherence to specific stabilized approach criteria. The importance of adequate cockpit resource management is also discussed. Recommendations concerning these issues were made to the Federal Aviation Administration. Author

N93-32409 Civil Aviation Authority, London (England).
UK AIRMISSES INVOLVING COMMERCIAL AIR TRANSPORT, SEPTEMBER - DECEMBER 1991
Jul. 1992 33 p
(ISSN 0951-6301)
(ETN-93-93930) Copyright Avail: Issuing Activity (Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, England)
Statistics and reports concerning commercial air transport airmisses in the United Kingdom (UK) are presented. Copies of the airmiss reports include summaries of the information reported and of the working group's discussions, and an assessment of risk and cause. ESA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A93-44143
A LOCALIZER DESIGN TO IMPROVE MISSED APPROACH GUIDANCE
RICHARD H. MCFARLAND (Ohio Univ., Athens) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251) vol. 29, no. 2 April 1993 p. 302-309. Research supported by Analytical Sciences Corp., DOT, and FAA refs
Copyright
Attention is given to a novel VHF localizer system that has been designed, built, and successfully tested to provide increased reliability and safety of commercial and general aviation air transportation. The system also offers more precise tracks for aircraft executing a missed approach, reduced volume of the airspace needed for missed approaches, and reduced sizes of areas affected by noise. The design employs contemporary ILS hardware to provide dual independent front and back course directional localizer operation with two carriers in the receiver passband offset 4 KHz from the nominal carrier frequency. An example of an application and solution to an ILS problem at Reno, Nevada, is presented. AIAA

A93-44505
AIRPORT RADAR SYSTEMS (2ND REVISED AND ENLARGED EDITION) [RADIOLOKATSIONNYE SISTEMY AEHROPORTOV /2ND REVISED AND ENLARGED EDITION/]
LEV T. PEREVEZENTSEV and VITALIJ N. OGARKOV Moscow Izdatel'stvo Transport 1991 360 p. In RUSSIAN refs
(ISBN 5-277-00610-9) Copyright
The fundamental principles of the design of civil aviation ground radar systems and methods of implementing these principles are reviewed. In particular, attention is given to the functions and classification of radars; processing, transmission, and display of radar data; the main characteristics of radars; and functional schemes of radars and radar complexes. The discussion also covers systems for the suppression of the sidelobe signals of antenna radiation patterns; radar transmitters; antenna and feeder devices; radar receivers; moving target selection systems; and equipment for the processing of primary and secondary radar data. AIAA

A93-45165
THE USE OF DIGITAL MAP DATA TO PROVIDE ENHANCED NAVIGATION AND DISPLAYS FOR POOR WEATHER PENETRATION AND RECOVERY
PETER J. BENNETT (GEC-Marconi Avionics, Ltd., Edinburgh, United Kingdom) Journal of Navigation (ISSN 0373-4633) vol. 46, no. 2 May 1993 p. 208-222.
Copyright
The philosophy and architecture of a digital terrain system called Penetrate (passive enhanced navigation with terrain referenced avionics) are addressed. The Penetrate system is based on a digital data-store with a 3D model of the terrain including cultural details, obstructions, and tactical intelligence information. It incorporates terrain-referenced navigation to provide accurate position information relative to the ground contours. Navigation information displayed in a sophisticated digital map that includes intelligence and intervisibility overlays. The Penetrate system enhances the pilot's forward view and makes it posssible to continue at low level with degraded visual or sensor displays. It is concluded that the Penetrate system greatly enhances the safety of military low-level flight in both peace and war by displaying the terrain profile well beyond visual range and by cueing the approach of vertical obstructions. AIAA

A93-45166
EUROPEAN STUDIES TO INVESTIGATE THE FEASIBILITY OF USING 1000 FT VERTICAL SEPARATION MINIMA ABOVE FL(290). III - FURTHER RESULTS AND OVERALL CONCLUSIONS
G. MOEK, J. M. TEN HAVE (National Aerospace Lab., Amsterdam, Netherlands), D. HARRISON (Civil Aviation Authority, London, United Kingdom), and M. E. COX (EUROCONTROL, Brussels, Belgium) Journal of Navigation (ISSN 0373-4633) vol. 46, no. 2 May 1993 p. 245-261. refs
Copyright
European studies of vertical separation above FL(290) are reported. It is concluded that a reduction of the VSM above FL(290) would provide more usable flight levels above FL(290), thus making better use of the available space and would enable more aircraft to operate closer to their optimum flight levels, thus providing reduction of fuel consumption. The development of a Minimum Altimetry System Performance Specification necessary for a reduced vertical separation minimum above FL(290) makes the global application of a 1000 ft VSM feasible in the current ATS infrastructure. A major contribution to the implementation and use of 1000 ft VSM in the North Atlantic region is provided by Eurocontrol work on the development of height-monitoring units. AIAA

A93-45650
ADAPTIVE FILTERING OF DOPPLER VELOCIMETER ERRORS DUE TO THE CHARACTERISTICS OF THE REFLECTING SURFACE [ADAPTIVNAYA FIL'TRATSIYA OSHIBOK DIS, OBUSLOVLENNYKH KHARAKTEROM OTRAZHAYUSHCHEJ POVERKHNOSTI]
S. YA. ZHUK and S. K. GORBACHEVSKIJ (Kievskoe Vysshee Voennoe Aviatsionnoe Inzhenernoe Uchilishche, Kiev, Ukraine) Radioehlektronika (ISSN 0021-3470) vol. 36, no. 4 April 1993 p. 57-64. In RUSSIAN refs
Copyright
The formalism of mixed Markov processes in discrete time is

used to synthesize optimal and quasi-optimal algorithms of the adaptive filtering of Doppler velocimeter errors associated with the characteristics of the reflecting surface. The quasi-optimal algorithm is analyzed, and its performance is compared with that of a known algorithm using a computer simulation. AIAA

A93-46889
AN OPTIMAL DETECTION ALGORITHM FOR HARMONIC INTERFERENCE SIGNALS IN LORAN-C
ANDRE K. NIEUWLAND (Delft Univ. of Technology, Netherlands) Navigation (ISSN 0028-1522) vol. 40, no. 1 Spring 1993 p. 35-47. refs
Copyright

In Western Europe, the radionavigation system Loran-C experiences serious interference problems from harmonic (HM) signals passed by the input bandpass filter. Since the influence of an HM signal on the performance of a Loran-C system depends strongly on the signal's frequency, the frequency spectrum must be analyzed with high resolution for an optimal interference suppression strategy. Only the signals with a harmful influence on the operation of the Loran-C system must be suppressed. The approach taken in this paper is to apply a special windowing function in the time domain, together with a nonstandard sampling pattern in the frequency domain, when performing spectrum analysis. The spectral weighting created in this way corresponds with the receiver's sensitivity for interference signals. Therefore, the signal detected as the most powerful will be equal to the most harmful.

A93-46891
RECEIVER AUTONOMOUS INTEGRITY MONITORING (RAIM) OF GPS AND GLONASS
P. MISRA, E. BAYLISS, R. LAFREY, M. PRATT, and R. MUCHNIK (MIT, Lexington, MA) Navigation (ISSN 0028-1522) vol. 40, no. 1 Spring 1993 p. 87-104. refs
(Contract DTFA01-89-Z-02030)
Copyright

The RAIM algorithm presented analyzes the integrity monitoring performance of potential stand-alone systems based on GPS, GLONASS, GPS with geostationary overlay, and enhanced GPS constellations. Attention is given to the quality of the position estimate, rather than operational diagnoses. Redundant measurements are used to generate a position estimate and measure its quality, or 'integrity level', defined as an upper bound on the position error. The RAIM algorithm is used to compute a position estimate that can be shown to meet user accuracy requirements with high confidence, on the basis of a snapshot of pseudorange measurements containing one measurement that may be in error. AIAA

N93-31120# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
EXPERIENCES WITH TWO GPS RECEIVERS IN NORTHERN EUROPE
O. B. M. PIETERSEN 22 Apr. 1991 34 p
(NLR-TP-91168-U; ETN-93-94059) Avail: CASI HC A03/MF A01

The results of measurements with two handheld GPS (Global Positioning System) C/A-code SPS (Standard Positioning Service) receivers at thirty locations in Finland, Norway and Sweden, are presented. The computed positions obtained from receivers and positions in geographic maps are compared. The results showed that both receivers are not satisfactorily operated. A combination of the characteristics of the two would give a nearly ideal receiver. The measured accuracies are within the specifications given by the U.S. for SPS receivers. However to arrive at these results extra coordinate transformations, not available to an ordinary user, were necessary in the case of Finland and Sweden. ESA

N93-31269# Institut fuer Angewandte Geodaesie, Frankfurt am Main (Germany).
THE USE OF DIGITAL ROAD DATA BY A NAVIGATION SYSTEM [NUTZUNG DIGITALER STRASSENDATEN FUER KFZ-NAVIGATIONSSYSTEME]
JOACHIM SIEBOLD *In its* Reports on Cartography and Topography, Series 1, Report No. 103 p 113-120 1989 In GERMAN
Avail: CASI HC A02/MF A02

The principles of location and route search with vehicle navigation systems are summarized. The Bosch TRAVELPILOT, an autonomous navigation system for motorists is described. Use of digital road network data by means of navigation and direction finding systems is discussed. The EURECA and EC Projects intended to develop an exchange format for digital road data and to build up a European digital road data base are described. ESA

N93-31271# European Space Agency, Paris (France).
FLIGHT TEST OF AVIONIC AND AIR-TRAFFIC CONTROL SYSTEMS
HELMUT BOTHE (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick, Germany.) Jan. 1993 277 p Transl. into ENGLISH of Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 1-262 Presented at DLR Institute for Flight Guidance and Control Scientific Conference, Brunswick, Germany, 4-5 Jun. 1991 Original language document was announced as N92-25590
(ESA-TT-1279; DLR-MITT-91-11; ETN-93-93917) Avail: CASI HC A13/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany

Papers concerning the flight testing of avionics and air traffic control systems are presented. Either the tools and methods employed are discussed, or the systems in the process of development and their testing are discussed. ESA

N93-31281# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugfuehrung.
GROUND- AND SATELLITE-DERIVED FLIGHT-PATH MEASUREMENTS AS DEMONSTRATED IN THE AFES AVIONICS FLIGHT EVALUATION SYSTEM (AFES)
BERNHARD STIELER and KARLHEINZ HURRASS *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 184-218 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 177-206 Original language document was announced as N92-25600
Avail: CASI HC A03/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany

A description of the AFES is given, and its future expansion is considered. A microwave radar and an inertial system are currently the basic AFES sensors; in the airfield vicinity, up to a radius of approximately 10 km, they are supplemented by a laser tracker. All measurement signals are obtained in an online system on board the aircraft, using optimum estimation algorithms for highly accurate calculation of the reference path. The system has proven its merit in the testing of the following systems: inertial navigation and attitude reference systems, very high frequency omnidirectional range/Distance Measuring Equipment (DME); various integrated navigation systems; precision DME; geographic positioning system receiver; microwave landing system; three way DME (developed for flight guidance and control); and the 'image reconnaissance' experimental system. The following points are the subject of tests, particularly for navigation systems: coverage and accuracy, influence of faults, operation suitability, and system demonstrations. The means by which the reference path is determined is outlined. The accuracy of the AFES reference system is discussed. ESA

N93-31282# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugfuehrung.

ON-BOARD DERIVED FLIGHT-PATH MEASUREMENT AS DEMONSTRATED BY AN ILS MEASUREMENT SYSTEM

BERNHARD STIELER and KARLHEINZ HURRASS *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 219-248 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik von Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 207-232 Original language document was announced as N92-25601

Avail: CASI HC A03/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany

The structure, problems, and advantages of a fully airborne, as opposed to satellite-derived, flight path measurement system are described in the light of an Instrument Landing System (ILS). In the case of this airborne measurement technology, the inertial system is far more important than in the case of ground supported and satellite supported measurement technology, where it has been used predominantly for interpolation between external measurement data. Further conventional sensors for independent aircraft flight path measurement technology are the barometric and radar altimeters. Charge coupled device cameras provide the means of introducing new technologies into the field of airborne aircraft flight path measurement. At the present state of the art, a system with support by optical measurements will require correlation of the recorded image with stored image position information. This topic is the basis of quite a recent branch of research which is entitled 'image supported navigation'. Work is also in hand to define the principles for applying an Inertial Navigation System (INS) to flight path measurements totally independent of prestored information. These principles are discussed. A measurement system for testing radio navigation systems is defined, its system concept is described, results obtained using it to date are given, and scope for its improvement are described. Airborne and satellite based flight path measurement and independent aircraft measurement are compared with particular regard to image processing, that is, the processing of terrain features for INS support, in a critical juxtaposition. The arguments set out are equally applicable for navigation. ESA

N93-32225*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

FLIGHT EVALUATION OF A COMPUTER AIDED LOW-ALTITUDE HELICOPTER FLIGHT GUIDANCE SYSTEM

HARRY N. SWENSON, RAYMOND D. JONES (Army Avionics Lab., Fort Monmouth, NJ.), and RAYMOND CLARK (Army Avionics Lab., Fort Monmouth, NJ.) Jan. 1993 14 p Presented at the AGARD FMP/GCP Symposium on Combat Automation for Airborne Weapons Systems: Man/Machine Interface Trends and Technologies, Scotland, England, 19-22 Oct. 1992

(Contract RTOP 505-64-36)

(NASA-TM-103998; A-93033; NAS 1.15:103998) Avail: CASI HC A03/MF A01

The Flight Systems Development branch of the U.S. Army's Avionics Research and Development Activity (AVRADA) and NASA Ames Research Center developed for flight testing a Computer Aided Low-Altitude Helicopter Flight (CALAHF) guidance system. The system includes a trajectory-generation algorithm which uses dynamic programming and a helmet-mounted display (HMD) presentation of a pathway-in-the-sky, a phantom aircraft, and flight-path vector/predictor guidance symbology. The trajectory-generation algorithm uses knowledge of the global mission requirements, a digital terrain map, aircraft performance capabilities, and precision navigation information to determine a trajectory between mission waypoints that seeks valleys to minimize threat exposure. This system was developed and evaluated through extensive use of piloted simulation and has demonstrated a 'pilot centered' concept of automated and integrated navigation and terrain mission planning flight guidance. This system has shown a significant improvement in pilot situational awareness, and mission effectiveness as well as a decrease in training and proficiency time required for a near terrain, nighttime, adverse weather system. Author (revised)

N93-32336# Federal Aviation Administration, Atlantic City, NJ. Technical Center.

INVESTIGATION OF ADVANCED TECHNOLOGY FOR AIRWAY FACILITIES MAINTENANCE TRAINING Technical Note, Aug. 1991 - Jun. 1992

LORI ADKISSON, JULIE JONES (Galaxy Scientific Corp., Atlanta, GA.), and JOSEPH JACKSON (Galaxy Scientific Corp., Atlanta, GA.) Jun. 1993 32 p

(Contract DTFA03-90-C-00010)

(DOT/FAA/CT-TN92/24) Avail: CASI HC A03/MF A01

The phase one activities of a three-phase research plan are described. The first activity investigated the status of advanced technology in currently available Airway Facilities (AF) computer-based maintenance training. The second activity applied simulation, Expert System, and Intelligent Tutoring Technology in developing a prototype system for trouble shooting proficiency training. Author (revised)

N93-32337# National Aerospace Lab., Amsterdam (Netherlands). Aircraft Instrumentation Dept.

THE APPLICATION OF PHASE TRACKING GPS FOR FLIGHT TEST TRAJECTORY DETERMINATION

R. VANDELEIJGRAAF and STORM VANLEEUWEN 18 Oct. 1991 20 p Presented at the 1st International Symposium on Real Time Differential Applications of the Global Positioning System, Brunswick, Germany, 16-20 Sep. 1991

(NLR-TP-91349-U; ETN-93-94070; AD-B168788L) Avail: CASI HC A03/MF A01

Geodesists have been using the Navstar Global Positioning System (GPS) for a number of years for high accuracy position measurements. For the last two or three years, GPS receivers with carrier phase tracking capability have been used onboard aircraft for photommetry and gravitational research. The phase tracking technique appears to be suitable for a flight test positioning system. The behavior of GPS receivers in the dynamic environment of a test aircraft is discussed. The set up and execution of the tests are described. The test program that was carried out in the Summer of 1991 consisted of a limited dynamics test on the ground and a full dynamics test in flight. Since the analysis of the data is not finished, only preliminary results are presented. ESA

N93-32348*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

EXPANSION-BASED PASSIVE RANGING

YAIR BARNIV Jun. 1993 59 p

(Contract RTOP 505-64-36)

(NASA-TM-104025; A-93087; NAS 1.15:104025) Avail: CASI HC A04/MF A01

A new technique of passive ranging which is based on utilizing the image-plane expansion experienced by every object as its distance from the sensor decreases is described. This technique belongs in the feature/object-based family. The motion and shape of a small window, assumed to be fully contained inside the boundaries of some object, is approximated by an affine transformation. The parameters of the transformation matrix are derived by initially comparing successive images, and progressively increasing the image time separation so as to achieve much larger triangulation baseline than currently possible. Depth is directly derived from the expansion part of the transformation. To a first approximation, image-plane expansion is independent of image-plane location with respect to the focus of expansion (FOE) and of platform maneuvers. Thus, an expansion-based method has the potential of providing a reliable range in the difficult image area around the FOE. In areas far from the FOE the shift parameters of the affine transformation can provide more accurate depth information than the expansion alone, and can thus be used similarly to the way they were used in conjunction with the Inertial Navigation Unit (INU) and Kalman filtering. However, the performance of a shift-based algorithm, when the shifts are derived from the affine transformation, would be much improved compared to current algorithms because the shifts - as well as the other parameters - can be obtained between widely separated images. Thus, the main advantage of this new approach is that, allowing the tracked window to expand and rotate, in addition to moving laterally, enables one to correlate images over a very long time span which, in turn, translates into a large spatial baseline - resulting in a proportionately higher depth accuracy. Author (revised)

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A93-44850
AIRCRAFT BRAKING SYSTEMS
DANIEL J. HOLT Aerospace Engineering (ISSN 0736-2536) vol. 13, no. 6 June 1993 p. 7-11.
Copyright

Different aircraft brake designs are reviewed focusing on carbon-carbon brake heat sink materials. Carbon brake advantages over conventional steel brakes include weight savings of 33 percent, superior rejected take-off performance, longer brake life, carbon strength retention, and dimensional stability. Increased design considerations encompass temperature control, environmental factors (runway deicers), and corrosion control (wheel protective coatings). Thermal control design features of typical steel vs carbon brake installations are compared. AIAA

A93-44852
THE EVOLUTION OF A NOSE-WHEEL STEERING SYSTEM
CHARLES A. SMITH (Vickers, Inc., Sterer Div., Los Angeles, CA) Aerospace Engineering (ISSN 0736-2536) vol. 13, no. 6 June 1993 p. 23-25.
Copyright

The evolution of the T-45A and its nose-wheel steering system is reviewed with particular attention given to a digital steering-control box system. The digital nose-wheel steering system is capable of adapting to changing aircraft requirements due to easily modifiable software, which acts as a power and motion control multiplier. AIAA

A93-44888* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MESH GENERATION FOR THE COMPUTATION OF FLOWFIELDS OVER COMPLEX AERODYNAMIC SHAPES
TIMOTHY BAKER (Princeton Univ., NJ) Computers and Mathematics with Applications (ISSN 0097-4943) vol. 24, no. 5-6 1992 p. 103-127. refs
(Contract NAG2-734)
Copyright

Methods are presented for generating both structured and unstructured meshes about three dimensional shapes. Results for both approaches are shown and their strengths and weaknesses are compared. For relatively simple configurations, such as wing/body combinations, a structured mesh is the preferred approach. For a complete aircraft, however, structured meshes lack the necessary flexibility, but unstructured meshes do offer the opportunity to treat completely general configurations with relative ease. Author

A93-45124
THEORETICAL STUDIES OF THE ACTIVE CONTROL OF PROPELLER INDUCED CABIN NOISE USING SECONDARY FORCE INPUTS
D. R. THOMAS, P. A. NELSON, and S. J. ELLIOTT (Southampton Univ., United Kingdom) *In* Structural dynamics: Recent advances; Proceedings of the 4th International Conference, Univ. of Southampton, United Kingdom, July 15-18, 1991 London and New York Elsevier Applied Science 1991 p. 649-658. refs
Copyright

Simulations are presented which indicate that large global reductions in the acoustic energy within the thin cylinder mode of an aircraft fuselage can be obtained using very few secondary forces on the fuselage. These results are accounted for by the very specific coupling between the structural and acoustic modes of the structure. It is pointed out that, at the second harmonic, the benefits of using secondary force inputs are perhaps even more significant as they allow global reductions in sound pressure level to be obtained where the use of acoustic secondary sources had only allowed localized reduction in sound pressure level. AIAA

A93-45143
ZERO-THRUST GLIDE TESTING FOR DRAG AND PROPULSIVE EFFICIENCY OF PROPELLER AIRCRAFT
JACK NORRIS and ANDREW B. BAUER (Douglas Aircraft Co., Orange, CA) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 505-511. AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990, AIAA Paper 90-0233. Previously cited in issue 06, p. 763, Accession no. A90-19747 refs
Copyright

A93-45147* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STATIC AEROELASTIC CONTROL OF AN ADAPTIVE LIFTING SURFACE
S. M. EHLERS (McDonnell Douglas Technologies, Inc., San Diego, CA) and T. A. WEISSHAAR (Purdue Univ., West Lafayette, IN) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 534-540. AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 31st, Long Beach, CA, Apr. 2-4, 1990, Technical Papers. Pt. 3, p. 1611-1623. Previously cited in issue 11, p. 1613, Accession no. A90-29386 refs
(Contract NSG-1157)
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A93-45168* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
VORTEX FLAP FLIGHT TEST OPERATIONS, A SAFE APPROACH
DANIEL J. DICARLO and JAMES R. ELLIOTT (NASA, Langley Research Center, Hampton, VA) SAFE Journal vol. 23, no. 2 Mar.-Apr. 1993 p. 39-45. refs
Copyright

A flight test experiment was conducted at the Langley Research Center to evaluate a wing leading-edge vortex flap concept designed for use on an aircraft with highly swept wings. The flap concept was designed as a modification to the wing leading edge of an F-106B airplane. The flight testing required operations at conditions that would exceed the structural load envelope of the basic airplane in order to acquire desired research data for the modified configuration. Accordingly, the operational envelope of the modified aircraft was incrementally expanded and real-time monitoring of airframe strains at critical wing locations was mandated to insure safety of flight. The flight tests were conducted in two phases: Phase I to establish baseline data with the unmodified wing, and Phase II to determine the effects of the vortex flap on performance, handling qualities, and flow field characteristics. This paper focuses on a description of the approach and procedures used to provide the strain-gage monitoring to insure structural integrity. Highlights of the wing modification and the overall operation are also included. Within a -year period, 110 research flights were successfully completed, providing researchers with sufficient data to assess the potential benefits ascribed to the vortex flap concept without encountering severe structural problems or mishaps. Author

A93-45432* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATIONS TO FIXED-WING AIRCRAFT AND SPACECRAFT
HIROKAZU MIURA (NASA, Ames Research Center, Moffett Field, CA) and DOUGLAS J. NEILL (Northrop Corp., Aircraft Div., Hawthorne, CA) *In* Structural optimization: Status and promise Washington American Institute of Aeronautics and Astronautics, Inc. 1993 p. 705-742. refs
Copyright

Aerospace-industry applications of general-purpose structural optimization codes have not progressed as far as they might due to the lack of preprocessor capabilities. With the emergence of a new generation of graphic preprocessors that are capable of creating design models, these methods will gain acceptance. Attention is given to recent innovative applications of the Flutter and Strength Optimization Program and TSO, and the role of structural optimization in a multidisciplinary design system. Illustrative aircraft structure examples are used throughout the presentation. AIAA

A93-45660
CLASSIFICATION OF THE PRINCIPAL FUEL SAVING METHODS IN FLIGHT OPERATIONS [KLASSIFIKATSIYA OSNOVNYKH METODOV EHKONOMII AVIATOPLIVA V LETNOJ EHKSPLUATATSII]
S. YU. SKRIPNICHENKO *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 3-6. In RUSSIAN
Copyright

Fuel saving methods in flight operations are classified into the following five general groups: pilot training, preflight and postflight preparatory work, fuel saving flight techniques, air traffic control, and technical preparation of aircraft. Specific methods within each group are examined. AIAA

A93-45663
OPTIMIZATION OF THE BLADE ANGLE OF THE AV-2 PROPELLER FOR IMPROVING THE FLIGHT PERFORMANCE CHARACTERISTICS OF AN-2 AIRCRAFT [OPTIMIZATSIYA USTANOVOCHNOGO UGLA LOPASTI VOZDUSHNOGO VINTA AV-2 DLYA ULUCHSHENIYA LTKH SAMOLETOV AN-2]
G. E. MASLENNIKOVA *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 14-19. In RUSSIAN refs
Copyright

Results of a study of the AV-2 propeller blade angle on the flight performance and takeoff/landing characteristics of An-2 aircraft are presented. It is found that changes in the flight performance and takeoff/landing characteristics of each specific aircraft with the blade angle depend on the engine power, flight altitude, and ambient air temperature. Optimization of the set angles makes it possible to significantly improve the thrust characteristics of An-2 aircraft. AIAA

A93-45665
RESULTS OF OPERATIONAL TESTING OF A SYSTEM FOR COMPUTING OPTIMAL FLIGHT REGIMES [REZUL'TATY EHKSPLUATATSIONNOJ PROVERKI VYCHISLITELYA OPTIMAL'NYKH REZHIMOV]
S. YU. SKRIPNICHENKO and A. ŠIMEONOV *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 26-33. In RUSSIAN
Copyright

Results of the flight testing of a system for computing the optimal flight regimes of the Tu-154B aircraft are reported. The general architecture of the system, its main functions, and special features are discussed. It is shown that the use of the system makes it possible to achieve good fuel economy. Some improvements to the system are suggested. AIAA

A93-45669
USING SPECTRAL ANALYSIS FOR ESTIMATING THE EFFECT OF RUNWAY IRREGULARITIES ON THE LOADING OF TRANSPORT AIRCRAFT STRUCTURES [ISPOL'ZOVANIE SPEKTRAL'NOGO ANALIZA DLYA OTSENKI VLIYANIYA NEROVNOSTEJ AEHRODROMOV NA NAGRUZHENNOST' KONSTRUKTSIJ TRANSPORTNYKH SAMOLETOV]
A. V. VASIL'EV and K. Z. KARAEV *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 56-60. In RUSSIAN refs
Copyright

The loading of aircraft structures during takeoff and landing is examined with reference to flight test data obtained for transport aircraft. In particular, it is shown that the presence of shock absorbers, which are essentially nonlinear elements, complicates the problem of constructing a spectral loading model. In order to obtain reliable frequency characteristics of an aircraft as a whole, linearization of shock absorbers is required along with stable estimates of the effect of speed and aircraft parameters. AIAA

A93-45671
CALCULATION OF THE POSITION OF AIRCRAFT CENTER OF GRAVITY ON AN IBM PC [AVTOMATIZATSIYA RASCHETA TSENTROVKI SAMOLETA NA PERSONAL'NOJ EHVM TIPA IBM PC]
YU. N. MILOTOV, A. YU. RUDAKOV, and V. N. STADNIK *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 70-73. In RUSSIAN
Copyright

The software and the required input data for calculating the position of the aircraft center of gravity on an IBM PC as part of preflight preparation are described. The advantages of the computer-aided procedure over the traditional method of calculating the position of center of gravity using special graphs are discussed. AIAA

A93-45672
THE FUEL/TIMING PROBLEM IN A COMPUTER-AIDED FLIGHT PREPARATION SYSTEM FOR CIVIL AIRCRAFT [TOPLIVNO-VREMENNAYA ZADACHA V AVTOMATIZIROVANNOJ SISTEME PODGOTOVKI POLETA /ASPP/ VS GA]
A. YU. KAZANTSEV and V. YU. PETROV *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 73-78. In RUSSIAN
Copyright

A method for determining the fuel consumption and time in flight is described which is based on the use of an iterative procedure. The fuel/timing problem is solved in an interactive mode using an IBM PC/XT/AT computer. Good agreement is obtained between the calculated and actual fuel consumption and time in flight. AIAA

A93-45673
GENERAL CONCEPTS RELATED TO THE DETERMINATION OF THE INDIVIDUAL FLIGHT PERFORMANCE CHARACTERISTICS OF AIRCRAFT FOR ESTABLISHING FUEL CONSUMPTION STANDARDS AND OPTIMAL FLIGHT REGIMES [OBSHCHIE KONTSEPTSII OPREDELENIYA INDIVIDUAL'NYKH LTKH SAMOLETOV DLYA TSELEJ NORMIROVANIYA RASKHODA AVIATOPLIVA I OPREDELENIYA OPTIMAL'NYKH REZHIMOV POLETA]
A. YU. KAZANTSEV, YU. N. MILOTOV, V. N. STADNIK, and B. V. YAKOVENKO *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 78-81. In RUSSIAN refs
Copyright

The principles of determining the individual flight performance characteristics of civil aircraft operated as part of a fleet are examined. The flight performance characteristics are used for determining optimal flight regimes for a particular fleet of aircraft. The optimal regimes are then used as the initial information for calculating fuel consumption norms and flight time with allowance for the specific conditions of a given subdivision. Specific examples are presented. AIAA

A93-45674

COMPUTER-AIDED STUDY OF FLIGHT REGIMES AND FUEL CONSUMPTION FOR HELICOPTER FLIGHT OPERATIONS [AVTOMATIZIROVANNYE ISSLEDOVANIYA REZHIMOV POLETA I RASKHODOV TOPLIVA V LETNOJ EHKSPLUATATSII VERTOLETOV GA NA EHVM]

A. I. TARASOV and S. V. SHILOV *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 85-90. In RUSSIAN

Copyright

The conditions and methods of helicopter flight operations are evaluated based on the computerized processing of statistical data derived from flight documentation. Mathematical helicopter models are examined which are represented by expressions for total fuel consumption and flying time. A set of software implementing the method presented here is described. AIAA

A93-45741

NONLINEAR LARGE AMPLITUDE AEROELASTIC BEHAVIOR OF COMPOSITE ROTOR BLADES

TAEHYOUN KIM and JOHN DUGUNDJI (MIT, Cambridge, MA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 8 Aug. 1993 p. 1489-1497. AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 33rd, Dallas, TX, Apr. 13-15, 1992, Technical Papers. Pt. 3, p. 1350-1360. Previously cited in issue 13, p. 2096, Accession no. A92-34412 refs

Copyright

A93-45784

FUSELAGE LONGITUDINAL SPLICE DESIGN

AMOS W. HOGGARD (Douglas Aircraft Co., Long Beach, CA) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 167-181.

Copyright

A major commercial aircraft manufacturer's approach to the design problems posed by fuselage longitudinal skin splices is presented. Attention is given to the splice-design process, factors affecting fatigue life, design for ultimate tensile strength, damage tolerance, corrosion prevention, and fatigue resistance, the degree of splice inspectability, and applicable nondestructive tests. Detailed design features are noted for a five-element longitudinal splice, moisture-intrusion paths, and splice corrosion protection measures. AIAA

A93-46024

BACKFIRE UNVEILED

NEVILLE BECKETT Air International (ISSN 0306-5634) vol. 45, no. 1 July 1993 p. 23-30.

Copyright

A evaluation is presented of the design features and performance characteristics of the Tu22M3 variant of the NATO code-named 'Backfire-C' bomber. The maximum warload is 12,000 kg internally and 3000 kg on each of four multiple-weapon racks, but this entails the sacrifice of 24 percent of internal fuel load to ramain at the 124,000 kg maximum takeoff weight. The two engines powering the aircraft are NK-25 turbofans of 55,115 lb static thrust with afterburner. Maximum operational radius with maximum internal bomb load and 50 tonnes of fuel is 3336 km at high altitude. A cut-away drawing of the aircraft is included. AIAA

A93-46809* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

EFFECTS OF FLOOR LOCATION ON RESPONSE OF COMPOSITE FUSELAGE FRAMES

HUEY D. CARDEN, LISA E. JONES (NASA, Langley Research Center, Hampton, VA), and EDWIN L. FASANELLA (Lockheed Engineering & Sciences Co., Hampton, VA) Nov. 1991 19 p. DOD, NASA, and FAA, Conference on Fibrous Composites in Structural Design, 9th, Lake Tahoe, NV, Nov. 4-7, 1991, Paper refs

Copyright

Experimental and analytical results are presented which show the effect of floor placement on the structural response and strength of circular fuselage frames constructed of graphite-epoxy composite material. The research was conducted to study the behavior of conventionally designed advanced composite aircraft components. To achieve desired new designs which incorporate improved energy absorption capabilities requires an understanding of how these conventional designs behave under crash type loadings. Data are presented on the static behavior of the composite structure through photographs of the frame specimen, experimental strain distributions, and through analytical data from composite structural models. An understanding of this behavior can aid dynamist in predicting the crash behavior of these structures and may assist the designer achieve improved designs for energy absorption and crash behavior of future structures.

A93-46824* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THE ALL-ELECTRIC AIRCRAFT - IN YOUR FUTURE?

CARY R. SPITZER (NASA, Langley Research Center, Hampton, VA) Nov. 1984 5 p. Annual Symposium on Aerospace and Electronic Systems: Advanced Concepts and Pioneering Perspectus, 6th, Dayton, OH, Nov. 14, 15, 1984, Paper refs

Recent developments in all-electric aircraft technology are reviewed with particular attention given to models with a digital fly-by-wire quadraplex control systems and experimental mechanical actuators. It is shown that all-electric technologies can eliminate many traditional design constraints and open up enormous range of design possibilities. AIAA

A93-47079

A STUDY OF THE EFFECT OF THE SUPPORT FASTENING COMPLIANCE ON THE STRESS-STRAIN STATE OF AIRCRAFT TRANSPARENCIES [ISSLEDOVANIE VLIYANIYA PODATLIVOSTI OPORNOGO ZAKREPLENIYA NA NDS EHLEMENTOV OSTEKLENIJ LA]

V. A. FIRSOV and S. P. KUZNETSOV *In* Problems of the strength and fatigue of the elements of aircraft structures Kuibyshev, Russia Kujbyshevskij Aviatsionnyj Institut 1990 p. 19-23. In RUSSIAN refs

Copyright

Results of numerical parametric studies of the effect of the compliance of support fastening on the stress-strain state of aircraft transparency elements are reported. The accuracy of the results obtained is estimated. Ways of reducing dangerous stresses in the transparencies are recommended. AIAA

A93-47248*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

APPLICATION OF NATURAL LAMINAR FLOW TO A SUPERSONIC TRANSPORT CONCEPT

HENRI D. FUHRMANN (NASA, Langley Research Center, Hampton, VA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 536-548. refs

(AIAA PAPER 93-3467) Copyright

Results are presented of a preliminary investigation into an application of supersonic natural laminar flow (NLF) technology for a high speed civil transport (HSCT) configuration. This study focuses on natural laminar flow without regard to suction devices which are required for laminar flow control (LFC) or hybrid laminar flow control (HLFC). An HSCT design is presented with a 70 deg inboard leading-edge sweep and a 20 deg leading-edge outboard crank to obtain NLF over the outboard crank section. This configuration takes advantage of improved subsonic performance and NLF on the low-sweep portion of the wing while minimizing the wave drag and induced drag penalties associated with low-sweep supersonic cruise aircraft. In order to assess the benefits of increasing natural laminar flow wetted area, the outboard low-sweep wing area is parametrically increased. Using a range of supersonic natural laminar flow transition Reynolds numbers, these aircraft are then optimized and sized for minimum take-off gross weight (TOGW) subject to mission constraints. Results from this study indicate reductions in TOGW for the NLF concepts, due mainly to reductions in wing area and total wing weight. Furthermore, significant reductions in block fuel are calculated throughout the range of transition Reynolds numbers considered. Observations are made on the benefits of unsweeping the wingtips with all turbulent flow.

N93-31043# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Hubschrauber und Flugzeuge.
ADVANCED AIRCRAFT WITH THRUST VECTOR CONTROL [HOCHLEISTUNGSFLUGZEUGE MIT SCHUBVEKTORSTEUERUNG]
HANNES ROSS 6 Feb. 1992 110 p In GERMAN Presented at Techniche Univ. Munich, Germany, 6 Feb. 1992
(MBB-FE-1-S-PUB-0504; ETN-93-94192) Copyright Avail: CASI HC A06/MF A02

Overhead projections are presented. Thrust vectoring and deflection principles are examined with the examples of American and Russian military aircraft such as the F-14, X-31, and YAK-38. Curves on pitch and yaw deflection distribution are presented. Thrust vectoring systems were depicted in aircraft and ground tests. Vane temperature of vibration results were obtained. Curves of thrust moment versus aerodynamic moment were studied, and it is concluded that the thrust generated moment must be used at low Mach/dynamic pressure. Axisymmetric thrust vectoring potential utilization and trim requirements were examined. New aircraft concepts were proposed, with emphasis on elimination or reduction of tails. It is pointed out that thrust vectoring augmentation improves aircraft performances and weapon system modifications are necessary to exploit aircraft performance increases. ESA

N93-31046# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Hubschrauber und Flugzeuge.
DEVELOPMENT OF NOSE STRUCTURE OF A RECONNAISSANCE CONTAINER FOR A SUPERSONIC JET AIRCRAFT Thesis - Fachhochschule Munich [ENTWICKLUNG DER BUGSTRUKTUR EINES AUFKLAERUNGS-AUSSENLASTBEHAELTERS FUER EIN UEBERSCHALL-STRAHLFLUGZEUG]
MICHEAL RAUTER 31 Jul. 1992 263 p In GERMAN Original contains color illustrations
(MBB-LME-242-S-PUB-0451; ETN-93-94197) Copyright Avail: CASI HC A12/MF A03

A predesign study of the nose structure of a reconnaissance container is presented for implementation in a liquid film camera. The possible configurations of the nose structure were presented. The configurations were differentiated by camera system accessibility. The surveillance camera system and the optimization of camera window size were depicted. Static and dynamic loads were examined for strength determination by means of the finite element program NASTRAN, so that mainframe and sheathing can be predimensioned. Color tension graphics allow dimensioning load factors to be obtained. ESA

N93-31058# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Produktbereich Militaerflugzeuge.
AIRCRAFT STRUCTURES IN 2000: A TECHNOLOGICAL CHALLENGE? [FLUGZEUGSTRUKTUREN IM JAHR 2000: EINE TECHNOLOGISCHE HERAUSFORDERUNG?]
JOSEF WALTER VILSMEIER 7 Jul. 1992 12 p In GERMAN Presented at DGLR-Jahrestagung 1992, Bremen, Germany, 29 Sep. - 2 Oct. 1992
(MBB-LME-202-S-PUB-0485; ETN-93-94194) Copyright Avail: CASI HC A03/MF A01

Technology requirements for the next aircraft generation are reviewed. It is noticed that a foresighted planning of research programs is needed, such as short and cost optimized development times, by using concurrent or simultaneous engineering. Structure optimization must be achieved by taking into account weight reduction and boundary conditions. The importance of light metals, such as fiber reinforced aluminum alloys, and of fiber reinforced composites, is highlighted. It is shown that smart materials must be developed, and their effect on aircraft structures must be analyzed. Measurement and testing methods and facilities must be developed by considering design to cost requirements. ESA

N93-31197# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Abt. Zellenaerodynamik.
DEFINITION OF AN AIRFOIL FAMILY FOR THE EUROFAR ROTOR [ENTWICKLUNG EINER PROFILFAMILIE FUER DEN EUROFAR-ROTOR]
MATTHIAS SCHMIDT Dec. 1991 104 p In GERMAN
(ISSN 0939-2963)
(DLR-FB-92-04; ETN-93-93953) Avail: CASI HC A06/MF A02; DLR, Wissenschaftliches Berichtsewesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany, HC

The development of an airfoil family for the rotor of the European Tilt Rotor Project EUROFAR (European Future Advanced Rotorcraft) is reported. The design is based on requirements which included desired operation conditions and airfoil characteristics. Airfoils were designed for the inner radial stations of the rotor blade. Suitable existing airfoils are available for the outer stations. All the airfoils will be or were measured in a transonic wind tunnel. The root airfoils, having large relative thickness, were measured in low speed wind tunnels to examine high lift characteristics. In many cases the experimental results are in a good agreement with the calculated data, thus proving high quality of the calculation procedure and manufacturing technology for aerofoil models. The airfoil family presented meets nearly all requirements. ESA

N93-31275# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugfuehrung.
INSTIGATION AND PROCESSING OF FLIGHT TESTS IN DLR
HELMUT BOTHE *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 54-68 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 57-70 Original language document was announced as N92-25594
Avail: CASI HC A03/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany

The planning procedures taken when external users wish to use the DLR flight test installations, which mainly include test aircraft and helicopters together with their test equipment, are outlined. The calculation of the cost of use and the modifications necessary to the equipment are addressed. The most important of the airborne equipment items include the following: an airborne system for reference flight path, avionics sensor systems, measurement data acquisition and transmission systems, a system for flight measurement of aeronautical radio systems,and an experimental cockpit. The most important ground systems include the following: tracking radar, laser radar, recording theodolite system, telemetry receiver system with online data processing, gyro test system, air traffic simulatior, ground test vehicle, and RF irradiation system. ESA

N93-31277# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugfuehrung.
TESTING OF AN EXPERIMENTAL FMS
VOLKMAR ADAM *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 83-103 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 85-104 Original language document was announced as N92-25596
Avail: CASI HC A03/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany

The development of an experimental Flight Management System (FMS) with new functions is described, and the initial flight testing of this FMS in conjunction with air traffic simulations is illustrated. Functions of the FMS include the following: planning of flight trajectories, precise guidance of the aircraft, negotiation of trajectories and tubes with a ground based air traffic control planning computer, transmission of meteorological data measured onboard the aircraft to a ground based dynamic meteorological database, and sampling of sector related meteorological data from this meteorological data base for purpose of airborne flight planning. The testing of the FMS is performed by an experimental system consisting of the following: an airborne system represented by the ATTAS (Advanced Technologies Testing Aircraft Systems) test aircraft; a ground system based on ATMOS (Air Traffic Management and Operations Simulator); and a data link for communication between the airborne and ground systems. The different phases of the experimental program are outlined with attention being focused on the validation of planning and guidance functions and the air/ground negotiation of trajectories. ESA

N93-31840# National Aerospace Lab., Amsterdam (Netherlands). Aerodynamics Div.
REVIEW OF AERODYNAMIC DESIGN IN THE NETHERLANDS
T. E. LABRUJERE 12 Jul. 1991 35 p Presented at the 3rd International Conference on Inverse Design Concepts and Optimization in Engineering Sciences, Washington, DC, 23-25 Oct. 1991
(NLR-TP-91260-U; ETN-93-94065; AD-B169208L) Avail: CASI HC A03/MF A01

A survey of aerodynamic design activities in the Netherlands is given. The survey concentrates on the development of the Fokker 100 wing, glider design, and research in the field of aerodynamic design. Results to illustrate these activities are shown. Research work to extend the design system for wings in subsonic flow for application to wings of wing-body combinations in viscous transonic flow is in progress. The extension of this system for applications in multi-point wing design are being considered. ESA

N93-32203# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
AGEING AIRCRAFT RESEARCH IN THE NETHERLANDS
J. B. DEJONGE and G. BARTELDS 14 Nov. 1991 17 p Presented at the 1992 International Conference on Ageing Aircraft and Structural Airworthiness, Washington, DC, 19-20 Nov. 1991
(NLR-TP-91443-U; ETN-93-94076; AD-B169203L) Avail: CASI HC A03/MF A01

An overview of the research currently carried out on aircraft aging in the Netherlands is given. The work described is largely done at the National Aerospace Laboratory NLR. The major part is performed under contracts as part of cooperation agreements. The research programs are directed towards the prevention of aging aircraft problems in future aircraft and concentrated in two areas: prevention of multi-site damage in lap joints; improving knowledge on operational load experience. ESA

N93-32205# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
DAMAGE SEVERITY OF MONITORED FATIGUE LOAD SPECTRA
J. B. DEJONGE 15 Jan. 1992 10 p Presented at the 8th ICAS Congress, Beijing, China, Sep. 1992
(NLR-TP-92009-U; ETN-93-94078; AD-B168787L) Avail: CASI HC A02/MF A01

Many military aircraft are used more severely and over a longer period than originally intended. Consequently, a careful life management, including service load monitoring is required. The development of a method to quantify the severity in terms of 'potential crack growth' of recorded load spectra is described. This crack severity index accounts for load interaction effects under spectrum loading. Crack growth tests under different load spectra proved the validity of the crack severity index concept. It is shown that the crack severity index concept can also be used as a tool in studies to influence fatigue life consumption by operation measures. ESA

N93-32338# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
DEVELOPMENT OF A METHOD TO PREDICT TRANSONIC LIMIT CYCLE OSCILLATION CHARACTERISTICS OF FIGHTER AIRCRAFT
J. J. MEIJER and A. M. CUNNINGHAM, JR. (General Dynamics/Fort Worth, TX.) 18 Oct. 1991 26 p Presented at the AGARD Specialists Meeting on Transonic Unsteady Aerodynamics and Aeroelasticity, San Diego, CA, 9-11 Oct. 1991 Sponsored by USAF; General Dynamics; and National Aerospace Lab., Netherlands
(Contract NIVR-07801N)
(NLR-TP-91359-U; ETN-93-94071; AD-B169597L) Avail: CASI HC A03/MF A01

The analysis of steady wind tunnel data, obtained for a fighter type aircraft, indicated that shock induced and trailing edge separation plays a dominant role in the development of Limit Cycle Oscillations (LCO) at transonic speeds. On this basis, a semi-empirical LCO prediction method, which makes use of such steady wind tunnel data, was developed. The method has the potential for application in the design process of new aircraft to determine and understand the nonlinear aeroelastic characteristics. The method is still being evaluated, and upgrading and refinements are expected from unsteady wind tunnel force and pressure measurements to be obtained from oscillating models. The method and results of the latest predictions are presented. The results are compared with flight test trends and used to assess various parametric effects. ESA

N93-32416# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
EVALUATION OF THE FLYABILITY OF MLS CURVED APPROACHES FOR WIDE-BODY AIRCRAFT
LOUIS J. J. ERKELENS and JAN-HEIN VANDRONKELAAR 15 Dec. 1992 14 p Presented at the AIAA Guidance, Navigation and Control Conference, New Orleans, LA, 12-14 Aug. 1991 Sponsored by FAA
(NLR-TP-91396-U; ETN-93-94073; AD-B169205L) Copyright Avail: CASI HC A03/MF A01

The evaluation of the flight director aided curved Microwave Landing System (MLS) approach paths with a simulated wide body transport aircraft is presented. Four curved approach paths were evaluated. An MLS equivalent of the 13R Canarsie visual approach was investigated. Test objects were: to demonstrate the flyability of curved approaches for wide body type of aircraft; to collect scientific data in pilot performance and operational acceptance for manually flown curved approaches; and to determine the operationally acceptable minimum straight final segment length. The test included various wind and visual conditions. Winds yielding limiting conditions and winds providing airframe limiting conditions were included. 320 curved approaches were flown for data collection. The experimental results consisted of both objective and subjective data. Objective data concerned statistical data of path deviations, aircraft state and control variables. Subjective data were derived from questionnaire responses and pilot comments. ESA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A93-45681
ALGORITHMIC METHOD FOR OPTIMIZING THE PRECISION CHARACTERISTICS OF A FUEL METERING SYSTEM [ALGORITMICHESKIE METODY OPTIMIZATSII TOCHNOSTNYKH KHARAKTERISTIK TOPLIVOIZMERITEL'NOJ SISTEMY]
A. S. SLYUSARENKO *In* Mathematical methods for the analysis

of instruments and control systems Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 p. 95-100. In RUSSIAN refs
Copyright

Groups of algorithmic method for optimizing the precision characteristics of fuel metering systems are formalized and compared for a given set of hardware. It is shown that the formalized description proposed here, which involves constructing a sequence of optimal algorithms, is applicable to any primary data processing scheme. Procedures for constructing a sequence of optimal algorithms are presented for the most common functional schemes of fuel metering systems. AIAA

A93-46808* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A STUDY OF THE INFLUENCE OF THE DATA ACQUISITION SYSTEM SAMPLING RATE ON THE ACCURACY OF MEASURED ACCELERATION LOADS FOR TRANSPORT AIRCRAFT
JULIA H. WHITEHEAD (NASA, Langley Research Center, Hampton, VA) Apr. 1992 26 p. ISA, International Instrumentation Symposium, 38th, Las Vegas, NV, Apr. 26-30, 1992, Paper refs

A research effort was initiated at National Aeronautics and Space Administration (NASA) Langley Research Center (LaRC), to describe the relationship between the sampling rate and the accuracy of acceleration loads obtained from the data acquisition system of a transport aircraft. An accelerometer was sampled and digitized at a rate of 100 samples per second onboard a NASA Boeing 737 (B-737) flight research aircraft. Numerical techniques were used to reconstruct 2.5 hours of flight data into its original input waveform and then re-sample the waveform into rates of 4, 8, 16, and 32 samples per second. Peak-between-means counting technique and power spectral analysis were used to evaluate each sampling rate using the 32 samples per second data as the comparison. This paper presents the results from these methods and includes in appendix A, the peak-between-means counting results used in a general fatigue analysis for each of the sampling rates.

N93-31273# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugfuehrung.
THE BASIC MEASUREMENT EQUIPMENT OF THE DLR TEST AIRCRAFT
HELMUT BOTHE *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 31-44 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 35-48 Original language document was announced as N92-25592
Avail: CASI HC A03/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany

The basic measurement equipment of a test aircraft is described. The primary functions of the instruments are as follows: to obtain, via a comprehensive sensor system, all the parameters which are required for the widest range of investigations and operating modes; to process, filter, and adapt signals; and to retransmit them to the terminals of existing flight data processing systems. An integrated Pulse Code Modulation (PCM) system digitizes analog sensor signals and constructs a serial PCM data stream in which data from aircraft data processing systems can also be incorporated as required. During flight tests, this PCM signal is stored onboard in magnetic tapes and can be transmitted in parallel to the ground via a RF telemetry link. This basic equipment is supplemented by components which also enable transmission of data from ground to air. ESA

N93-31279# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugfuehrung.
PALLET FOR HELICOPTER TEST INSTRUMENTATION
GEORG HAEHNLEIN and PETER JAENSCH *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 115-156 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 114-153 Original language document was announced as N92-25598
Avail: CASI HC A03/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany

The system concept, its implementation, and some typical applications of an airworthy helicopter experimental system are described. The BO-105 is used as the test platform. This flight test platform is distinguished from the standard production machine by two substantial modifications: a modified, large capacity experimental cockpit, and a four axis fly by wire/fly by light control system. The items of equipment present in a general survey are presented and are discussed with regard to their functions or selection criteria. The equipment items in the BO-105 are as follows: flight controls (electronic signal pick off from the jogstick or side stick in all four control axes); fly by wire/light control (electro hydraulic actuators in all four control axes); sensors (Doppler ASI, strapdown attitude reference system, radio altimeter, air data computer); navigation (global positioning system, VOR (Very high frequency Omnidirectional Range), distance measuring equipment, instrument landing equipment receiver); data processing (aircraft computer, measurement data conditioning); data save (logging, quick look) (up/down PCM (Pulse Code Modulation) telemetry, data logging in the air and on the ground); and instruments (test cockpit) (electronic 5 inch color displays, multifunctional controls). Ground simulation, used for direct flight test preparation, is discussed. The five years of successful use of the helicopter experimental system is stressed. ESA

N93-32218*# Computer Sciences Corp., Hampton, VA.
ADVANCED TRANSPORT OPERATING SYSTEM (ATOPS) UTILITY LIBRARY SOFTWARE DESCRIPTION Final Report, Jun. 1988 - Nov. 1991
WINSTON C. CLINEDINST, CHRISTOPHER J. SLOMINSKI, RICHARD W. DICKSON, and DAVID A. WOLVERTON Apr. 1993 55 p
(Contract NAS1-19038; RTOP 505-64-13)
(NASA-CR-191469; NAS 1.26:191469) Avail: CASI HC A04/MF A01

The individual software processes used in the flight computers on-board the Advanced Transport Operating System (ATOPS) aircraft have many common functional elements. A library of commonly used software modules was created for general uses among the processes. The library includes modules for mathematical computations, data formatting, system database interfacing, and condition handling. The modules available in the library and their associated calling requirements are described. Author (revised)

N93-32223*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRBORNE DERIVATION OF MICROBURST ALERTS FROM GROUND-BASED TERMINAL DOPPLER WEATHER RADAR INFORMATION: A FLIGHT EVALUATION
DAVID A. HINTON Aug. 1993 31 p Original contains color illustrations
(Contract RTOP 505-64-12-01)
(NASA-TM-108990; NAS 1.15:108990) Avail: CASI HC A03/MF A01; 3 functional color pages

An element of the NASA/FAA windshear program is the integration of ground-based microburst information on the flight deck, to support airborne windshear alerting and microburst avoidance. NASA conducted a windshear flight test program in the summer of 1991 during which airborne processing of Terminal Doppler Weather Radar (TDWR) data was used to derive microburst alerts. Microburst information was extracted from TDWR, transmitted to a NASA Boeing 737 in flight via data link, and processed to estimate the windshear hazard level (F-factor) that would be experienced by the aircraft in each microburst. The microburst location and F-factor were used to derive a situation display and alerts. The situation display was successfully used to maneuver the aircraft for microburst penetrations, during which atmospheric 'truth' measurements were made. A total of 19 penetrations were made of TDWR-reported microburst locations, resulting in 18 airborne microburst alerts from the TDWR data and two microburst alerts from the airborne reactive windshear detection system. The primary factors affecting alerting performance were spatial offset of the flight path from the region of strongest shear, differences in TDWR measurement altitude and airplane penetration altitude, and variations in microburst outflow profiles. Predicted and measured F-factors agreed well in penetrations near microburst cores. Although improvements in airborne and ground processing of the TDWR measurements would be required to support an airborne executive-level alerting protocol, the practicality of airborne utilization of TDWR data link data has been demonstrated. Dissert. Abstr.

N93-32332# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
INSTRUMENTATION FOR IN-FLIGHT ACOUSTIC MEASUREMENTS IN AN ENGINE INLET DUCT OF A FOKKER 100 AIRCRAFT
J. M. KLIJN and E. R. RADEMAKER 28 May 1991 15 p
Presented at the SFTE 22nd Annual Symposium, Saint Louis, MO, 5-9 Aug. 1991
(NLR-TP-91200-U; ETN-93-94060; AD-B169204L) Avail: CASI HC A03/MF A01

Acoustic measurements in the engine intake duct of the Fokker 100 test aircraft during flight were performed. One of the engines was provided with an instrumented intake to determine the circumferential modes of the sound field. A digital data acquisition system had to be developed. The technical requirements of the acoustic instrumentation, the selection of the transducers and a description of the new data acquisition system are presented. Some of the Fokker 100 test aircraft instruments are described. Extensive system checks, including environmental and calibration tests, were carried out before installing the system in the aircraft. Some results of these tests are presented. The flight test program and the data processing are described. It is concluded that during the flights, the new measurement system operated well. The required data concerning the prevailing acoustic modes was obtained. ESA

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.

A93-44230*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A COMPUTATIONAL INVESTIGATION OF FUEL MIXING IN A HYPERSONIC SCRAMJET
BRETT W. FATHAUER (George Washington Univ., Hampton, VA) and R. C. ROGERS (NASA, Langley Research Center, Hampton, VA) Jul. 1993 12 p. AIAA, Fluid Dynamics Conference, 24th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2994)

A parabolized, Navier-Stokes code, SHIP3D, is used to numerically investigate the mixing between air injection and hydrogen injection from a swept ramp injector configuration into either a mainstream low-enthalpy flow or a hypervelocity test flow. The mixing comparisons between air and hydrogen injection reveal the importance of matching injectant-to-mainstream mass flow ratios. In flows with the same injectant-to-mainstream dynamic pressure ratio, the mixing definition was altered for the air injection cases. Comparisons of the computed results indicate that the air injection cases overestimate the mixing performance associated with hydrogen injection simulation. A lifting length parameter, to account for the time a fluid particle transverses through the mixing region, is defined and used to establish a connection of injectant mixing in hypervelocity flows, based on nonreactive, low-enthalpy flows. Author

A93-45550
A PROPULSION DEVICE DRIVEN BY REFLECTED SHOCK WAVES
S. EIDELMAN, W. GROSSMANN, and I. LOTTATI (Science Applications International Corp., McLean, VA) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 1283-1288. refs
Copyright

A concept of an airbreathing propulsion device operating on intermittent detonations is described. The airbreathing Pulsed Detonation Engine (PDE) is analyzed by direct simulations of its cycle using Computational Fluid Dynamics. Based on this analysis, the PDE performance is predicted for a range of flight conditions and engine configurations. Examination of the key processes in the PDE device shows that the largest portion of its thrust is produced in a very short time interval when the detonation wave reflects from the thrust wall, and that detonation cycle frequency up to 200 Hz is feasible. We conclude that the PDE-type devices can compete with small-diameter turbojet engines in performance while surpassing them in simplicity of design and price.

A93-45779
A DAMAGE TOLERANCE APPROACH FOR MANAGEMENT OF AGING GAS TURBINE ENGINES
W. D. COWIE (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 99-114. refs
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An account is given of the bases and implementation to data of the USAF gas turbine engine damage-tolerance philosophy, as embodied since 1984 in MIL-STD 1783, 'Engine Structural Integrity Program' (ENSIP). The ENSIP structural durability and damage tolerance assessments have been applied to such fighter aircraft powerplants as the F-100, TF-34, F100-PW-220 and -229, F110-GE-100 and -129, and F-101-GE-102. ENSIP criteria are also embodied in the designs of the next-generation F-119 and F-120 engines. AIAA

A93-46926
SOCIETE FRANCAISE DES MECANICIENS, SNECMA, AND ONERA, SYMPOSIUM ON RECENT ADVANCES IN COMPRESSOR AND TURBINE AEROTHERMODYNAMICS, COURBEVOIE, FRANCE, NOV. 24, 25, 1992, REPORTS [SOCIETE FRANCAISE DES MECANICIENS, SNECMA ET ONERA, PROGRES RECENTS EN AEROTHERMODYNAMIQUE DES COMPRESSEURS ET TURBINES, JOURNEES, COURBEVOIE, FRANCE, NOV. 24, 25, 1992, COMMUNICATIONS]
GEORGES MEAUZE, ED. (ONERA, Chatillon, France) Revue Francaise de Mecanique (ISSN 0373-6601) no. 3 & 4 1992 p. no. 3, 104 p.; no. 4, 141 p. In French and English. For individual items see A93-46927 to A93-46946
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Various papers on mechanics are presented. Individual topics addressed include: 3D flow in a compressor cascade at design and off-design conditions, turbine blade forces due to partial admission, inverse problem using S2-S1 approach for the design of turbomachines, supersonic through-flow compressors, optimization of a highly loaded axial splittered rotor design, adaptation of a 3D pressure correction Navier-Stokes solver, propulsion system simulator with propfan for tests on a large-scale model IL-114 aircraft, prediction of 3D low frequency unsteady transonic flow and forced vibration in axial turbine stages. AIAA

A93-46930
SUPERSONIC THROUGH FLOW COMPRESSORS - A PRELIMINARY STUDY: COVAXS
M. DUMAS (Paris VI, Univ., France), L. VERDIER, P. THOURAUD

(SNECMA, Paris, France), H. MITON, and J. CHAUVIN (Paris VI, Univ., France) Revue Francaise de Mecanique (ISSN 0373-6601) no. 3 1992 p. 225-233. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 refs
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The first results are described of a study to identify the key design problems of a turbojet engine compressor capable of operating with an axial supersonic velocity at the inlet. Practical applications of such a compressor could be a fan or an aft fan rather than conventional first stage compressor applications. Advanced numerical solvers specially adapted to an axial supersonic flow configuration are used to provide credible blade loading and compressor performance assumptions. AIAA

A93-46931
OPTIMIZATION OF A HIGHLY-LOADED AXIAL SPLITTERED ROTOR DESIGN
K.-L. TZUOO, S. S. HINGORANI, and A. K. SEHRA (Textron Lycoming, Turbine Engine Div., Stratford, CT) Revue Francaise de Mecanique (ISSN 0373-6601) no. 3 1992 p. 235-246. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 refs
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The concept of a splittered axial rotor for achieving stage pressure ratios in excess of 3:1 was pioneered by Wennerstrom during the early 70s. However, lack of advanced analytical procedures resulted in a design that was well below its efficiency and surge margin goals. Recent advances in fully three dimensional viscous flow analysis procedures have prompted the authors of this paper to take a fresh look at this concept. This paper reviews the results of a detailed analytical study performed on Wennerstrom's rotor, followed by the details of a redesign effort using advanced design methodology. It is shown that the extensive flow separation observed in Wennerstrom's rotor can be completely eliminated by redesigning the main blade and splitter vane. Relevant details of the splitter rotor design methodology are also presented.

A93-46939
NUMERICAL SIMULATION OF AEROTHERMODYNAMICS PROCESSES IN GAS TURBINE ENGINE COMPONENTS
M. YA. IVANOV, V. K. KOSTEZH, V. G. KRUPA, R. Z. NIGMATULLIN, and T. V. SAMARKINA (Tsentral'nyj NII Aviatsionnogo Mashinostroeniya, Moscow, Russia) Revue Francaise de Mecanique (ISSN 0373-6601) no. 4 1992 p. 361-371. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 refs
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Prospective directions of numerical simulation of aerodynamic and thermophysic processes in gas turbine engine components are described. The transition to development of methods for solution of multicomponent and multidisciplinary problems for the whole engine and its components taking place at present time is illustrated. As typical examples, the quasi-3D models of a whole core of gas turbine engine, multistage compressors and turbine are presented which account for viscous losses, blowing in and out of cooling air, and the thermal-stressed state of high-temperature cooled turbine rotors. In the nearest future such complex mathematical models will accompany the design, production and use of prospective gas turbine engines and its following modifications. Author (revised)

A93-46942
THREE DIMENSIONAL AERO-THERMAL CHARACTERISTICS OF A HIGH PRESSURE TURBINE NOZZLE GUIDE VANE
T. ARTS (Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese, Belgium) and J. P. LAGRANGE (SNECMA, Centre de Villaroche, Moissy-Cramayel, France) Revue Francaise de Mecanique (ISSN 0373-6601) no. 4 1992 p. 393-399. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 Research supported by SNECMA refs
Copyright

This paper finds its motivation in the development of new test and measurement techniques applied to high pressure turbine components. Straight cascades model only very poorly the three dimensional flow in blade rows; the design and construction of an annular transonic facility were, therefore, recently completed at the von Karman Institute. Its operation is based upon the principles of an Isentropic Light Piston Compression Tube, in order to correctly simulate the operating conditions observed in modern aeroengines. The wind tunnel was effectively put in operation in January 1991. The purpose of the present contribution is twofold. The main characteristics of this new facility will first be described. In the second part of the paper, a partial determination of the aerodynamic and thermal performances of a three dimensional nozzle guide vane operated in subsonic and transonic regimes will be reported.

A93-46943
INTENSIVE INDUSTRIAL USE OF 3D EULER NUMERICAL METHODS FOR AXIAL FLOW TURBINE ANALYSIS AND DESIGN [UTILISATION INTENSIVE D'UNE METHODE EULER 3D POUR L'ANALYSE ET LA CONCEPTION DES TURBINES DE MOTEURS D'AVION]
B. PETOT (SNECMA, Centre de Villaroche, Moissy-Cramayel, France) Revue Francaise de Mecanique (ISSN 0373-6601) no. 4 1992 p. 401-408. In FRENCH Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 Research supported by DRET and STPA refs
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A numerical Euler method for predicting 3D steady flows in turbine blade channels developed at ONERA and currently used at Snecma is presented. The method is based on the 3D unsteady Euler equations which are solved by an explicit Lax-Wendroff scheme with an added implicit phase. The method is experimentally validated using a low-pressure turbine inlet guide vane, a high-pressure inlet guide vane at transonic Mach numbers, and a high-pressure turbine rotor. A 3D optimization of the shapes of the bladings is demonstrated using nonradial stacking of low-pressure turbine stators, an endwall contouring technique for a high pressure turbine inlet guide vane, and inclination of the struts of turbine rear frames. AIAA

A93-46945
THE PREDICTION AND THE ACTIVE CONTROL OF SURGE IN MULTI-STAGE AXIAL-FLOW COMPRESSORS
J. F. ESCURET and R. L. ELDER (Cranfield Inst. of Technology, United Kingdom) Revue Francaise de Mecanique (ISSN 0373-6601) no. 4 1992 p. 415-421. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 refs
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This paper presents a theoretical approach developed for predicting and controlling purely axial 1D instabilities in multi-stage axial-flow compressors. Firstly, the paper considers the derivation of a suitable model. The instability predictions obtained from a linearized form of this model are found to be very close to the actual stall/surge line of two compressor test cases. The paper continues with the development of a controller using linear optimal control theory. This controller is specifically designed to suppress the instabilities predicted by the linearized surge model. The control technique involves a bleed being dynamically varied in response to fluctuations of variables. It is shown that, under some conditions, a stabilizing optimal controller can always be found.

A93-47291#
DESIGN OPTIMIZATION STUDY FOR F-15 PROPULSION/FORWARD FAIRING COMPATIBILITY
K. E. ACHESON, S. E. LEHMAN, and T. D. SMITH (McDonnell Douglas Aerospace, Saint Louis, MO) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1071-1081. refs
(AIAA PAPER 93-3484) Copyright
An F-15E propulsion system compatibility analysis and test program was required in the preliminary design phase of a forward-mounted antenna fairing integration effort. The goal of the program was to identify antenna fairing configurations that would ensure compatibility with the F-15E propulsion system. Taguchi statistical methods were used to eliminate half of the required parametrics. Computational fluid dynamics numerical simulations and wind runnel testing were used in a complimentary manner to provide both qualitative and quantitative measures of performance.

A93-47508
MATHEMATICAL MODEL FOR THE EFFECT OF TURBULENT VELOCITY PULSATIONS ON THE STABILITY OF A POWERPLANT [MATEMATICHESKAYA MODEL' VLIYANIYA TURBULENTNYKH PUL'SATSIJ SKOROSTI NA USTOJCHIVOST' SILOVOJ USTANOVKI]
O. N. KONSTANTINOVSKIJ *In* Turbulent flow problems Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya 1991 p. 37-60. In RUSSIAN refs
Copyright
The effect of turbulent velocity pulsations arising in the air-intake channel on the stability of the powerplant is investigated. The mean time to loss of stability is determined numerically as a function of the intensity and integral scale of the pulsations. The minimum amplitudes and durations of external disturbances which lead to compressor stall are determined analytically in the framework of the mathematical model considered here. AIAA

A93-47509
LOCALIZATION OF NOISE SOURCES IN THE EXHAUST JET OF A TURBOFAN ENGINE [LOKALIZATSIYA ISTOCHNIKOV SHUMA V VYKHLOPNOJ STRUE TRDD]
S. V. DOVZHIK, S. YU. KRASHENINNIKOV, A. K. MIRONOV, and V. A. CHURSIN *In* Turbulent flow problems Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya 1991 p. 61-75. In RUSSIAN refs
Copyright
Experimental results are presented on the distribution of noise sources in the near acoustic field of the PS-90 turbofan engine with a common mixing chamber. The contributions of different sound sources to the total noise of the engine are identified. Digital processing is used to localize sound sources in the exhaust jet of the engine. A model for the propagation of pressure pulses in the near acoustic field of a turbulent jet is proposed that includes two propagation mechanisms: a wave mechanism and a convective one. AIAA

A93-47510
AN ACOUSTIC SUPPRESSOR FOR THE JET NOISE OF A TURBOJET ENGINE [AKUSTICHESKIJ GLUSHITEL' SHUMA REAKTIVNOJ STRUI TRD]
E. V. VLASOV, A. S. GINEVSKIJ, I. S. ZAGUZOV, and R. K. KARAVOSOV *In* Turbulent flow problems Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya 1991 p. 76-85. In RUSSIAN refs
Copyright
A novel technique for reducing the jet noise of turbojet engines is proposed which is based on the aeroacoustic interaction effect. The noise is reduced using a multitube nozzle consisting of a central nozzle and several peripheral ones, which have an order-of-magnitude-smaller diameter. The high-frequency noise effect of the peripheral streamlets leads to a reduction of the total noise in both the near and the far acoustic fields. Experiments were conducted on models as well as on a full-scale turbojet engine. AIAA

A93-47513
INVESTIGATION OF FLAME STABILIZERS IN THE FORM OF PERFORATED GRIDS [ISSLEDOVANIE STABILIZATOROV PLAMENI V VIDE PERFORIROVANNYKH RESHETOK]
V. YU. ALEKSEEV, V. B. RUTOVSKIJ, A. N. KULYAPIN, and A. P. KISELEV *In* Turbulent flow problems Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya 1991 p. 105-112. In RUSSIAN refs
Copyright
The paper presents an investigation of the flameout characteristics connected with using stabilizers in the form of perforated grids with and without a central aperture. The presence of two flame-stabilization zones is observed, whose formation is associated with change in the momentum of the jets issuing from the apertures. It is shown that the best characteristics are possessed by stabilizers with a small-aperture diameter of 3 mm and a central-aperture diameter of 40 mm, for a combustion-chamber diameter of 150 mm. AIAA

N93-31111# National Aerospace Lab., Amsterdam (Netherlands). Materials Dept.
PERFORMANCE OF GAS TURBINE COMPRESSOR CLEANERS
H. J. KOLKMAN 18 Jun. 1991 10 p Presented at 37th ASME International Gas Turbine and Aeroengine Congress and Exposition, Cologne, Germany, 1-4 Jun. 1992 Sponsored by Royal Netherlands Air Force, and Royal Netherlands Navy
(NLR-TP-91237-U; ETN-93-94064) Avail: CASI HC A02/MF A01
Deposits are regularly removed from compressor blades and vanes of installed jet engines and gas turbines by compressor washing. A compressor cleaner is sprayed into the compressor while operating at reduced or normal rpm. The cleaning efficiency of eight, old and new, compressor cleaners was determined. The experiments were performed by means of simulated compressor washing or 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 compressor cleaners. The corrosion inhibition offered by those cleaners that contain a corrosion inhibitor was found to be satisfactory. ESA

N93-31170# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany). Abt. fuer Numerische Stroemungsmechanik.
THE VIB-CODE TO SIMULATE 3-D STATOR/ROTOR FLOW IN AXIAL TURBINES
ACHIM HILGENSTOCK Jul. 1992 52 p Original contains color illustrations
(ISSN 0939-2963)
(DLR-FB-92-19; ETN-93-93955) Avail: CASI HC A04/MF A01; DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany, HC
The numerical simulation of the flow through an axial turbine stage using a finite volume Navier-Stokes method is reported. The methods for selecting the optimal grid and the grid generation are outlined. Numerous improvements are integrated into an existing numerical method to improve the flexibility and to extend the range of application. With the introduced Chimera grid embedding technique, it is possible to solve the Navier-Stokes equations on overlapping meshes. In addition to the existing code, now the flow can also be simulated within cylindrical geometries, even in a rotating frame of reference as for example in the turbine rotor. The results obtained with the method described show the quasi-instationary three dimensional flow through an axial turbine stage with nonrotating stator and rotating rotor blade rows. ESA

N93-31671*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ENGINE TECHNOLOGY CHALLENGES FOR A 21ST CENTURY HIGH-SPEED CIVIL TRANSPORT
ROBERT J. SHAW, SAMUEL GILKEY (General Electric Co., Evendale, OH.), and RICHARD HINES (Pratt and Whitney Aircraft, East Hartford, CT.) Sep. 1993 13 p Proposed for presentation at the International Symposium on Air Breathing Engines, Tokyo, Japan, 20-24 Sep. 1993 Original contains color illustrations
(Contract RTOP 537-02-00)
(NASA-TM-106216; E-7925; NAS 1.15:106216) Avail: CASI HC A03/MF A01; 3 functional color pages

Ongoing NASA-funded studies by Boeing, McDonnell-Douglas, General Electric, and Pratt & Whitney indicate that an opportunity exists for a 21st Century High-Speed Civil Transport (HSCT) to become a major part of the international air transportation system. However, before industry will consider an HSCT product launch and an investment estimated to be over $15 billion for design and certification, major technology advances must be made. An overview of the propulsion-specific technology advances that must be in hand before an HSCT product launch could be considered is presented. Author (revised)

N93-31741# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
AGARD ENGINE DISC COOPERATIVE TEST PROGRAMME [RAPPORT SUR LE PROGRAMME D'ESSAIS COMMUN DES DISQUES MOTEUR (SUPPLEMENT)]
Apr. 1993 242 p
(AGARD-R-766-ADD; ISBN-92-835-0709-6) Copyright Avail: CASI HC A11/MF A03

Fatigue and crack growth tests of Ti-Al6-4V, IMI 685, and Ti-17 specimens under constant amplitude and under variable amplitude TURBISTAN loading sequences at room temperature are described. Five crack growth models are evaluated and compared against experimental data. Microstructure and fractography data for the tested materials are also presented.

N93-31742# National Aerospace Lab., Amsterdam (Netherlands).
FRACTOGRAPHIC AND MICROSTRUCTURAL ANALYSIS OF FATIGUE CRACK GROWTH IN TI-6AL-4V FAN DISC FORGINGS
R. J. H. WANHILL and C. E. W. LOOIJE *In* AGARD, AGARD Engine Disc Cooperative Test Programme 40 p Apr. 1993
Copyright Avail: CASI HC A03/MF A03

The constant amplitude and flight simulation (TURBISTAN) fatigue crack growth behavior of Ti6Al-4V fan disc forgings tested in the AGARD engine disc cooperative test program was investigated by fractographic and microstructural analysis. The crack growth curve shapes and fractographic characteristics were similar. Transitions in the fatigue crack growth curves correlated with a change from structure-sensitive to continuum-mode crack growth, primarily in the transformed and aged Beta grains, and decreased fracture surface roughness. The transitions were most probably caused by the maximum plane strain cyclic plastic zone sizes becoming equal to and exceeding the average platelet Alpha packet sizes. The significance of such transitions for prediction of fatigue crack growth and service failure analysis is discussed. Author

N93-31743# Defence Research Agency, Farnborough (England).
FRACTOGRAPHIC INVESTIGATION OF IMI 685 CRACK PROPAGATION SPECIMENS FOR SMP SC33
CHRIS WILKINSON and PAUL HEULER (Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn, Germany.) *In* AGARD, AGARD Engine Disc Cooperative Test Programme 4 p Apr. 1993
Copyright Avail: CASI HC A01/MF A03

Fracture surfaces from compact tension and corner crack specimens were examined for various complex waveforms. Features were related to the various stages of crack growth, as well as to the known response of the material. Author

N93-31744# Department of National Defence, Ottawa (Ontario). Quality Engineering Test Establishment.
MATERIAL CHARACTERIZATION AND FRACTOGRAPHIC EXAMINATION OF TI-17 FATIGUE CRACK GROWTH SPECIMENS FOR SMP SC33
MARKO YANISHEVSKY, BRYAN CORNWALL, and MARTIN ROTH *In* AGARD, AGARD Engine Disc Cooperative Test Programme 44 p Apr. 1993
Copyright Avail: CASI HC A03/MF A03

Material characterization and metallographic examination of the Ti-17 material tested as part of the Supplemental Program for Engine Disc Damage Tolerance Testing AGARD SC33 are included. As well, a complete fractographic examination is provided for the compact tension specimens tested under the six types of simple spectra load conditions and the four levels of load excursion damage level omission of the complex spectrum TURBISTAN, this latter spectrum representing NATO gas turbine engine missions used in fighter aircraft applications. Author (revised)

N93-31745# National Aerospace Lab., Amsterdam (Netherlands).
LOW CYCLE FATIGUE BEHAVIOUR OF TITANIUM DISC ALLOYS
C. E. W. LOOIJE *In* AGARD, AGARD Engine Disc Cooperative Test Programme 12 p Apr. 1993
Copyright Avail: CASI HC A03/MF A03

The low cycle fatigue behavior of the titanium alloys IMI 685, Ti-17 and Ti-6Al-4V tested in the AGARD Engine Disc Cooperative Test Program are described. Load controlled low cycle fatigue tests were carried out on smooth cylindrical and flat double edge notched specimens at room temperature. The test results were statistically analyzed and discussed. The tests showed that the differences in low cycle fatigue behavior between IMI 685 and Ti-6Al-4V are negligible and that Ti-17 has superior low cycle fatigue properties. Author (revised)

N93-31746# Institute for Aerospace Research, Ottawa (Ontario).
FATIGUE CRACK GROWTH RESULTS FOR TI-6AL-4V, IMI 685, AND TI-17
M. D. RAIZENNE *In* AGARD, AGARD Engine Disc Cooperative Test Programme 33 p Apr. 1993
Copyright Avail: CASI HC A03/MF A03

The fatigue crack growth results for the titanium alloys IMI 685, Ti-6Al-4V and Ti- 17 that were tested in the Supplemental phase of the AGARD SC.33 Engine Disc Cooperative Test Program are presented. The fatigue crack growth work was carried out under load control using compact tension and corner crack specimen geometries. Tests were conducted under the following loading conditions: constant amplitude ($R = 0.1$ and $R = 0.7$), constant amplitude ($R = 0$) with minor cycles, an $R = 1.7$ single overload sequence and the cold TURBISTAN variable amplitude sequence. The data is presented using a point to point or secant method. The constant amplitude and single overload data base was subsequently used by five participating laboratories to predict a series of 60 load cases using their respective crack growth prediction models. Author (revised)

N93-31747# Centre d'Essais Aeronautique Toulouse (France).
CRACK GROWTH PREDICTION MODELS
ERIC JANY and PAUL HEULER (Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn, Germany.) *In* AGARD, AGARD Engine Disc Cooperative Test Programme 6 p Apr. 1993
Copyright Avail: CASI HC A02/MF A03

Seven companies or laboratories initially entered the exercise: CEAT, FFA, GE, NASA, NLR, Pratt & Whitney, and Rolls-Royce. Two of them withdrew (GE, Pratt & Whitney). A short description of the models and some information on how the data base was handled in order to carry out the predictions are presented. A list of references on each model is given. Author (revised)

N93-32220*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
ENGINE EXHAUST CHARACTERISTICS EVALUATION IN SUPPORT OF AIRCRAFT ACOUSTIC TESTING
KIMBERLY A. ENNIX Jun. 1993 12 p Presented at the Society of Women Engineers National Conference, Chicago, IL, 21-27 Jun. 1993
(Contract RTOP 537-03-20)
(NASA-TM-104263; H-1873; NAS 1.15:104263) Avail: CASI HC A03/MF A01

NASA Dryden Flight Research Facility and NASA Langley Research Center completed a joint acoustic flight test program. Test objectives were (1) to quantify and evaluate subsonic climb-to-cruise noise and (2) to obtain a quality noise database for use in validating the Aircraft Noise Prediction Program. These tests were conducted using aircraft with engines that represent the high nozzle pressure ratio of future transport designs. Test flights were completed at subsonic speeds that exceeded Mach 0.3 using F-18 and F-16XL aircraft. This paper describes the efforts of NASA Dryden Flight Research Facility in this flight test program. Topics discussed include the test aircraft, setup, and matrix. In addition, the engine modeling codes and nozzle exhaust characteristics are described. Author

N93-32272# Imperial Coll. of Science and Technology, London (England).
STRUCTURAL DYNAMIC CHARACTERISTICS OF INDIVIDUAL BLADES
D. J. EWINS and R. HENRY (Institut National des Sciences Appliquees, Lyon, France.) *In* VKI, Vibration and Rotor Dynamics 28 p 1992 Previously announced as N89-10008 Repr. from AGARD Manual on Aeroelasticity in Axial-Flow Turbo Machines. Volume 2: Structural Dynamics and Aeroelasticity 27 p
Copyright Avail: CASI HC A03/MF A04

The necessary introduction and grounding for a study of the vibrational characteristics of individual turbomachine blades are given. Only the structural dynamic properties are considered, and particular attention is given to the natural frequencies and the corresponding mode shapes. Before proceeding to a discussion of methods for predicting the structural dynamic properties of an individual turbomachine blade, the basic nature of these characteristics is summarized using simple models of blades. Further, the influence of a number of relevant design features is examined in order to establish parameters which have an effect on the actual values of natural frequency or mode shape. Prediction methods used for design calculations are included. ESA

N93-32273# Imperial Coll. of Science and Technology, London (England). Dept. of Mechanical Engineering.
STRUCTURAL DYNAMIC CHARACTERTISTICS OF BLADED ASSEMBLIES
D. J. EWINS *In* VKI, Vibration and Rotor Dynamics 38 p 1992 Previously announced as N89-10009 Repr. from AGARD Manual on Aeroelasticity in Axial-Flow Turbo Machines. Volume 2: Structural Dynamics and Aeroelasticity 37 p
Copyright Avail: CASI HC A03/MF A04

The main features of the structural dynamic properties of blade assemblies are established. The patterns of both natural frequencies and mode shapes for various assemblies are illustrated and the major controlling factors in each case are identified. Simplified mathematical models of a bladed assembly are applied because they allow to perform the detailed parametric studies required to determine the behavior patterns. The following models are summarized: a basic model which admits a single degree of freedom for each blade and includes a simplified representation of the disk and/or shroud coupling; models based on simple beam and plate components; models containing few or no simplifications and based on finite element techniques. All these models are used for direct design predictions, but are inappropriate for exploratory studies, and are almost always limited to tubed and/or cyclically symmetric assemblies. ESA

N93-32274# Liege Univ. (Belgium).
VIBRATION ANALYSIS IN TURBOMACHINES
MICHEL GERADIN, N. KILL, and J. C. GOLINVAL *In* VKI, Vibration and Rotor Dynamics 123 p 1992 Prepared in cooperation with Samtech S.A., Liege, Belgium
Copyright Avail: CASI HC A06/MF A04

The physical aspects of the mathematical models and the numerical methods applied to rotordynamics are discussed. Special attention is given to the physical aspects involving the breakdown of the rotating and fixed parts and of the interaction elements. The following formalisms are reviewed: the Hamilton's principle, the kinematics of rotating structures, the kinetic, the strain and the structural damping energy of rotating parts, the interaction elements and the system equations. The finite element discretization and the reduction methods are outlined. The numerical methods presented are the stability analysis, the harmonic and the transient response analysis. ESA

N93-32351*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PROPULSION TECHNOLOGY CHALLENGES FOR TURN-OF-THE-CENTURY COMMERCIAL AIRCRAFT
JOSEPH A. ZIEMIANSKI and CALVIN L. BALL Jun. 1993 14 p Prepared for presentation at the 11th ISABE Conference, Tokyo, Japan, 20-24 Sep. 1993
(Contract RTOP 505-62-10)
(NASA-TM-106192; E-7898; NAS 1.15:106192) Avail: CASI HC A03/MF A01

This paper highlights the efforts being performed or sponsored by NASA, in cooperation with the U.S. civil aviation industry, to address the propulsion system technological challenges that must be met in order to ensure a viable future for the industry. Both the subsonic and supersonic aeropropulsion programs are considered. Subsonic transport propulsion program elements, including ultra-high-bypass-ratio turbofans with attendant noise reduction efforts, high-efficiency cores, and combustor emissions reductions are discussed in terms of goals, technical issues, and problem solutions. Similarly, the high-speed research propulsion efforts addressing a high-speed commercial transport are reviewed in terms of environmental barrier issues, such as oxides of nitrogen and noise reduction, and the related economic issues.
Author (revised)

N93-32368*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INITIAL RESULTS FROM THE NASA-LEWIS WAVE ROTOR EXPERIMENT
JACK WILSON (Sverdrup Technology, Inc., Brook Park, OH.) and DENNIS FRONEK May 1993 11 p Presented at the AIAA, SAE, ASME, and ASEE 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28 Jun. - 1 Jul. 1993; sponsored by AIAA
(Contract RTOP 505-62-10)
(NASA-TM-106148; E-7831; NAS 1.15:106148; AIAA PAPER 93-2521) Avail: CASI HC A03/MF A01

Wave rotors may play a role as topping cycles for jet engines, since by their use, the combustion temperature can be raised without increasing the turbine inlet temperature. In order to design a wave rotor for this, or any other application, knowledge of the loss mechanisms is required, and also how the design parameters affect those losses. At NASA LeRC, a 3-port wave rotor experiment operating on the flow-divider cycle, has been started with the objective of determining the losses. The experimental scheme is a three factor Box-Behnken design, with passage opening time, friction factor, and leakage gap as the factors. Variation of these factors is provided by using two rotors, of different length, two different passage widths for each rotor, and adjustable leakage gap. In the experiment, pressure transducers are mounted on the rotor, and give pressure traces as a function of rotational angle at the entrance and exit of a rotor passage. In addition, pitot rakes

monitor the stagnation pressures for each port, and orifice meters measure the mass flows. The results show that leakage losses are very significant in the present experiment, but can be reduced considerably by decreasing the rotor to wall clearance spacing.
Author (revised)

N93-32372# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
LOW CYCLE FATIGUE BEHAVIOUR OF TITANIUM DISC ALLOYS
C. E. W. LOOIJE 9 Sep. 1991 17 p Presented at AGARD Subcommittee 33 on Engine Disc Cooperative Test Programme
(NLR-TP-91346-U; ETN-93-94069; AD-B168790L) Avail: CASI HC A03/MF A01

The low cycle fatigue behavior of the titanium alloys IMI 685, Ti-17, and Ti-6Al-4V is described. The specimens were extracted from fan disc forgings provided by Rolls-Royce and General Electric. The forgings were in the solution treated and aged conditions. The Ti-6Al-4V was (alpha + beta) processed, while the IMI 685 and Ti-17 were beta processed. Load controlled low cycle fatigue tests were carried out on smooth cylindrical and flat double edge notched specimens at room temperature. The test results were statistically analyzed and discussed. The tests showed that the differences in low cycle fatigue behavior between IMI 685 and Ti-6Al-4V are negligible and that Ti-17 has superior low cycle fatigue properties. ESA

N93-32374*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ANALYTICAL AND EXPERIMENTAL INVESTIGATIONS OF THE OBLIQUE DETONATION WAVE ENGINE CONCEPT
GENE P. MENEES, HENRY G. ADELMAN (Eloret Corp., Palo Alto, CA.), and JEAN-LUC CAMBIER (Eloret Corp., Palo Alto, CA.) Feb. 1991 18 p Presented at the AGARD PEP 75th Symposium, Madrid, Spain, 28 May - 1 Jun. 1990 Previously announced as N91-23169
(Contract RTOP 506-62-31)
(NASA-TM-102839; A-90195; NAS 1.15:102839) Avail: CASI HC A03/MF A01

Wave combustors, which include the Oblique Detonation Wave Engine (ODWE), are attractive propulsion concepts for hypersonic flight. These engines utilize oblique shock or detonation waves to rapidly mix, ignite, and combust the air-fuel mixture in thin zones in the combustion chamber. Benefits of these combustion systems include shorter and lighter engines which will require less cooling and can provide thrust at higher Mach numbers than conventional scramjets. The wave combustor's ability to operate at lower combustor inlet pressures may allow the vehicle to operate at lower dynamic pressures which could lessen the heating loads on the airframe. The research program at NASA-Ames includes analytical studies of the ODWE combustor using CFD codes which fully couple finite rate chemistry with fluid dynamics. In addition, experimental proof-of-concept studies are being carried out in an arc heated hypersonic wind tunnel. Several fuel injection designs were studied analytically and experimentally. In-stream strut fuel injectors were chosen to provide good mixing with minimal stagnation pressure losses. Measurements of flow field properties behind the oblique wave are compared to analytical predictions.
Author (revised)

N93-32386# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
TRANSMISSION OF SOUND THROUGH A ROTOR
J. B. H. M. SCHULTEN 29 Jan. 1992 13 p Presented at the DGLR/AIAA 14th Aeroacoustic Conference, Aachen, Germany, 11-14 May 1992
(NLR-TP-92014-U; ETN-93-94079; AD-B169664L) Avail: CASI HC A03/MF A01

The dominant sound of a turbofan engine is usually generated by rotor wakes when they impinge on a downstream stator. Consequently, to reach the intake the sound waves must pass the rotor. The rotating blades represent an obstacle that partly reflects and partly transmits the incident sound field. The calculation of this process is by means of a three dimensional lifting surface approximation of the rotor. It is shown that the reflection-transmission process can be treated as an unsteady aerodynamic problem. The method is illustrated by numerical examples. The results show that, depending on the relative angle of incidence of the sound waves, the shielding effect of the rotor can yield a reduction from negligible up to the order of 30 dB in acoustic power. ESA

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A93-44142
REAL-TIME PARAMETER IDENTIFICATION APPLIED TO FLIGHT SIMULATION
LUIS A. PINEIRO (USAF, Wright-Patterson AFB, OH) and DANIEL J. BIEZAD (California Polytechnic State Univ., San Luis Obispo) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251) vol. 29, no. 2 April 1993 p. 290-301. refs
Copyright

In-flight simulations are normally accomplished using model-following control laws which depend on accurate knowledge of the stability derivatives of the host aircraft. Degraded simulation results if the stability derivatives deviate considerably from their presumed values. Gain scheduling is often employed to compensate for plant parameter variations, but this form of open-loop compensation usually requires extensive flight testing for proper fine tuning. An adaptive, fast-sampling control law to compensate for changing aircraft parameters is described. The step-response matrix required for implementation is identified recursively using a technique which does not need special 'test' signals and which automatically discounts old data depending on the input excitation detected. Tracking fidelity is maintained despite parameter changes which occur either abruptly or slowly, and actuator position and rate limiting are discussed. The performance of the resulting system is excellent and demonstrates the relative advantages of adaptive controllers for in-flight simulation. Author

A93-44151
STIFFNESS ENHANCEMENT OF FLIGHT CONTROL ACTUATOR
VINCENT B. BLAIGNAN and VICTOR A. SKORMIN (New York State Univ., Binghampton) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251) vol. 29, no. 2 April 1993 p. 380-390. refs
Copyright

A modification of the model reference approach, employing numerical optimization, is proposed for the estimation of external forces applied to control surfaces of an aircraft. This estimation provides the basis for the feed-forward control of the surface position. Incorporated into the control system of a flight control actuator, this technique allows for a significant enhancement of the actuator stiffness. Author

A93-44233*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACTUATED FOREBODY STRAKE CONTROLS FOR THE F-18 HIGH ALPHA RESEARCH VEHICLE
DANIEL G. MURRI, GAUTAM H. SHAH, DANIEL J. DICARLO (NASA, Langley Research Center, Hampton, VA), and TODD W. TRILLING (Lockheed Engineering and Sciences Co., Hampton, VA) Aug. 1993 12 p. AIAA, Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 9-11, 1993 refs
(AIAA PAPER 93-3675) Copyright

A series of ground-based studies have been conducted to develop actuated forebody strake controls for flight test evaluations using the NASA F-18 High-Alpha Research Vehicle. The actuated forebody strake concept has been designed to provide increased levels of yaw control at high angles of attack where conventional rudders become ineffective. Results are presented from tests conducted with the flight-test strake design, including static and dynamic wind-tunnel tests, transonic wind-tunnel tests, full-scale wind-tunnel tests, pressure surveys, and flow visualization tests. Results from these studies show that a pair of conformal actuated forebody strakes applied to the F-18 HARV can provide a powerful and precise yaw control device at high angles of attack. The preparations for flight testing are described, including the fabrication of flight hardware and the development of aircraft flight control laws. The primary objectives of the flight tests are to provide flight validation of the groundbased studies and to evaluate the use of this type of control to enhance fighter aircraft maneuverability. Author

A93-44234*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MICROBURST AVOIDANCE CREW PROCEDURES FOR FORWARD-LOOK SENSOR EQUIPPED AIRCRAFT
DAVID A. HINTON and ROSA M. OSEGUERA (NASA, Langley Research Center, Hampton, VA) Aug. 1993 15 p. AIAA, Aircraft Design, Systems and Operations Meeting, Monterey, CA, Aug. 11-13, 1993 refs
(AIAA PAPER 93-3942) Copyright

Microburst, airplane, and sensor characteristics relevant to the development of crew procedures are summarized. A set of system requirements and performance standards which are consistent with microburst and airplane performance characteristics have been developed. It is suggested that an evasive turn to avoid a microburst is not required for airplane survival, if the microburst detected in time to effectively perform the turn. The use of straight-ahead recovery procedures will reduce the impact of windshear equipment on the ATC system and prevent secondary hazards. AIAA

A93-45137* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACTIVE CONTROL OF AEROTHERMOELASTIC EFFECTS FOR A CONCEPTUAL HYPERSONIC AIRCRAFT
JENNIFER HEEG, MICHAEL G. GILBERT (NASA, Langley Research Center, Hampton, VA), and ANTHONY S. POTOTZKY (Lockheed Engineering & Sciences Co., Hampton, VA) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 453-458. AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Pt. 1, p. 200-208. Previously cited in issue 21, p. 3314, Accession no. A90-47597 refs
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A93-45144
AILERON AND SIDESLIP-INDUCED UNSTEADY AERODYNAMIC MODELING FOR LATERAL PARAMETER ESTIMATION
JATINDER SINGH and S. C. RAISINGHANI (Indian Inst. of Technology, Kanpur, India) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 512-518. refs
Copyright

Aileron inputs and sideslipping motion of an aircraft will give rise to a trailing vortex system that is a function of time. To account for such unsteady aerodynamic effects into the lateral equations of motion, a model is proposed based on a simple vortex system. The expressions for induced sidewash and downwash angles obtained for such vortex system are recast so that the resulting equations of motion can be used for parameter estimation. Maximum likelihood method in frequency domain is used to analyze simulated flight data of an example airplane to study the effects of inclusion and omission of unsteady aerodynamic modeling on estimated parameters. Sensitivity of the extracted parameters to different control input forms is shown to reduce with the inclusion of unsteady aerodynamics. Author

A93-45152* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATION OF LEADING-EDGE VORTEX MANIPULATIONS TO REDUCE WING ROCK AMPLITUDES
JAMES WALTON and JOSEPH KATZ (San Diego State Univ., CA) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 555-557. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA, Paper 92-0279. Previously cited in issue 09, p. 1362, Accession no. A92-25733 refs
(Contract NCC2-458)
Copyright

A93-45401
WIND IDENTIFICATION ALONG A FLIGHT TRAJECTORY. III - 2D DYNAMIC APPROACH
A. MIELE, T. WANG, C. Y. TZENG (Rice Univ., Houston, TX), and W. W. MELVIN (Delta Airlines, Atlanta, GA; Airline Line Pilots Association, Washington) Journal of Optimization Theory and Applications (ISSN 0022-3239) vol. 77, no. 1 April 1993 p. 1-29. Research supported by Air Line Pilots Association, United States Aviation Underwriters, and Texas Advanced Technology Program refs
Copyright

An account is given of a 2D-dynamic method for the identification of the wind profile along a flight trajectory, in which wind velocity components are computed as the difference between the inertial velocity components and the airspeed components. The application of this 2D-dynamic approach to the case of Flight Delta 191 indicates that, in the 180 sec prior to impact, the values of the multiplicative factors implied that the actual values of thrust, drag, and lift were respectively 9, 16, and 11 percent below their nominal values. The approach is well suited to the analysis of takeoff and landing windshear accidents. AIAA

A93-45662
DETERMINATION OF THE TAKEOFF AND LANDING CHARACTERISTICS OF AIRCRAFT BY USING A CONDITIONAL POLAR [OPREDELENIE VZLETNO-POSADOCHNYKH KHARAKTERISTIK /VPKH/ SAMOLETA S ISPOL'ZOVANIEM USLOVNOJ POLYARY]
YU. L. BYCHKOV *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 10-13. In RUSSIAN
Copyright

A method for constructing a conditional polar is presented whereby the engine thrust is used as a sufficiently reliable quantity in the analysis of the balance of forces acting on the aircraft. The thrust value is determined on the basis of certification tests, actual values of the engine parameters (rotation speed, fuel consumption, etc), and parameter changes with the altitude and velocity. The approach presented here has been applied to the processing of flight test data obtained for the Yak-42 aircraft. AIAA

A93-45664
DETERMINATION OF THE VERTICAL VELOCITY COMPONENT OF AIRCRAFT LANDING ON AN AIRFIELD WITH A LONGITUDINALLY SLOPING RUNWAY [OPREDELENIE SOSTAVLYAYUSHCHEJ VERTIKAL'NOJ SKOROSTI SAMOLETA PRI POSADKE NA AEHRODROM S PRODOL'NYM UKLONOM VPP]
A. M. KHODORKOVSKIJ and M. A. BLAGODARNYJ *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 20-26. In RUSSIAN refs
Copyright

A formula for determining the vertical velocity component of aircraft during landing is obtained from the results of flight experiments involving student pilots. It is found that the vertical velocity component is invariant with respect to significant gradients of the runway. The results of the study are examined from the standpoint of possibilities for reducing the power capacity of the takeoff and landing equipment, extending the life of aircraft, and constructing runways on inclined surfaces. AIAA

A93-45666

CHARACTERISTICS OF THE DETECTION OF OVERLOADS IN THE CENTER OF MASS OF IL-76 AND AN-12 AIRCRAFT DUE TO RUNWAY IRREGULARITIES BY A STANDARD ON-BOARD RECORDER [ZAKONOMERNOSTI REGISTRATSII SHTATNYM BORTOVYM SAMOPISTSEM K3-63 VOZNIKAYUSHCHIKH PRI NAEZDAKH NA NEROVNOSTI IVPP PEREGRUZOK V TSENTRE MASS SAMOLETOV TIPA IL-76 I AN-12]

A. V. ALAKOZ, A. A. VOLKOV, and V. P. FILIPPOV *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 33-40. In RUSSIAN refs

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Results of earlier studies indicate that the dynamic loads on the aircraft structures resulting from the irregularities of the runway surface are detected by the standard recorder K3-63 with significant errors. The sources of the errors are examined. Based on test results obtained for Il-72 and An-12 aircraft, expressions are obtained for estimating the overloads with an accuracy that is sufficient for practical applications. AIAA

A93-45667

OPERATING AN AIRCRAFT DURING THE LANDING ON AN AIRFIELD WITH A SUBSTANTIAL LONGITUDINAL MACROSLOPE OF THE RUNWAY [OSOBENNOSTI PILOTIROVANIYA SAMOLETA PRI VYPOLNENII POSADKI NA AEHRODROM SO ZNACHITEL'NYM PRODOL'NYM MAKROUKLONOM VPP]

A. M. KHODORKOVSKIJ and M. A. BLAGODARNYJ *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 40-46. In RUSSIAN refs

Copyright

The possibility of the safe aircraft landing on runways with large longitudinal slopes (up to 10 deg) without any changes in the airframe and landing gear design is examined analytically by calculating the associated loads on the aircraft structures. Several safe techniques for landing aircraft on such runways are described and illustrated graphically. AIAA

A93-46807* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

TWO LEADING-EDGE DROOP MODIFICATIONS FOR TAILORING STALL CHARACTERISTICS OF A GENERAL AVIATION TRAINER CONFIGURATION

HOLLY M. ROSS (NASA, Langley Research Center, Hampton, VA) and JOHN N. PERKINS (North Carolina State Univ., Raleigh) Mar. 1992 21 p. Symposium on General Aviation Systems, 2nd, Wichita, KS, Mar. 16, 17, 1992, Paper refs

The high-angle-of-attack testing intended to develop leading-edge modifications for tailoring the stall characteristics of model is described. Two different leading-edge modifications are considered: a small profile leading-edge droop on the outboard 24 percent of the wing and a large profile leading-edge droop on the outboard 50 percent of the wing. Results indicate that the longitudinal stability for the unmodified and both modified configurations was good for low angle of attack, but the modified configurations exhibited neutral longitudinal stability just prior to stall. The unmodified and both modified configurations demonstrated good lateral stability characteristics for low angles of attack, but all configurations were directionally unstable for high angles of attack. AIAA

A93-47205#

TANGENTIAL FOREBODY BLOWING-YAW CONTROL AT HIGH ALPHA

W. J. CROWTHER and N. J. WOOD (Bath Univ., United Kingdom) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 34-42. refs

(AIAA PAPER 93-3406) Copyright

Aircraft yaw control at high angles of attack by Tangential Forebody Blowing has been investigated experimentally. Tests were performed in the University of Bath 2.1 x 1.5 m low speed wind tunnel using an approximately 6 percent scale generic combat aircraft model fitted with blowing slots in the nose cone. Six component strain gauge balance force and moment data were measured for angles of attack up to 90 deg and for a number of different slot geometries and locations. The performance of momentum and mass flow based aerodynamic scaling parameters was assessed. It was found that small blowing rates from short slots at the front of the forebody could produce large controlled yawing moments up to around 60 deg angle of attack; however, longer slots at larger blowing rates could provide control at angles of attack up to 90 deg, where no coherent vortical flow is present. The effect of slot angular position is demonstrated and a slot stall phenomenon described. A geometry dependent forebody/wing flow-field coupling has been identified which can lead to unexpected yawing moments and uncommanded rolling moments.

Author (revised)

A93-47206#

SIDE-FORCE CONTROL ON A FOREBODY OF DIAMOND CROSS-SECTION AT HIGH ANGLES OF ATTACK

DHANVADA M. RAO and GAUTAM SHARMA (Vigyan, Inc., Hampton, VA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 43-52. Research supported by USAF refs

(AIAA PAPER 93-3407) Copyright

A high-alpha side force control concept for diamond cross-section forebodies is presented. A full-length strake deployed on one of the lower facets forces a large-scale separation vortex adjacent to the forebody surface, whose suction provides side force across an appreciable alpha range. Simultaneously, the leeside vortex suction and consequently the forebody normal force are reduced, leading to pitch-up alleviation and drag reduction at high angles of attack. Low-speed wind tunnel measurements of surface pressures and six-component load characteristics, supported by flow visualizations, obtained on an isolated diamond forebody model validated the control concept and verified its control effectiveness to nearly 70 deg angle of attack.

A93-47219#

THE MOVING WALL EFFECT VIS-A-VIS OTHER DYNAMIC STALL FLOW MECHANISMS

LARS E. ERICSSON *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 208-216. refs

(AIAA PAPER 93-3424) Copyright

An analysis is performed to determine the importance of the so called moving wall effect relative to other unsteady flow mechanisms present in the dynamic stall process. Analysis of existing theoretical and experimental results indicates that the tangential moving wall effect on the initial boundary layer development, close to the flow stagnation point, is not satisfactorily represented in present numerical methods. The analysis shows also that whereas this moving wall effect plays a dominant role in inciting self-excited oscillations, such as the wing rock of advanced aircraft, it probably plays a rather insignificant role in so called supermaneuvers of these aircraft, performed at very high angular rates.

A93-47222#

EFFECT OF CANARD OSCILLATIONS ON THE VORTICAL FLOWFIELD OF A X-31A-LIKE FIGHTER MODEL IN DYNAMIC MOTION

SHESHAGIRI K. HEBBAR, MAX F. PLATZER, and DA-MING LIU (U.S. Naval Postgraduate School, Monterey, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993,

Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 241-250. Research supported by U.S. Navy refs
(AIAA PAPER 93-3427)

A water tunnel flow visualization investigation was carried out in the Naval Postgraduate School water tunnel using the dye injection technique to study the effects of oscillating a close-coupled canard on a 2.3 percent scale model of a X-31A-like fighter aircraft. The investigation focussed primarily on the effects of canard oscillations on the breakdown characteristics of the wing root vortex for both static and dynamic conditions of the model at zero sideslip angle. The main results of this first of a kind flow visualization data suggest that for the static conditions of the model the LF/HF canard oscillations tend to destabilize/augment the wing vortex core, i.e., promote/delay bursting of the wing vortex core. The dynamic tests indicate that the large amplitude LF oscillations of the canard interact favorably with the wing vortical flowfield to delay vortex bursting during both pitch-up and pitch-down motions. Author (revised)

A93-47235*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FOREBODY VORTEX CONTROL WITH JET AND SLOT BLOWING ON AN F/A-18
BRIAN R. KRAMER, CARLOS J. SUAREZ, GERALD N. MALCOLM (Eidetics International, Inc., Torrance, CA), and KEVIN D. JAMES (Sterling Federal Systems, Inc., Palo Alto, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 387-397. refs
(Contract NAS2-13383)
(AIAA PAPER 93-3449) Copyright

A wind tunnel test program was conducted in October, 1992, on a 6-percent F/A-18 model, to determine the most effective methods of forebody vortex control for providing increased yaw control at high angles of attack. A series of circular jet blowing configurations were investigated with variations in blowing rate, fuselage station, circumferential position, and blowing angle. Slot configurations were also tested and included variations in blowing rate, forward fuselage station, and length. The optimum jet and slot configurations were then also tested at -10 deg of sideslip. Yawing moments from both the jet and slot blowing configurations were found to have very good trends with increasing blowing rates and the maximum yaw control available at 50-deg angle of attack (where rudder power had dropped to near zero) was found to be 40 percent greater than the level provided by the rudder at 0-deg angle of attack. Author (revised)

A93-47236*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FOREBODY VORTEX CONTROL ON AN F/A-18 USING SMALL, ROTATABLE 'TIP-STRAKES'
CARLOS J. SUAREZ, BRIAN R. KRAMER, and GERALD N. MALCOLM (Eidetics International, Inc., Torrance, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 398-408. refs
(Contract NAS2-13383)
(AIAA PAPER 93-3450) Copyright

A mechanical scheme for manipulating the forebody vortices of an F/A-18, therefore creating controlled yawing moments at moderate and high angles of attack, was investigated in a wind tunnel. The technique consists of rotating miniature strakes (single or dual) about the radome centerline very close to the tip of the model. Forces, moments, and pressures were measured for angles of attack up to 60 deg and sideslip angles up to -10 deg. Results indicate that single and dual strakes can produce changes in side force and yawing moment, with magnitudes comparable to, or in some cases higher than, the directional changes produced by a 30-deg rudder deflection at 0-deg angle of attack. According to its circumferential position, the strake alters the separation location, inducing different degrees of asymmetry in the forebody vortex flow field that are translated into changes in side force and yawing moment. In comparison, the dual strakes appear to provide more gradual and better behaved changes than the single strake. Excellent correlation was found between this test and water tunnel tests performed on a similar configuration. Author (revised)

A93-47280*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLOW VISUALIZATION OF MAST-MOUNTED-SIGHT/MAIN ROTOR AERODYNAMIC INTERACTIONS
TERENCE A. GHEE (Analytical Services and Materials, Inc., Hampton, VA) and HENRY L. KELLEY (U.S. Army, Aeroflightdynamics Directorate; NASA, Langley Research Center, Hampton, VA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 903-920. refs
(AIAA PAPER 93-3517)

Flow visualization tests were conducted on a 27 percent-scale AH-64 attack helicopter model fitted with various mast-mounted-sight configurations in an attempt to identify the cause of adverse vibration encountered during full-scale flight tests of an Apache/Longbow configuration. The tests were conducted at the NASA Langley Research Center in the 14- by 22-Foot Subsonic Tunnel. A symmetric and an asymmetric mast-mounted-sight oriented at several skew angles were tested at forward and rearward flight speeds of 30 and 45 knots. A laser light sheet seeded with vaporized propylene glycol was used to visualize the wake of the sight in planes parallel and perpendicular to the freestream flow. Analysis of the flow visualization data identified the frequency of the wake shed from the sight, the angle-of-attack at the sight, and the location where the sight wake crossed the rotor plane. Differences in wake structure were observed between the various sight configurations and slew angles. Postulations into the cause of the adverse vibration found in flight test are given along with considerations for future tests.

N93-31068 Stanford Univ., CA.
EXPERIMENTS IN THE CONTROL OF WING ROCK AT HIGH ANGLE OF ATTACK USING TANGENTIAL LEADING EDGE BLOWING Ph.D. Thesis
GRANT SURE-MAN WONG 1993 204 p
Avail: Univ. Microfilms Order No. DA9309684

Supermaneuverability of highly swept delta wing aircraft requires operation in regions of the flight envelope where very high angles-of-attack are encountered. In these regions, the vortical flow on the lee side of the wing characteristic of highly swept wings at low to moderate angles-of-attack becomes highly unsteady and disappears completely. Conventional control surfaces operating in the wake of such stalled flow are incapable of generating the necessary forces and moments to control the aircraft. The investigation is motivated by the success of recent research in the use of thin, high momentum jet sheets blown tangentially along the wing leading edges as a means to reestablish and to control directly the vortical flow at post-stall angles-of-attack. It is found presently that a good strategy for generating linear roll control torque is to first blow symmetrically, i.e., blowing equally along both leading edges of the wing. This produces a controllable attached flow. Then by asymmetrically increasing the blowing strength along either the left or the right leading edge, positive or negative rolling moment is generated. It is this resultant rolling moment that is used to control the rolling motion of the wing. A parametric semi-empirical aerodynamics model is developed to simulate the static effects of tangential leading edge blowing on both the vortical flow field and the resulting wing rolling moment. Parameters of the model are identified from experimental data by means of a least-squares parameter identification method. The completed aerodynamics model is coupled with a one-degree-of-freedom dynamics model to simulate the natural, i.e., wing rock, and the controlled wing rolling behavior. Fidelity of the parametric models is verified by comparing simulated roll responses with experimental wind tunnel data. An active feedback control algorithm is designed to regulate the amount of asymmetric blowing to achieve roll control. The effectiveness of tangential leading edge blowing as a roll control device is demonstrated experimentally in wind tunnel tests by the stabilization of a delta wing model which underwent wing rock at an angle-of-attack of fifty-five degrees. Dissert. Abstr.

N93-31278# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugfuehrung.
TESTING CONCEPT OF A TAXIING CONTROL SYSTEM, SUMMARY
A. BECKER *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 104-114 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 105-113 Original language document was announced as N92-25597
Avail: CASI HC A03/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany

The requirements and testing necessary for the design of a ground traffic control system are addressed. Work is focused on the following: construction of a planning, monitoring, and guidance system for ground traffic on the airfield; construction of a system for detection of any obstacles and of the state vector of the targets (traffic units) on the airfield; and construction of a communication system for air to ground and ground to air data links. The requirements for target state vector determination are as follows: location accuracy 5 m; velocity accuracy 0.5 m/s; heading accuracy 5 deg; minimum measurement rate 1/sec; and individual identification. Requirements for digital communication are as follows: data exchange between airborne and ground systems; transmission of guidance information to the pilot; uplink capacity 400 bit/s per traffic unit; and downlink capacity 300 bit/s per traffic unit. The following candidate elements are considered as supplementary elements for location: the differential multialteration method (hyperbola navigation; based on SSR mode S or DME (Distance Measuring Equipment) basic systems); the differential GPS (Global Positioning System); and a composite system of coherent pulsed dislocated radar elements with fixed antenna (noncooperative system). ESA

N93-31280# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugfuehrung.
DEVELOPMENT AND FLIGHT TESTING OF A FAULT-TOLERANT FLY-BY-LIGHT YAW CONTROL SYSTEM
G. MANSFELD, K. BENDER, and J. TERSTEEGEN *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 157-183 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 154-176 Original language document was announced as N92-25599
Avail: CASI HC A03/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany

An overview of a fly by light yaw control system which uses the DISCUS (Digital Self healing Control for Upgraded Safety) computing system, its implementation, and the results of flight testing are provided. The objectives of the program described were to utilize innovative technologies in signal transmissions, actuator systems, and redundancy management and to test a single axis feed forward controller with 100 percent actuation accuracy. Plans to expand DISCUS to build a 4 axis control system are outlined. Details of the DISCUS system concept, computer architecture, and data processing concept are given. The integrated fiber optic intelligent actuator has command input via fiber optical cables. The main goals in the design and evaluation of the yaw controller were to improve the helicopter's handling characteristics and to expand its range of operation. These goals and the flight testing of the yaw controller are addressed. ESA

N93-32380*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A HIGH-FIDELITY, SIX-DEGREE-OF-FREEDOM BATCH SIMULATION ENVIRONMENT FOR TACTICAL GUIDANCE RESEARCH AND EVALUATION
KENNETH H. GOODRICH Washington Jul. 1993 53 p
(Contract RTOP 505-64-30-01)
(NASA-TM-4440; L-17096; NAS 1.15:4440) Avail: CASI HC A04/MF A01

A batch air combat simulation environment, the tactical maneuvering simulator (TMS), is presented. The TMS is a tool for developing and evaluating tactical maneuvering logics, but it can also be used to evaluate the tactical implications of perturbations to aircraft performance or supporting systems. The TMS can simulate air combat between any number of engagement participants, with practical limits imposed by computer memory and processing power. Aircraft are modeled using equations of motion, control laws, aerodynamics, and propulsive characteristics equivalent to those used in high-fidelity piloted simulations. Data bases representative of a modern high-performance aircraft with and without thrust-vectoring capability are included. To simplify the task of developing and implementing maneuvering logics in the TMS, an outer-loop control system, the tactical autopilot (TA), is implemented in the aircraft simulation model. The TA converts guidance commands by computerized maneuvering logics from desired angle of attack and wind-axis bank-angle inputs to the inner loop control augmentation system of the aircraft. The capabilities and operation of the TMS and the TA are described. Author

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RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A93-44886* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CRYOGENIC WIND TUNNELS
ROBERT A. KILGORE (NASA, Langley Research Center, Hampton, VA) Dec. 1990 11 p. ONERA, Symposium on Cryogenic Wind Tunnels, Toulouse, France, Dec. 7, 1990, Paper refs

Some of the major problems in wind tunnel research and testing are reviewed and solutions are suggested. Support interference, wall interference, flow unsteadiness, and low Reynolds number are all discussed. The evolution of cryogenic wind tunnels, principles of operation, and testing capabilities are reviewed. Several test facilities are described and the use of cryogenic wind tunnels to increase test Reynolds number is suggested. AIAA

A93-44892* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LANGLEY 8-FOOT HIGH-TEMPERATURE TUNNEL OXYGEN MEASUREMENT SYSTEM
DANNY R. SPRINKLE (NASA, Langley Research Center, Hampton, VA), TONY D. CHEN, and SUSHIL K. CHATURVEDI (Old Dominion Univ., Norfolk, VA) May 1991 20 p. ISA, International Instrumentation Symposium, 37th, San Diego, CA, May 5-9, 1991, Paper refs
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In order to ensure that there is a proper amount of oxygen necessary for sustaining test engine operation for hypersonic propulsion systems testing at the NASA Langley 8-foot high-temperature tunnel, a quickly responding real-time measurement system of test section oxygen concentration has been designed and tested at Langley. It is built around a zirconium oxide-based sensor which develops a voltage proportional to the oxygen partial pressure of the test gas. The voltage signal is used to control the amount of oxygen being injected into the combustor air. The physical operation of the oxygen sensor is described, as well as the sampling system used to extract the test gas from the tunnel test section. Results of laboratory tests conducted to verify sensor accuracy and response time performance are discussed, as well as the final configuration of the system to be installed in the tunnel. AIAA

A93-45167
RECENT IMPROVEMENTS ON THE DYNAMIC FLIGHT SIMULATOR
JACOB EYTH, JR. and PEGGY L. HEFFNER (U.S. Navy, Naval Air Warfare Center, Warminster, PA) SAFE Journal vol. 23, no. 2 Mar.-Apr. 1993 p. 10-23. refs
Copyright
The Dynamic Flight Simulator located at the Naval Air Warfare Center, Aircraft Division, Warminster has demonstrated a unique capability to perform motion-based flight simulation over the years. Using a 50-foot human centrifuge as its motion platform, it bridges the gap from fixed-based flight simulators to flight testing by creating the actual stresses of flight on the pilot. Under these realistic conditions, simple tasks become difficult and decision making can often be delayed. By using the Dynamic Flight Simulator, operational deficiencies can be identified early in the development program before they are uncovered in flight tests. This approach can result in significantly lower development costs. This paper will explain the overall design of the Dynamic Flight Simulator and describes several successful test programs in which it has been used. Applications range from early NASA astronaut training to the current high angle of attack (HAOA) and thrust vectored aircraft studies. Also included in the paper are discussions of future applications and upgrades intended for the facility. Author

A93-45452
SHOCK TUBE APPLICATION - HIGH ENTHALPY EUROPEAN WIND TUNNELS
H. GROENIG (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 3-16. refs
Copyright
High enthalpy wind tunnels which are used in Europe for the development of new hypersonic vehicles are described. Also included are three new tunnels which will be in operation shortly. More details are given for one piston tunnel (Longshot at VKI in Brussels, Belgium) and two shock tunnels (C2 at Vernon, France and TH2 at Aachen, Germany). A key problem is the knowledge of the test section flow. A technique has been developed to rely only on the measured test section data for the determination of Stanton numbers and pressure coefficients.

A93-45496* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN OVERVIEW OF AMES EXPERIMENTAL AEROTHERMODYNAMICS
C. PARK (NASA, Ames Research Center, Moffett Field, CA) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 591-596. refs
Copyright
This paper reviews the recent experimental research activities on aerothermodynamics within NASA Ames Research Center. The activities included in this review are those in (1) the electric arc-driven shock tubes, (2) the combustion-driven shock tube, (3) the ballistic ranges, and (4) the arc-jet wind tunnel facilities. The paper is a collection and collation of the papers published previously in the open literature on the activities in these facilities. The paper highlights the contributions made by each facility in the high temperature real-gas flow regimes.

A93-45497
PERFORMANCE CONSIDERATIONS IN THE OPERATION OF FREE-PISTON DRIVEN HYPERSONIC TEST FACILITIES
D. M. JENKINS, R. J. STALKER, and W. R. B. MORRISON (WBM Stalker, Pty., Ltd., Brisbane, Australia) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 597-602. refs
Copyright
There are two fundamental limitations to useful test time in a free-piston driven shock tunnel. One is the contamination of the test flow by driver gas (a limitation in all shock tunnels). The second is the ability to maintain a nearly constant stagnation pressure in the gas driving the nozzle flow. However, practical experience has shown that it is possible to manipulate the operating variables of a tunnel of a given design so as to trade off these two phenomena and obtain the optimum conditions for particular experimental requirements. While contamination remains an absolute limit to performance, both experimental results and theoretical investigations have shown that the requirement for 'constant' pressure can be relaxed. With appropriate treatment of data, valid and useful tests can be carried out in a falling (or rising) pressure regime.

A93-45498* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PERFORMANCE DATA OF THE NEW FREE-PISTON SHOCK TUNNEL T5 AT GALCIT
H. HORNUNG, B. STURTEVANT, J. BELANGER, S. SANDERSON, M. BROUILLETTE (California Inst. of Technology, Pasadena), and M. JENKINS (WBM Stalker, Pty., Ltd., Brisbane, Australia) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 603-610. refs
(Contract N00014-90-J-1305; NAG1-1209)
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A new free piston shock tunnel has been constructed at the Graduate Aeronautical Laboratories at Caltec. Compression tube length is 30 m and diameter 300 mm. Shock tube length is 12 m and diameter 90 mm. Piston mass is 150 kg and maximum diaphragm burst pressure is 130 MPa. Special features of this facility are that the pressure in the driver gas is monitored throughout the compression process until well after diaphragm rupture, and that the diaphragm burst pressure can be measured dynamically. An analysis of initial performance data including transient behavior of the flow over models is presented.

A93-45528
FREE PISTON FACILITIES WITH AIR DRIVER GAS
C. N. ANDERSON (Allgas Energy, Ltd., Mansfield, Australia), A. PAULL, R. J. STALKER, and J. M. SIMMONS (Queensland Univ., St. Lucia, Australia) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 985-990. refs
Copyright
The advantageous use of air rather than helium as the driver gas is discussed with reference to three simple forms of free piston shock tube or shock tunnel. Firstly, a small free piston shock tube with air driver gas initially at atmospheric pressure is shown to be a simple facility with short re-cycling time. The test conditions that can be obtained, typically 4000 K and 100 microsec test time, are suitable for a range of strong shock studies. Secondly, it is shown that air can be used as the driver gas in an expansion tube when relatively low enthalpies are required (typically 10MJ/kg). Useful test times in the particular facility are not possible with helium driver gas at these enthalpies. Lastly, a shock tube with a light piston compressing air driver gas is described for use in ignition and combustion studies of large particles of a cellulosic fuel. Such studies require test times of some milliseconds and near atmospheric pressure, conditions that can be achieved in the reflected shock zone.

A93-45529
A NOVEL DEVELOPMENT OF THE LUDWIEG TUBE, FOR EXTENDED TEST DURATION
L. Z. DUMITRESCU (Inst. of Aeronautics, Bucharest, Romania) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York

Springer-Verlag 1992 p. 991-996.
Copyright

In order to increase the running time of a Ludwieg tube, a simple modification of the configuration is devised: the discharge-tube is connected, at its upstream end, to a larger tank, through a properly-sized diaphragm orifice. In this way, one cancels the successive reflections, at the upstream end, of the expansion wave which sets the flow in motion in the tube. A three to four-fold increase in run-time is experimentally demonstrated. Applications envisaged are in extending the flow duration for aerodynamic testing (e.g. flutter, buffet), in improving the operation and flow quality of blow-down wind-tunnels, etc. This set-up may also be thought of as an inexpensive device to produce, albeit for a limited time, a constant-flow discharge from a tank, without the need for a piloted control valve.

A93-45530* National Aeronautics and Space Administration, Washington, DC.
HYPERVELOCITY FLOWS OF ARGON PRODUCED IN A FREE PISTON DRIVEN EXPANSION TUBE
A. J. NEELY and R. J. STALKER (Queensland Univ., St. Lucia, Australia) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 997-1004. Research supported by Australian Research Council refs
(Contract NAGW-674)
Copyright

An expansion tube with a free piston driver has been used to generate quasi-steady hypersonic flows in argon at flow velocities in excess of 9 km/s. Irregular test flow unsteadiness has limited the performance of previous expansion tubes. Test section measurements of pitot pressure, static pressure, and flat plate heat transfer rates are used to confirm the presence of quasi-steady flow, and comparisons are made with predictions for the equilibrium flow of an ideal, ionizing, monatomic gas. The results of this work indicate that expansion tubes can be used to generate quasi-steady hypersonic flows in argon at speeds in excess of Earth orbital velocity. Author (revised)

A93-45532
A COMBINED FACILITY OF BALLISTIC RANGE AND SHOCK TUNNEL USING A FAST ACTION VALVE
T. ABE, K. FUNABIKI (Inst. of Space and Astronautical Science, Sagamihara, Japan), and H. OGUCHI (Lasertec Lab., Tokyo, Japan) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 1025-1030. refs
Copyright

A combined ballistic range and shock tunnel facility has been developed, in which the rupture disks conventionally employed in those facilities are replaced by a fast action valve. This enables a short turn-around time of the facility and a good repeatability of the experiment to be achieved. Examples of ballistic range and shock tunnel operation of the facility are presented and demonstrate the capability of the present facility in future applications.

A93-45794
TEST FACILITY FOR EVALUATION OF STRUCTURAL INTEGRITY OF STIFFENED AND JOINTED AIRCRAFT CURVED PANELS
G. SAMAVEDAM, D. HOADLEY (Foster-Miller, Inc., Waltham, MA), and J. DAVIN (DOT, Transportation Systems Center, Cambridge, MA) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 321-337. Research sponsored by FAA refs
Copyright

An account is given of a test facility for fatigue and fracture-strength evaluation of stiffened and jointed aircraft fuselage panels with up to 40-deg curved sectors and as much as 58 x 120 inches in dimension. Internal pressure loads of up to 20 psi, with corresponding hoop and longitudinal restraining loads, can be applied; cyclic pressurization can also be applied for fatigue behavior-related studies. The test facility can identify factors contributing to multiple site damage in curved structures, as well as generate fatigue data for comparing data from flat coupons, and evaluating a FEM-based theoretical model that is under development. AIAA

A93-46525#
AEDC H2 FACILITY - NEW TEST CAPABILITIES FOR HYPERSONIC AIR-BREATHING VEHICLES
J. H. STEWART (Calspan Corp., Arnold AFB, TN) Jul. 1993 9 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 Research supported by National Aerospace Plane Joint Program Office refs
(AIAA PAPER 93-2781)

The USAF Arnold Engineering Development Center's H2 test facility furnishes combustion performance at simulated flight conditions in excess of Mach 11, as well as materials/structures performance-evaluation conditions for the most severe region of the hypersonic airbreathing corridor. True-temperature aerodynamic testing will extent to Mach 8. An account is given of the AEDC H2 facility's upgrading to furnish a steady-state direct-connect capability for scramject combustor testing. AIAA

A93-46526#
FLOW CALIBRATION OF TWO HYPERSONIC NOZZLES IN THE AEDC HEAT-H2 HIGH-ENTHALPY ARC-HEATED WIND TUNNEL
D. M. SMITH and D. B. CARVER (Calspan Corp., Arnold AFB, TN) Jul. 1993 10 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 Research supported by USAF refs
(AIAA PAPER 93-2782)

The Arnold Engineering Development Center (AEDC) has added to its test facility inventory an arc-heated wind tunnel that can provide a large free-jet (up to 42-in. diam at the nozzle exit) hypersonic flow. The tunnel, designated HEAT-H2, uses air for true-temperature, true-pressure simulations at velocities up to 15,000 ft/sec and altitudes up to 165,000 ft. Existing conical nozzles yield flow Mach numbers from 4 to 8. Included herein is a summary of facility capabilities and selected results from an initial flow-field calibration. Two free-jet nozzles were calibrated, a 9-in.-exit diam nozzle and a 24-in.-exit diam nozzle, both with 1.5-in.-diam throats. Measurements within the free jet included distributions of pitot pressure, total enthalpy, and flow angle. Surface pressure and heat flux data on blunt cones and wedges were also obtained. Arc heater chamber conditions ranged from 31 to 65 atm pressure, with total enthalpy from 1,500 to 2,160 Btu/lbm. The facility should prove useful for a wide variety of hypersonic testing requirements including aerothermal testing of structures, heat shields, antenna windows, etc., and aeropropulsion testing of scramjet combustors.

A93-46656#
A REPORT ON THE STATUS OF MHD HYPERSONIC GROUND TEST TECHNOLOGY IN RUSSIA
VADIM ALFEROV (TsAGI, Moscow, Russia) Jul. 1993 6 p. AIAA, Plasmadynamics and Lasers Conference, 24th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-3193) Copyright

The paper describes the TsAGI (Tsentral'nyi Aero-Gidrodinamicheskii Institut) hypervelocity wind tunnel and its substructures, including the conductive gas source comprising the arc heater and the seed supply system, the primary nozzle, the MHD channel itself with segmented electrodes, the magnetic system, the system of electrode power supply, the secondary nozzle, the test section, and the exhaust system. Particular attention is given to the methodology used in the hypersonic ground tests and to data processing. It is shown that the distribution of heat fluxes on the MHD channel elements is well described by the Spalding-Chi relationships. A method for calculating the flow parameters of nozzles' output was developed assuming the dependence of the velocity of chemical reaction on the translational and vibrational temperatures, and the calculated data were compared with experimental results. AIAA

A93-46806* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
USE OF CONVEX SUPERCOMPUTERS FOR FLIGHT SIMULATION AT NASA LANGLEY
JEFF I. CLEVELAND, II (NASA, Langley Research Center, Hampton, VA) May 1992 12 p. Convex User Group Worldwide Conference, Richardson, TX, May 17-22, 1992, Paper refs
The use of the Convex Computer Corporation supercomputers for flight simulation is discussed focusing on a real-time input/output system for supporting the flight simulation. The flight simulation computing system is based on two single processor control data corporation CYBER 175 computers, coupled through extended memory. The Advanced Real-Time Simulation System for digital data distribution and signal conversion is a state-of-the-art, high-speed fiber-optic-based, ring network system which is based on the computer automated measurement and control technology. AIAA

A93-46825* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE ADAPTIVE WALL TEST SECTION FOR THE NASA LANGLEY 0.3-M TRANSONIC CRYOGENIC TUNNEL
RAYMOND E. MINECK (NASA, Langley Research Center, Hampton, VA) Oct. 1985 30 p. Supersonic Tunnel Association, Semi-Annual Meeting, 64th, San Diego, CA, Oct. 1-3, 1985, Paper refs
The effect of wind tunnel wall interference on transonic aerodynamic data obtained in a ventilated test section is difficult to predict. The magnitude of the interference can be reduced and the prediction of the level of interference can be simplified by testing in a test section with solid, adaptive walls. An adaptive wall test section configured for two dimensional testing has been installed in the circuit of the Langley 0.3-m Transonic Cryogenic Tunnel. The unique features of the tunnel and the new test section are described. An overview of computer software to configure the walls along streamsurfaces is presented along with a description of the of the experiments planned to assess the capabilities of the new test section.

A93-46915
THE CRYOGENIC WIND TUNNEL
M. J. GOODYER (Southampton Univ., United Kingdom) Progress in Aerospace Sciences (ISSN 0376-0421) vol. 29, no. 3 1992 p. 193-220. refs
Copyright
Until recently engineers have been unable to reach full scale Reynolds number in most wind tunnel tests. The cryogenic wind tunnel has been introduced to provide the aerospace community with the means to test models at near-full-scale Reynolds numbers, satisfying a particular need at transonic speeds. The background to the need for high Reynolds number wind tunnels is outlined together with options. The main advantages of the cryogenic option are highlighted which led to this type being adopted for transonic testing. The novel technology is described together with brief descriptions of several of the more major tunnel projects.

A93-46933
PROPULSION SYSTEM SIMULATOR WITH PROPFAN FOR TESTS ON A LARGE SCALE MODEL OF IL-114 AIRPLANE IN A FULL-SIZE WIND TUNNEL OF TSAGI
A. G. POPOVYAN, B. G. DUL'SKIJ, G. V. RODZEVICH (TsAGI, Zhukovski, Russia), E. HOEFLER, and B. SIROK (Turboinst., Ljubljana, Slovenia) Revue Francaise de Mecanique (ISSN 0373-6601) no. 3 1992 p. 269-278. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07
Copyright
A model of the IL-114 turboprop passenger aircraft designed to carry out research on takeoff/landing characteristics is described. The model has two propulsion system simulation models consisting of a three-stage hot-air turbine, planetary gear, and a six-bladed propeller. The model has a power of 482 kW and is equipped with measurement and control system to monitor turbine operation. Typical measurement results are presented. AIAA

A93-47015* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LANGLEY PROPOSED ADVANCED HYPERVELOCITY AEROPHYSICS FACILITY - A STATUS REPORT
ROBERT D. WITCOFSKI and WILLIAM I. SCALLION (NASA, Langley Research Center, Hampton, VA) Oct. 1989 21 p. Supersonic Tunnel Association, Semi-Annual Meeting, 72nd, Princeton Univ., NJ, Oct. 3, 4, 1989, Paper refs
A ground-based facility capable of performing flight tests on relatively large highly instrumented models and scaled vehicle components at velocities and densities representative of a hypervelocity flight in earth and planetary atmospheres is reviewed. This facility proposed by the Langley Research Center is based on a launcher, a test chamber, and a model impact/deceleration chamber. It would initially utilize existing light-gas gun launcher technology scaled to 4 times present launcher size. It is planned to enhance its velocity and model size capability either by an electromagnetic launcher or a ram accelerator. AIAA

A93-47021* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TESTING EXPERIENCE WITH UNHEATED STAIN-GAGE BALANCES IN THE NTF
PETER F. JACOBS and ALICE T. FERRIS (NASA, Langley Research Center, Hampton, VA) Oct. 1986 20 p. Supersonic Tunnel Association, Semiannual Meeting, 66th, Albuquerque, NM, Oct. 6, 7, 1986, Paper refs
A series of cryogenic (cryo) cycles was conducted in the cryo chamber at the National Transonic Facility (NTF) in order to identify the cause of apparent strain shifts in axial force with temperature for the Pathfinder I model and to minimize their effects. The results of the investigation indicated that the major cause of axial force end point shifts and thermal hysteresis loops was the thickness of the Teflon insulation on the instrumentation wires crossing the balance. By reducing the thickness of the insulation and the total number and size of the wires, apparent strain values were achieved for the model with instrumentation wires which were nearly identical to those for the model without wires. Because of the special design features used, the balance output was very accurate and repeatable over the entire NTF temperature range, even with balance thermal gradients as large as 64 F and transient conditions as large as 3 F/minute. Author (revised)

A93-47022* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ANALYSIS OF AEROELASTIC AND RESONANCE RESPONSES OF A WIND TUNNEL MODEL SUPPORT SYSTEM
WOODROW WHITLOW, JR., ROBERT M. BENNETT (NASA, Langley Research Center, Hampton, VA), and THOMAS W. STRGANAC (Texas A & M Univ., College Station) Sep. 1991 7 p. International Symposium on Computational Fluid Dynamics, 4th, Davis, CA, Sept. 9-12, 1991, Paper refs
Vibrations of the National Transonic Facility model support system were analyzed using CAP-TSD (Computational Aeroelasticity Program-Transonic Small Disturbance), a three-dimensional transonic small disturbance potential code designed for aeroelastic analysis of complex configurations. The model support system was represented as a tunnel-spanning flexible wing whose structural properties were obtained from measured responses. Aeroelastic transients were calculated, assuming no structural damping, and analyzed to obtain modal stability characteristics. The results showed that there is a tendency toward a hump mode instability in one of the modes and that there are other weakly damped or unstable modes. The close proximity of the solid wind-tunnel diffuser side walls to the model support system was shown to have adverse effects on its aeroelastic stability characteristics. When the effects of the wind-tunnel walls were modeled, the analyses indicated the

presence of wind-tunnel resonance modes which were not present when free-air boundary conditions were used.

A93-47024* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
REQUIREMENTS FOR FACILITIES AND MEASUREMENT TECHNIQUES TO SUPPORT CFD DEVELOPMENT FOR HYPERSONIC AIRCRAFT
WILLIAM L. SELLERS, III and DOUGLAS L. DWOYER (NASA, Langley Research Center, Hampton, VA) Apr. 1992 11 p. NATO, Advanced Research Workshop on New Trends in Instrumentation for Hypersonic Research, Toulouse, France, Apr. 27-May 1, 1992, Paper refs
The design of a hypersonic aircraft poses unique challenges to the engineering community. Problems with duplicating flight conditions in ground based facilities have made performance predictions risky. Computational fluid dynamics (CFD) has been proposed as an additional means of providing design data. At the present time, CFD codes are being validated based on sparse experimental data and then used to predict performance at flight conditions with generally unknown levels of uncertainty. This paper will discuss the facility and measurement techniques that are required to support CFD development for the design of hypersonic aircraft. Illustrations are given of recent success in combining experimental and direct numerical simulation in CFD model development and validation for hypersonic perfect gas flows.

A93-47230#
A VISUALIZING METHOD OF STREAMLINES AROUND HYPERSONIC VEHICLES
MASATOMI NISHINO (Fukuyama Univ., Japan) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 332-337. refs
(AIAA PAPER 93-3440) Copyright
The present method for streamline visualization around a hypersonic vehicle by means of an electric discharge is demonstrated for the case of a streamline around a wedge with a 2D rectangular afterbody. The streamline is compared with the theoretical case obtained by the method of characteristics. This comparison confirms the accuracy of the electric discharge visualization method. AIAA

A93-47240#
FREE-SPIN DAMPING MEASUREMENT TECHNIQUES
E. J. MARQUART (Calspan Corp., Arnold AFB, TN) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 455-462.
(AIAA PAPER 93-3457)
The present supersonic wind tunnel tests have ascertained the static longitudinal stability and rolling moment, roll-damping moment, and Magnus force derivative characteristics of a high-speed missile model whose rolling moment was generated by canting its tail fins relative to the wind tunnel flow. Analysis of these dynamic data shows that the applied rolling-moment coefficient was independent of model roll rate, and equal to the rolling moment coefficient. A comparison with another spin test program that obtained different trends indicates significant differences in the tail fin region. AIAA

A93-47281*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MEASUREMENTS IN 80- BY 120-FOOT WIND TUNNEL OF HAZARD POSED BY LIFT-GENERATED WAKES
V. J. ROSSOW, J. N. SACCO, P. A. ASKINS, L. S. BISBEE, and S. M. SMITH (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 921-939. refs
(AIAA PAPER 93-3518) Copyright
The large, low speed wind tunnel at NASA-Ames has been used to study the characteristics of lift-generated vortices involved in the definition of aircraft-separation criteria, in order to enhance airport capacity without compromising safety. Attention is given to the potential hazard caused by the vortex wake of several configurations of a subsonic transport. Measured downwash distributions in the wake of three different wake-generator configurations are obtained by means of a vortex-lattice method, in order to predict the lift and rolling moment on several models of wake-following aircraft. AIAA

N93-31042# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
A BREAK-DOWN OF STING INTERFERENCE EFFECTS
A. ELSENAAR and S. O. T. H. HAN 1 May 1991 66 p Presented at DGLR/DNW Symposium on Model Support Corrections in Wind Tunnels, DNW, Marknesse, Netherlands, 16-17 May 1991
(NLR-TP-91220-U; ETN-93-94063) Avail: CASI HC A04/MF A01
Results from long static pipe measurements, from wind tunnel tests, and theoretical calculations were compared. A correction procedure for the assessment of model support effects for arbitrary model support configurations is discussed. In this procedure a distinction between 'near field', to be determined from dummy sting measurements, and 'far field', to be calculated by theory, contributions is made. Experimental results obtained for two different model support systems were used to evaluate the correction procedure. A good agreement is found in lift and pitching moment after the corrections. The corrected drag polars show a similar lift dependence but an as yet unexplained difference in drag level. ESA

N93-31274# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugfuehrung.
GROUND INSTALLATIONS FOR PREPARATION AND EVALUATION OF FLIGHT TESTS
G.-J. BARTH *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 45-53 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 49-56 Original language document was announced as N92-25593
Avail: CASI HC A02/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany
Ground test installations for the flight guidance and control offered by telemetry equipment are discussed. The equipment available for telemetry can be employed centrally for all flight testing, but it does not cover the whole range. Consequently, there are other important installations for special tests and test platforms, which, for example, enable safety critical flight tests. The conditions applicable to telemetry are focused upon. These inlude output of measurement values by conventional analog means. Furthermore, calibrated data can be displayed on screen as numerical values or bar charts. Chronological curves can also be displayed on screen and hardcopy plotter. The three groups of equipment currently available for telemetry, which differ considerably as to their display and analysis facilities, are discussed. One group uses Pulse Code Modulator (PCM) decoders which operate without further support of any kind, another uses decommutators with support (one advantage of this is that it enables data storage), and the other uses a PC decommutator. Telemetry ground installations also include an installation which transmits data in the ground-to-air direction. The PCM encoder which is necessary to do this is discussed. ESA

N93-31276# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugfuehrung.
ATTAS EXPERIMENTAL-COCKPIT AND ATMOS FOR COMPONENT AND SYSTEM INVESTIGATIONS IN FLIGHT GUIDANCE
RALF BEYER *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 69-82 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 71-84 Original language

document was announced as N92-25595
Avail: CASI HC A03/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany

The installations created in the ATTAS (Advanced Technologies Testing Aircraft Systems) experimental cockpit and the ATMOS (Air Traffic Management and Operations Simulator) for implementation of experimental investigations into corresponding airborne and ground based components and systems, and in particular the air to ground interaction, are described. The ATTAS experimental cockpit is the airborne test environment for component and system investigations into future air traffic guidance. The ATMOS air traffic control simulator is the ground based test environment for components and system investigations into the air traffic control of the future. The systems being added to ATMOS for future research projects include the following: COMPAS (Computer Oriented Metering, Planning and Advisory System), a simulator of taxiing traffic, and a visual system for the display of sumulated taxing aircraft. Future prospects are considered. ESA

N93-31836*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
LARGE ANGLE MAGNETIC SUSPENSION TEST FIXTURE Progress Report, 1 Nov. 1992 - 31 May 1993
COLIN P. BRITCHER Jun. 1993 80 p
(Contract NAG1-1056)
(NASA-CR-193123; NAS 1.26:193123) Avail: CASI HC A05/MF A01

Progress made under the subject grant in the period from 1 Nov. 1992 to 31 May 1993 is presented. The research involves the continued development of the Large Angle Magnetic Suspension Test Fixture (LAMSTF) and also the recommissioning of an additional piece of exisiting hardware. During the period in question, the initial configuration of LAMSTF was completed and made routinely and reliably operational. A digital phase advance controller was completed and documented. The goal of a controlled 360 deg rotation was achieved. Work started on the recommissioning of the Annular Suspension and Pointing System (ASPS). Work completed during the report period included: modeling; position sensing; controller; support of the Second International Symposium on Magnetic Suspension Technology; and recommissioning of the Annular Suspension and Pointing System. Author (revised)

N93-31848*# Hampton Univ., VA. Dept. of Engineering.
EVALUATION OF CANDIDATE WORKING FLUID FORMULATIONS FOR THE ELECTROTHERMAL-CHEMICAL WIND TUNNEL Final Report
JALE F. AKYURTLU and ATES AKYURTLU 1993 28 p
(Contract NAG1-767)
(NASA-CR-193366; NAS 1.26:193366) Avail: CASI HC A03/MF A01

A new hypersonic test facility which can simulate conditions typical of atmospheric flight at Mach numbers up to 20 is currently under study at the NASA/LaRC Hypersonic Propulsion Branch. In the proposed research, it was suggested that a combustion augmented electrothermal wind tunnel concept may be applied to the planned hypersonic testing facility. The purpose of the current investigation is to evaluate some candidate working fluid formulations which may be used in the chemical-electrothermal wind. The efforts in the initial phase of this research were concentrated on acquiring the code used by GASL to model the electrothermal wind tunnel and testing it using the conditions of GASL simulation. The early version of the general chemical kinetics code (GCKP84) was obtained from NASA and the latest updated version of the code (LSENS) was obtained from the author Dr. Bittker. Both codes are installed on a personal computer with a 486 25 MHz processor and 16 Mbyte RAM. Since the available memory was not sufficient to debug LSENS, for the current work GCKP84 was used. Derived from text

N93-31916# Army Research Lab., Aberdeen Proving Ground, MD.
NUMERICAL SIMULATION OF THE FLOW IN A 1:57-SCALE AXISYMMETRIC MODEL OF A LARGE BLAST SIMULATOR Final Report, 15 Jan. - 31 Dec. 1992
KLAUS O. OPALKA Apr. 1993 35 p
(AD-A265551; ARL-TR-111) Avail: CASI HC A03/MF A01

This report presents an assessment of the suitability of the USA-RG2 hydrocode for simulating the flow in a variable-area shock tunnel. A multi-zone gridding technique is used to model the 1:57-Scale LBS test facility at the U.S. Army Research Laboratory. Computations for various grid configurations employing inviscid and viscous solution algorithms and three turbulence models were executed and the results are compared to experimental data. The need for an adequate mesh density in the grid to obtain a realistic flow simulation and the advantage of solving the full Navier-Stokes equations with added k-epsilon turbulence model for the experiment chosen as a bench mark are demonstrated. DTIC

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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.

A93-44380
SINGULAR ARCS FOR BLUNT ENDOATMOSPHERIC VEHICLES
I. M. ROSS (U.S. Naval Postgraduate School, Monterey, CA) and ROBERT G. MELTON (Pennsylvania State Univ., University Park) Journal of the Astronautical Sciences (ISSN 0021-9142) vol. 41, no. 1 Jan.-Mar. 1993 p. 35-51. AIAA/AAS Astrodynamics Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Pt. 2, p. 916-925. Previously cited in issue 24, p. 3838, Accession no. A90-53053 refs
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A93-45145* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AEROSPACE PLANE DESIGN CHALLENGE - CREDIBLE COMPUTATIONS
UNMEEL B. MEHTA (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 519-525. AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990, AIAA Paper 90-5248. Previously cited in issue 08, p. 1160, Accession no. A91-22877 refs
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A93-45441
NEAR-TERM TWO-STAGE-TO-ORBIT, FULLY REUSABLE, HORIZONTAL TAKE-OFF/LANDING LAUNCH VEHICLE
V. WELDON and L. FINK (Boeing Defense and Space Group, Seattle, WA) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270) vol. 13, no. 3 May 1993 p. 301-310. IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991, IAF Paper 91-194. Previously cited in issue 02, p. 164, Accession no. A92-12566
Copyright

A93-45444
HOW TO ENHANCE SAFETY FOR FUTURE SPACE TRANSPORTATION SYSTEMS
ERNST W. MESSERSCHMID and ALEXANDER WEIGAND (Stuttgart Univ., Germany) Space Technology - Industrial and

Commercial Applications (ISSN 0892-9270) vol. 13, no. 3 May 1993 p. 329-347. IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991, IAF Paper 91-586. Previously cited in issue 05, p. 690, Accession no. A92-18573 refs
Copyright

A93-45499
SHOCK TUBE VALIDATION EXPERIMENTS FOR THE SIMULATION OF RAM-ACCELERATOR-RELATED COMBUSTION AND GASDYNAMIC PROBLEMS
J. SRULIJES, G. SMEETS, F. SEILER, A. GEORGE, G. MATHIEU, and R. RESWEBER (Saint-Louis, Inst. de Recherches Franco-Allemand, France) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 611-616. refs
Copyright

This paper presents the work done at the ISL for validating the shock tube as a useful tool for simulating ram-accelerator-related combustion and gasdynamic phenomena. We were able to show that, with a specially devised expansion shock tube, an explosive gas mixture can be accelerated to a superdetonative velocity without autoignition. By reducing the driver length, a test flow of decreasing velocity was generated enabling the observation of all three detonative regimes of interest namely super-, trans- and subdetonative in only one experiment. Pressure measurements in a combustion test chamber provided the ignition conditions for different gas mixtures and varying flow geometry. An unexpected sharp onset of the ignition was found. The experiments in the shock tube will be able to support and optimize the operation of two ram accelerator facilities, a small and a large one that are presently being built at the ISL.

A93-45501* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
INITIATION OF COMBUSTION IN THE THERMALLY CHOKED RAM ACCELERATOR
A. P. BRUCKNER, E. A. BURNHAM, C. KNOWLEN, A. HERTZBERG (Washington Univ., Seattle), and D. W. BOGDANOFF (NASA, Ames Research Center, Moffett Field, CA) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 623-630. refs
Copyright

The methodology for initiating stable combustion in a ram accelerator operating in the thermally choked mode is presented in this paper. The ram accelerator is a high velocity ramjet-in-tube projectile launcher whose principle of operation is similar to that of an airbreathing ramjet. The subcaliber projectile travels supersonically through a stationary tube filled with a premixed combustible gas mixture. In the thermally choked propulsion mode subsonic combustion takes place behind the base of the projectile and leads to thermal choking, which stabilizes a normal shock system on the projectile, thus producing forward thrust. Projectiles with masses in the 45-90 g range have been accelerated to velocities up to 2650 m/sec in a 38 mm bore, 16 m long accelerator tube. Operation of the ram accelerator is started by injecting the projectile into the accelerator tube at velocities in the 700 - 1300 m/sec range by means of a conventional gas gun. A specially designed obturator, which seals the bore of the gun during this initial acceleration, enters the ram accelerator together with the projectile. The interaction of the obturator with the propellant gas ignites the gas mixture and establishes stable combustion behind the projectile. Author (revised)

A93-45533
DOUBLE DIAPHRAGM DRIVEN FREE PISTON EXPANSION TUBE
R. G. MORGAN and R. J. STALKER (Queensland Univ., St. Lucia, Australia) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 1031-1038. Research supported by Australian Research Council refs
Copyright

This paper reports on the preliminary findings of a pilot study aimed at increasing the simulation capability of pulsed facilities by compounding the expansion tube concept with a free piston driven double diaphragm helium driver. By running the shock heated driver section overtailored, it is possible to create higher shock speeds in the test gas section than can be achieved with a free piston driver alone. Alternatively, the same shock speeds can be achieved a higher test gas density by means of the compound driver. The accelerator gas used was helium, which allows for high shock speeds with minimal pressure and temperature ratios. Shock speeds of up to 18.7 km/s were achieved in the acceleration tube.

A93-46528*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DEVELOPMENT AND OPERATION OF NEW ARC HEATER TECHNOLOGY FOR A LARGE-SCALE SCRAMJET PROPULSION TEST FACILITY
JOHN BALBONI (NASA, Ames Research Center, Moffett Field, CA) and DOUG ATLER (Calspan Corp., Moffett Field, CA) Jul. 1993 11 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2786)

An arc-heater technology development effort conducted at NASA-Ames has led to the creation of a 100 MW Huels arc heater which has been integrated into the hydrogen-fueled Direct Connect Arcjet Facility for long-duration, high Mach-number scramjet performance evaluation. This development effort has significantly advanced the design of vortex-stabilized arc heaters; air enthalpy levels of 2.8-7.5 MJ/kg, at stagnation pressures of up to 45 atm, are produced. The facility furnishes technology-development support that is critical to the definition of NASP-related propulsion systems. AIAA

A93-46540*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MEASUREMENT AND ANALYSIS OF NITRIC OXIDE RADIATION IN AN ARC-JET FLOW
DIKRAN S. BABIKIAN (Eloret Inst., Palo Alto, CA), NIGEL K. J. M. GOPAUL (Stanford Univ., CA), and CHUL PARK (NASA, Ames Research Center, Moffett Field, CA) Jul. 1993 9 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(Contract NCC2-420)
(AIAA PAPER 93-2800) Copyright

On the bases of the centerline enthalpy value deduced from heat transfer measurements and the NOZNT code, it is possible to predict the freestream conditions in an arcjet wind tunnel flow. The translational-rotational and vibrational temperature of NO is nearly reproducible by NOZNT. Relative to the electron and electronic temperatures, the vibrational temperature of N2 and NO are significantly lower at enthalpies of less than 45 MJ/kg. The enthalpy deduced from spectroscopic measurements is in rough agreement with that deduced from heat transfer measurements. AIAA

N93-31583*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OVERVIEW OF AEROTHERMODYNAMIC LOADS DEFINITION STUDY
RAYMOND E. GAUGLER *In its* Structural Integrity and Durability of Reusable Space Propulsion Systems p 247-254 May 1991
Avail: CASI HC A02/MF A03

The objective of the Aerothermodynamic Loads Definition Study is to develop methods of accurately predicting the operating environment in advanced Earth-to-Orbit (ETO) propulsion systems, such as the Space Shuttle Main Engine (SSME) powerhead. Development of time averaged and time dependent three dimensional viscous computer codes as well as experimental verification and engine diagnostic testing are considered to be essential in achieving that objective. Time-averaged, nonsteady, and transient operating loads must all be well defined in order to accurately predict powerhead life. Described here is work in unsteady heat flow analysis, improved modeling of preburner flow, turbulence modeling for turbomachinery, computation of three dimensional flow with heat transfer, and unsteady viscous multi-blade row turbine analysis. Derived from text

N93-31585*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

THREE-DIMENSIONAL FLOW CALCULATIONS INSIDE SSME GGGT FIRST STAGE BLADE ROWS

CHUNILL HAH, STEVEN NASH (Sverdrup Technology, Inc., Brook Park, OH.), and GREGORY SWARTWOUT *In its* Structural Integrity and Durability of Reusable Space Propulsion Systems p 263-271 May 1991

Avail: CASI HC A02/MF A03

A numerical analysis of the first stage of the Space Shuttle Main Engine (SSME) GGGT was conducted using a 3-D Reynolds averaged Navier-Stokes flow solver. This turbine stage was designed to improve both aerodynamic efficiency and durability. The blade has an unconventional shape with a large blade thickness. No experimental data is available to verify the computational results. The objective of the current study is to analyze this turbine blade stage with a well established Navier-Stokes computational method in order to determine if the turbine is operating in the subsonic flow regime and if these are any significant separated flow regions. The stage was analyzed in a steady state flow condition. The inlet vane was analyzed with the flow conditions from the axisymmetric entire stage solution. The viscous flow solution of the first vane is used as the inlet flow condition for the rotor. Derived from text

N93-32379*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THE X-15/HL-20 OPERATIONS SUPPORT COMPARISON

W. DOUGLAS MORRIS Washington Jun. 1993 18 p

(Contract RTOP 906-11-01-01)

(NASA-TM-4453; L-17190; NAS 1.15:4453) Avail: CASI HC A03/MF A01

During the 1960's, the United States X-15 rocket-plane research program successfully demonstrated the ability to support a reusable vehicle operating in a near-space environment. The similarity of the proposed HL-20 lifting body concept in general size, weight, and subsystem composition to that of the X-15 provided an opportunity for a comparison of the predicted support manpower and turnaround times with those experienced in the X-15 program. Information was drawn from both reports and discussions with X-15 program personnel to develop comparative operations and support data. Based on the assumption of comparability between the two systems, the predicted staffing levels, skill mix, and refurbishment times of an operational HL-20 appear to be similar to those experienced by the X-15 for ground support. However, safety, environmental, and support requirements have changed such that the HL-20 will face a different operating environment than existed at Edwards during the 1950's and 1960's. Today's operational standards may impose additional requirements on the HL-20 that will add to the maintenance and support burden estimate based on the X-15 analogy. Author

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A93-45517

SHOCK TUNNEL STUDIES OF EXTERNAL COMBUSTION IN HIGH SUPERSONIC AIR FLOWS

G. SMEETS (Saint-Louis, French-German Research Inst., France) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 781-786. refs

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External combustion experiments were performed in a flow generated in a shock at flow parameters corresponding to Mach 6 flight at low altitude. A flat plate was used as the model. Gaseous or liquid fuels were ejected at the front of the model and premixed with air in the turbulent boundary layer. Within any detached flow region resulting from shock boundary layer interaction, a stable flame could be achieved and sustained by injecting hydrogen or acetylene into the upstream boundary layer. The detached flow region could thereby be much extended in the upstream direction. In the high stagnation enthalpy flow, combustion always originated by spontaneous ignition. Injecting the fuel right at the front of the model was much more effective than injection further downstream directly into the detached zone. Under favorable conditions, a stable external combustion could also be obtained with liquid fuels.

A93-45689

EFFECT OF AQUEOUS SOLUTIONS OF WATER-CRYSTALLIZATION INHIBITING FLUIDS ON THIOCOL-BASED SEALANTS [VLIYANIE VODNYKH RASTVOROV PROTIVOVODOKRISTALLIZATSIONNYKH ZHIDKOSTEJ NA TIOKOLOVYE FERMETIKI]

N. M. LIKHTEROVA, O. A. STARODUBTSEVA, T. A. LIFANOVA, and T. YA. VAKULENKO (NPO VIAM; Moskovskij Inst. Tonkoj Khimicheskoj Tekhnologii; Gosudarstvennyj NII Khimii, Moscow, Russia) Khimiya i Tekhnologiya Topliv i Masel (ISSN 0023-1169) no. 2 1993 p. 15-17. In RUSSIAN refs

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The resistance of a Thiocol-based sealant, UZOMES-5, to water-crystallization inhibitors was tested using the GOST 9.068-76 method. The ratio of the area of the sealant to the volume of the aggressive medium was 0.05/cm, close to that used in aircraft systems. Results of long-term tests involving 100-h, 90 C cycles showed that solutions of the three compositions tested (tetrahydrofurfuryl (THF) alcohol, methylcellosolve (MC), and a compound designated 'I') differed in the severity of their effect on the sealing properties of UZOMES-5. Thus, the rate of the mass change of UZOMES-5 was higher in solutions of THF alcohol than in MC or 'I'. AIAA

A93-45778

THE EFFECT OF EXFOLIATION CORROSION ON THE FATIGUE BEHAVIOR OF STRUCTURAL ALUMINIUM ALLOYS

J. P. CHUBB, T. A. MORAD, B. S. HOCKENHULL (Cranfield Inst. of Technology, United Kingdom), and J. W. BRISTOW (Civil Aviation Authority, Gatwick, United Kingdom) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 87-97. Research supported by Civil Aviation Authority of United Kingdom refs

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The effect of prior exfoliation corrotion on the fatigue behavior of 7178-T6 and 2024-T351 aluminum alloys is investigated. The fatigue crack growth rate in both as received and prior corroded material is measured in both wet and dry environments. The exfoliation corrosion is shown to enhance the fatigue crack growth rate in the 7178-T6 material whereas the same effect was not observed in 2024-T351.

A93-45987
BOEING 777 GETS A BOOST FROM TITANIUM
STEVEN ASHLEY Mechanical Engineering (ISSN 0025-6501) vol. 115, no. 7 July 1993 p. 60-65.
Copyright
A survey is conducted of emerging aircraft structure applications of metastable beta Ti alloys, which are replacing not only alpha-beta Ti alloys that are more difficult to process, but even high strength steels, as exemplified by such B 777 and P&W 4084 engine components as the exhaust nozzles and nacelle plugs (Timetal 21S) and main landing gear (Ti-10V-2Fe-3Al). The conventional alloy Ti-6Al-4V is also used by the B 777 in such secondary structures as the aircraft tailcone, and will replace Al alloys in several cases where weightsavings are critical. Attention is given to the processing condition-mechanical property relationships of the novel alloys. AIAA

A93-46532*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THERMAL RESPONSE AND ABLATION CHARACTERISTICS OF LIGHT WEIGHT CERAMIC ABLATORS
HUY K. TRAN, DANIEL J. RASKY (NASA, Ames Research Center, Moffett Field, CA), and LILI ESFAHANI (San Jose State Univ., CA) Jul. 1993 11 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2790) Copyright
An account is given of the thermal performance and ablation characteristics of the NASA-Ames Lightweight Ceramic Ablators (LCAs) in supersonic, high-enthalpy convective environments, which use low density ceramic or carbon fiber matrices as substrates for main structural support, with organic resin fillers. LCA densities are in the 0.224-1.282 g/cu cm range. In-depth temperature data have been obtained to determine thermal penetration depths and conductivity. The addition of SiC and PPMA is noted to significantly improve the ablation performance of LCAs with silica substrates. Carbon-based LCAs are the most mass-efficient at high flux levels. AIAA

A93-47356
MECHANICAL ANISOTROPY IN DIRECTIONALLY SOLIDIFIED TURBINE BLADE
YOSHIO OHTA, Y. G. NAKAGAWA, and HIROSHI HATTORI Ishikawajima-Harima Engineering Review (ISSN 0578-7904) vol. 33, no. 3 May 1993 p. 133-137. In JAPANESE refs
The mechanical properties of turbine blades and vanes made by directional solidification technology are investigated using the results of tests of directionally solidified components made of Mar-M247LC, TMD-5, CMSX-2, alloy 454, and TMS26 alloys which were cast in the 100-line-oriented direction, parallel to the major stress axis of the component. Both the elastic and plastic properties were found to be anisotropic. It is pointed out that the mechanical strength of this principle orientation in directionally solidified components must be tested and analyzed. AIAA

A93-47512
CHEMICAL-KINETICS CHARACTERISTICS OF COMBUSTION IN A SUPERSONIC TURBULENT FLOW [KHIMIKO-KINETICHESKIE OSOBENNOSTI GORENIYA V SVERKHZVUKOVOM TURBULENTNOM POTOKE]
S. I. BARANOVSKIJ, A. S. NADVORSKIJ, and D. D. ROMASHKOVA *In* Turbulent flow problems Moscow Tsentral'nyj Institut Aviatsionnogo Motorostroeniya 1991 p. 94-104. In RUSSIAN refs
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The main reasons why chemical-kinetics processes play a significant role in combustion in supersonic flow are indicated with particular reference to processes in ramjet-engine combustion chambers. It is emphasized that detailed kinetic mechanisms should be taken into account when calculating monocoaxial reactive flows. It is further pointed out that, in interpreting data on combustion in supersonic flow obtained under ground conditions and in extrapolating them to actual flight conditions, it is necessary to use mathematical models that account for the detailed kinetic mechanisms of chemical interaction. AIAA

N93-31044# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Hubschrauber und Flugzeuge.
CONSIDERATION OF IMPACT DAMAGES BY DIMENSIONING CFC (CARBON FIBER REINFORCED COMPOSITES) COMPONENTS [BERUECKSICHTIGUNG VON IMPACT-SCHAEDEN BEI DER DIMENSIONIERUNG VON CFK-BAUTEILEN]
J. BAUER Jun. 1991 10 p In GERMAN Presented at DGLR-Symposium Leichtbaustrukturen unter Kurzzeiter Beanspruchung (Impact, Crash), Bremen, Germany, 6-7 Jun. 1991 Submitted for publication
(MBB-FE-221-S-PUB-0501; DGLR-91-27; ETN-93-94193)
Copyright Avail: CASI HC A02/MF A01
A method for adapting damage tolerance of structures to aircraft requirements is presented. Material properties were recalled which are needed for military aircraft design and development, such as traction and compression modules and residual stresses with consideration of weight reduction. The qualities of resin fiber systems were highlighted, such as fracture toughness. The structure influence on damage tolerance was characterized, in terms of absorbed damage energy. It is concluded, that the damage tolerance of a composite structure depends on geometric conditions such as density and curvatures. A statistical dimensioning criterion is proposed, which limits dilatation in fibers, for estimating wall strength. A compression after impact test was carried out, and impact energy was defined as dimensioning characteristic value. ESA

N93-31192# McDonnell-Douglas Electronics Co., Saint Louis, MO.
USE OF TITANIUM CASTINGS WITHOUT A CASTING FACTOR Final Report, 26 Sep. 1989 - 30 Sep. 1992
DIANNE CHONG 30 Sep. 1992 131 p
(Contract AF PROJ. 2418)
(AD-A264414; WL-TR-92-4090) Avail: CASI HC A07/MF A02
The 'Use of Titanium Castings Without a Casting Factor' program was conducted to establish 'A' and 'B' allowables for Ti-6Al-4V. Taguchi methods were used to develop a more restrictive chemistry and annealing condition to provide parts with less variability in properties. 'A' and 'B' design allowables that were determined for full scale Ti-6Al-4V missile fins and step plates produced using these new parameters showed very low variability, the standard deviations of these data were less than 2 ksi. The 'A' basis allowables are F(sub tu) = 125 ksi and F(sub ty) = 120 ksi. A nondestructive inspection technique was developed to correlate measurement of microstructural features to mechanical properties. This was found to be of limited value because of the narrow property band that was established. A new AMS specification that included the new allowables, the microstructural inspection criteria, and the more refined chemistry and post-casting treatments was established for investment cast Ti-6Al-4V. Limited fracture mechanics evaluation was also performed on the cast fins. DTIC

N93-31272# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Flugabteilung.
THE DLR TEST AIRCRAFT IN THE FZ-BS, -VFW 614/ATTAS, DORNIER DO 228-101, MBB BO105 S-3
HANS-L. MEYER *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 6-30 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 9-34 Original language document was announced as N92-25591
Avail: CASI HC A03/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany
The particular equipment, capabilities, and flight characteristics of certain research aircraft are addressed: the DO 228, an all

metal high wing aircraft with two turboprops; the BO-105 flying helicopter simulator; and the VFW 614/ATTAS (Advance Technologies Testing Aircraft Systems) flying simulator. These are used in tests at Brunswick (Germany) where research programs center on flight mechanics, flight guidance, and aerodynamics. The high performance systems used for inflight measurements, trials, and tests are addressed. These include various simulators, telemetry,and data processing systems, and measurement equipment for each aicraft. These test facilities are used to pursue research objectives from the conceptual stage to that of flight testing as the final link in the chain. Flight tests are currently performed for the following programs: navigation and air traffic control, transport aircraft technologies, helicopter technologies, and simulation and design principles. ESA

N93-31643*# Virginia Univ., Charlottesville. School of Engineering and Applied Science.
NASA-UVA LIGHT AEROSPACE ALLOY AND STRUCTURE TECHNOLOGY PROGRAM SUPPLEMENT: ALUMINUM-BASED MATERIALS FOR HIGH SPEED AIRCRAFT Report, 1 Jan. - 30 Jun. 1992
E. A. STARKE, JR. Washington Jun. 1993 226 p
(Contract NAG1-745; RTOP 763-23-45-86)
(NASA-CR-4517; NAS 1.26:4517) Avail: CASI HC A11/MF A03

This report on the NASA-UVa Light Aerospace Alloy and Structure Technology Program Supplement: Aluminum-Based Materials for High Speed Aircraft covers the period from January 1, 1992 to June 30, 1992. The objective of the research is to develop aluminum alloys and aluminum matrix composites for the airframe which can efficiently perform in the HSCT environment for periods as long as 60,000 hours (certification for 120,000 hours) and, at the same time, meet the cost and weight requirements for an economically viable aircraft. Current industry baselines focus on flight at Mach 2.4. The research covers four major materials systems: (1) ingot metallurgy 2XXX, 6XXX, and 8XXX alloys, (2) powder metallurgy 2XXX alloys, (3) rapidly solidified, dispersion strengthened Al-Fe-X alloys, and (4) discontinuously reinforced metal matrix composites. There are ten major tasks in the program which also include evaluation and trade-off studies by Boeing and Douglas aircraft companies. Author (revised)

N93-31739*# Virginia Univ., Charlottesville. Dept. of Materials Science and Engineering.
NASA-UVA LIGHT AEROSPACE ALLOY AND STRUCTURES TECHNOLOGY PROGRAM (LA2ST) Progress Report, 1 Jan. - 30 Jun. 1993
RICHARD P. GANGLOFF, JOHN R. SCULLY, GLENN E. STONER, EARL A. THORNTON, FRANKLIN E. WAWNER, JR., and JOHN A. WERT 20 Jul. 1993 441 p
(Contract NAG1-745)
(NASA-CR-193412; NAS 1.26:193412; UVA-528266-MS-94-113)
Avail: CASI HC A19/MF A04

The NASA-UVA Light Aerospace Alloy and Structures Technology (LA2ST) Program continues a high level of activity. Progress achieved between 1 Jan. and 30 Jun. 1993 is reported. The objective of the LA2ST Program is to conduct interdisciplinary graduate student research on the performance of next generation, light weight aerospace alloys, composites, and thermal gradient structures in collaboration with NASA-Langley researchers. The following projects are addressed: environmental fatigue of Al-Li-Cu alloys; mechanisms of localized corrosion and environmental fracture in Al-Cu-Li-Mg-Ag alloy X2095 and compositional variations; the effect of zinc additions on the precipitation and stress corrosion cracking behavior of alloy 8090; hydrogen interactions with Al-Li-Cu alloy 2090 and model alloys; metastable pitting of aluminum alloys; cryogenic fracture toughness of Al-Cu-Li + In alloys; the fracture toughness of Weldalite (TM); elevated temperature cracking of advanced I/M aluminum alloys; response of Ti-1100/SCS-6 composites to thermal exposure; superplastic forming of Weldalite (TM); research to incorporate environmental effects into fracture mechanics fatigue life prediction codes such as NASA FLAGRO; and thermoviscoplastic behavior. Derived from text

N93-31795 Pratt and Whitney Aircraft, West Palm Beach, FL. Government Engines and Space Propulsion.
FATIGUE IN SINGLE CRYSTAL NICKEL SUPERALLOYS Technical Progress Report, 16 Apr. - 15 May 1993
DANIEL P. DELUCA and CHARLES ANNIS 15 May 1993 6 p
Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract N00014-91-C-0124)
(AD-A265451; PW/GESP-FR21998-19) Avail: CASI HC A02

This program investigates the seemingly unusual behavior of single crystal airfoil materials. The fatigue initiation processes in single crystal (SC) materials are significantly more complicated and involved than fatigue initiation and subsequent behavior of a (single) macrocrack in conventional, isotropic, materials. To understand these differences, it is helpful to review the evolution of high temperature airfoils. Modern gas turbine flight propulsion systems employ single crystal materials for turbine airfoil applications because of their superior performance in resisting creep, oxidation, and thermal mechanical fatigue (TMF). These properties have been achieved by composition and alloying, of course, but also by appropriate crystal orientation and associated anisotropy. DTIC

N93-32085 Logistics Management Inst., Bethesda, MD.
MAKING CLEAN GASOLINE: THE EFFECT ON JET FUELS
ROBERT W. SALTHOUSE Sep. 1992 73 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(Contract MDA903-90-C-0006)
(AD-A264302; LMI-PL015-R1) Avail: CASI HC A04

Persistently high concentrations of carbon monoxide and low-altitude ozone in the air of the Nation's major urban centers led Congress in the 1990 Clean Air Act Amendments to mandate changes to the composition of gasoline and diesel fuel. Those gasoline composition changes will require major modifications to the manufacturing processes that refiners use to produce gasoline for sale in much of the United States. Since petroleum refining is a complex process involving a variety of chemical interactions between final products, many observers--including DoD fuel managers--fear possible declines in the quality and availability of jet fuel. Currently, the Air Force plans to convert from naphtha-based JP-4 jet fuel to distillate-based JP-8 jet fuel. Despite the extent of the required refinery process modifications, however, we conclude that neither the quality nor the availability of jet fuel purchased by the military is likely to change significantly. Among the provisions of the 1990 Clean Air Act Amendments is a limit on aromatic compounds in gasoline, which led to fears that refiners would divert excess aromatic compounds into jet fuel. However, refiners are unlikely to do that for two reasons. First, existing jet fuel specification--'smoke point' and a maximum aromatic ceiling--already limit the refiners' ability to increase the volume of aromatics in jet fuel. Second, the manufacture of aromatics to improve gasoline performance is expensive. DTIC

N93-32234*# Bell Helicopter Co., Fort Worth, TX.
CIVIL TILTROTOR TRANSPORT POINT DESIGN: MODEL 940A Final Report
CHARLES ROGERS and DALE REISDORFER Apr. 1993 92 p
Original contains color illustrations
(Contract NAS1-18796; RTOP 532-06-37-03)
(NASA-CR-191446; NAS 1.26:191446; REPT-699-099-352)
Avail: CASI HC A05/MF A01; 10 functional color pages

The objective of this effort is to produce a vehicle layout for the civil tiltrotor wing and center fuselage in sufficient detail to obtain aerodynamic and inertia loads for determining member sizing. This report addresses the parametric configuration and loads definition for a 40 passenger civil tilt rotor transport. A preliminary (point) design is developed for the tiltrotor wing box and center fuselage. This summary report provides all design details used in the pre-design; provides adequate detail to allow a preliminary design finite element model to be developed; and contains guidelines for dynamic constraints. Derived from text

N93-32385# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
ACCELERATED AND REAL-TIME CORROSION TESTING OF ALUMINUM-LITHIUM ALLOYS
L. SCHRA 30 May 1991 11 p Presented at the 6th International Aluminum-Lithium Conference, Garmisch-Partenkirchen, Germany, 7-11 Oct. 1991
(NLR-TP-91203-U; ETN-93-94061; AD-B168789L) Avail: CASI HC A03/MF A01

Aluminum-lithium (Al-Li) alloys are potentially attractive for aerospace structures. These alloys combine low density and high stiffness. Al-Li alloy development may be considered successful if other properties are maintained with respect to conventional alloys. Experimental programs were conducted to evaluate the engineering properties of Al-Li alloys and to explain their characteristic behavior. The corrosion and stress corrosion properties were initially assessed from accelerated laboratory tests. Atmospheric exposure tests were also done to investigate behavior in an environment closer to that of an aircraft, and to check whether laboratory tests give realistic predictions for these new materials. The laboratory and atmospheric exposure results are discussed. ESA

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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.

A93-44168
A MULTISENSOR-MULTITARGET DATA ASSOCIATION ALGORITHM FOR HETEROGENEOUS SENSORS
SOMNATH DEB, KRISHNA PATTIPATI, and YAAKOV BAR-SHALOM (Connecticut Univ., Storrs) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251) vol. 29, no. 2 April 1993 p. 560-568. refs
(Contract F49620-92-J-150; N00014-91-J-1950)
Copyright

The problem of associating data from three spatially distributed heterogeneous sensors, each with a set of detections at the same time is dealt with here. The sensors could be active (three-dimensional or two-dimensional radars), or passive (electro-optical sensors measuring the azimuth and elevation angles of the source). The source of a detection can be either a real target, in which case the measurement is the true observation variable of the target plus measurement noise, or a spurious one, i.e., a false alarm. In addition, the sensors may have nonunity detection probabilities. The problem is to associate the measurements from sensors to identify the real targets, and to obtain their position estimates. Mathematically, this (static) measurement-target association problem leads to a generalized 3-D assignment problem, which is known to be NP-hard. We discuss an algorithm suited for estimating the positions of a large number of targets in a dense cluster using a fast, but nearly optimal 3-D assignment algorithm. Performance results on several representative test cases with 64 targets solved by the algorithm are presented. Author

A93-44193
EVALUATION BY HOLOGRAPHIC INTERFEROMETRY OF IMPACT DAMAGE IN COMPOSITE AERONAUTICAL STRUCTURES
PIETRO FERRARO (Aleinia S.p.A., Pomigliano d'Arco, Italy) *In* Laser interferometry IV: Computer-aided interferometry; Proceedings of the Meeting, San Diego, CA, July 22-24, 1991 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1992 p. 349-357. refs
Copyright

The results of an experimental study of holographic interferometry for impact damage detection and evaluation, in composite aeronautical sandwich structures is presented. The results show that holographic interferometry using thermal loading can accurately estimate delaminated areas on test samples in respect to ultrasonic inspection. The capability of holographic interferometry for detection of such damages in large composite components is shown also. Author

A93-44194
VISUALISATION AND ANALYSIS OF THREE DIMENSIONAL TRANSONIC FLOWS BY HOLOGRAPHIC INTERFEROMETRY
D. P. TOWERS, C. E. TOWERS, P. J. BRYANSTON-CROSS (Zuerich, Eidgenoessische Technische Hochschule, Zurich, Switzerland), K. FRY, and A. E. HARRIS (Aircraft Research Association,. Ltd., Bedford, United Kingdom) *In* Laser interferometry IV: Computer-aided interferometry; Proceedings of the Meeting, San Diego, CA, July 22-24, 1991 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1992 p. 388-403. Research supported by SERC and Department of Trade and Industry refs
Copyright

Holographic interferometry has been used in a large scale transonic wind tunnel to produce a 3D flow visualization. The experiments have been carried out on a model civil transport aircraft wing and turbine powered engine simulator combination. This study is significant industrially as the method forms a diagnostic for turbofan installations. The holograms show many relevant flow features including shock waves, flow interactions between the engine simulator flow and the freestream flow, secondary flows, and acoustic waves. Quantitative 3D position information has also been obtained for some of these features. A comparison to other flow diagnostic methods has been made in this paper. Author (revised)

A93-44195
PARTICLE IMAGING TECHNIQUES AND APPLICATIONS
C. E. TOWERS, D. P. TOWERS (Zuerich, Eidgenoessische Technische Hochschule, Zurich, Switzerland), P. J. BRYANSTON-CROSS (Warwick Univ., Coventry, United Kingdom), J. GASS (Zuerich, Eidgenoessische Technische Hochschule, Zurich, Switzerland), and T. R. JUDGE (Warwick Univ., Coventry, United Kingdom) *In* Laser interferometry IV: Computer-aided interferometry; Proceedings of the Meeting, San Diego, CA, July 22-24, 1991 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1992 p. 404-417. Research supported by SERC and Department of Trade and Industry refs
Copyright

Application of particle image velocimetry (PIV) to a scale transonic wind tunnel and to a cold burner spray is described. It is shown that diffraction limited imaging makes it possible to extend the working range of PIV systems to several meters enabling a broad variety of industrial applications and to determine particle sizes with a high magnification objective. In both cases diffraction limited imaging significantly reduced the laser energy required to form satisfactory particle images. Particle images were recorded onto 35 mm film and a CCD video camera. AIAA

A93-44197
PROGRESS IN INDUSTRIAL HOLOGRAPHY IN FRANCE
PAUL SMIGIELSKI (Saint-Louis, French-German Research Inst., France) *In* Laser interferometry IV: Computer-aided interferometry; Proceedings of the Meeting, San Diego, CA, July 22-24, 1991 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1992 p. 436-446. refs
Copyright

Industrial applications of holography in France are briefly reviewed. Particular attention is given to nondestructive testing of helicopter blades at Aerospatiale Central Laboratory, the use of holography at Renault for car-engine vibration study, vibration characterization of turbo-jet engine components at SNECMA, and vibration analysis of plates in an industrial hemodynamic tunnel. AIAA

A93-44206
GENERATION OF UNSTRUCTURED TETRAHEDRAL MESHES BY ADVANCING FRONT TECHNIQUE
H. JIN and R. I. TANNER (Sydney Univ., Australia) International Journal for Numerical Methods in Engineering (ISSN 0029-5981) vol. 36, no. 11 June 15, 1993 p. 1805-1823. Research supported by Australian Research Council refs
Copyright
An algorithm for generating unstructured tetrahedral meshes by the advancing front technique is presented. Emphasis is placed on the construction of tetrahedral elements. Several measures are employed to prevent difficult situations. A control line/surface scheme is used to specify element size. Numerical examples are provided to show the performance of the algorithm. Author

A93-44222
EFFECTS OF LONGITUDINAL VORTEX GENERATORS ON HEAT TRANSFER AND FLOW LOSS IN TURBULENT CHANNEL FLOWS
J. X. ZHU, N. K. MITRA, and M. FIEBIG (Bochum, Ruhr-Univ., Germany) International Journal of Heat and Mass Transfer (ISSN 0017-9310) vol. 36, no. 9 June 1993 p. 2339-2347. Research supported by DLR refs
Copyright
The influences of four types of longitudinal vortex generators (delta wing, rectangular wing, delta winglet pair, and rectangular winglet pair) on heat transfer and flow loss in turbulent channel flows are investigated. A numerical solver of the Navier-Stokes equations, based on the MAC algorithm, has been extended with the k-epsilon turbulence model for this study. The results show that the longitudinal vortices produced by the vortex generators elevate significantly the level of turbulence kinetic energy in the flows and strongly disturb the thermal boundary layer. The mean heat transfer rate can be increased by 16-19 percent with the vortex generators for an area of channel wall which is 30 times larger than the vortex generator area. The ratio of heat transfer enhancement and flow loss increase indicates better performance for the rectangular winglet pair. Author (revised)

A93-44224
DIFFUSION CONTROLLED EVAPORATION OF A MULTICOMPONENT DROPLET - THEORETICAL STUDIES ON THE IMPORTANCE OF VARIABLE LIQUID PROPERTIES
R. KNEER, M. SCHNEIDER, B. NOLL, and S. WITTIG (Karlsruhe Univ., Germany) International Journal of Heat and Mass Transfer (ISSN 0017-9310) vol. 36, no. 9 June 1993 p. 2403-2415. refs
(Contract DFG-SFB-167)
Copyright
A well-known multicomponent droplet vaporization model, the Diffusion Limit Model, has been extended to account for property variations in the liquid phase. The model has been tested for typical conditions of modern gas turbine combustors. The results for a hexane/tetradecane droplet show that the temperature- and concentration-dependence of the liquid properties affect the vaporization process, especially with regard to a reduced diffusional resistance. Additionally, remarkable variations of the refractive index are observed yielding helpful information for the estimation of errors in optical particle sizing techniques. Regarding comprehensive spray calculations, the use of the constant property formulation is recommended with improved reference values based on variable property calculations. Author

A93-44231*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A CONVECTIVE AND RADIATIVE HEAT TRANSFER ANALYSIS FOR THE FIRE II FOREBODY
ROBERT B. GREENDYKE (Vigyan, Inc., Hampton, VA) and LIN C. HARTUNG (NASA, Langley Research Center, Hampton, VA) Jul. 1993 13 p. AIAA, Plasma Dynamics and Lasers Conference, 24th, Orlando, FL, July 6-9, 1993 refs
(Contract NAS1-19237)
(AIAA PAPER 93-3194)
A Navier-Stokes flowfield solution method (LAURA code) using finite-rate chemistry and two-temperature thermal nonequilibrium was used in combination with two nonequilibrium radiative heat transfer codes to calculate heating for the FIRE II vehicle. An axisymmetric model of the actual body shape was used. One radiative heating code (NEQAIR) was used in uncoupled fashion with the flowfield solver's energy equations, while the other code (LORAN) was used in both coupled and uncoupled variations. Several trajectory points ranging from highly nonequilibrium flow to near-equilibrium flow were used for a study of both convective and radiative heating over the vehicle. Considerable variation in radiative heating was seen at the extremes, while agreement was good in the intermediate trajectory points. Total heat transfer calculations gave good comparison until the peak heating trajectory points were encountered, and returned to good agreement for the last two equilibrium points. Author

A93-44851
ELECTRORHEOLOGICALLY CONTROLLED LANDING GEAR
Aerospace Engineering (ISSN 0736-2536) vol. 13, no. 6 June 1993 p. 17-22.
Copyright
State-of-the-art landing gear design concept is proposed focusing on the damping function and the energy storage or springing function. The control in the landing gear is based on the medium of an electrorheological (ER) fluid. The shear-mode damper uses multiple rotational shearing disks which provide a total control surface area that is constant and independent of the relative position of the landing gear, resulting in good control and a compact size. It is concluded that the rotary shear-mode damper makes it possible to obtain a fast response time and a high ratio of strut forces achieved under ER vs zero-field control. The design is compact and simple due to the use of the screw-nut mechanism and integration of the pneumatic spring. Results of computer simulations show that when using an ER fluid of a yield stress of 7 kPa, the energy absorption efficiency of the landing gear can reach almost 100 percent at various sink rates. AIAA

A93-44995#
A PERSPECTIVE ON A QUARTER CENTURY OF CFD RESEARCH
ROBERT W. MACCORMACK (Stanford Univ., CA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 1-15. refs
(AIAA PAPER 93-3291) Copyright
The times and some of the characters in CFD research over the past 25 yrs are discussed from a personal point of view. Work done on the Euler equations and the Navier-Stokes (NS) equations prior to 1970 and studies of the transonic small disturbance equation, the full potential equation, the Euler equations, the NS equations, turbulence modeling, and computational grids during the 1970s is examined. Research during the 1980s on the Euler and NS equations, the full potential equation, hypersonic reacting flow, and unstructured grids is reviewed along with 1990s research on computational combustion, the use of workstations, and gridless CFD is addressed. The author's expectations for future work on computational grids, computer architecture, algorithms, and turbulence are briefly given. AIAA

A93-44997#
THE STATUS OF CFD - AN AIR FORCE PERSPECTIVE
LEONIDAS SAKELL (USAF, Office of Scientific Research, Bolling AFB, DC) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 21-25.
(AIAA PAPER 93-3293)
The present state of CFD is discussed from the author's

perspective as a Program Manager in fluid mechanics basic research at the USAF Office of Scientifc Research (AFOSR). Current CFD capabilities are assessed with respect to their utility to the USAF. The needs of the USAF as seen by the author are discussed, and a brief overview of the future directions in CFD research at AFOSR is given. AIAA

A93-45019#
STABILITY ANALYSIS OF DYNAMIC MESHES FOR TRANSIENT AEROELASTIC COMPUTATIONS
M. LESOINNE and C. FARHAT (Colorado Univ., Boulder) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 309-314. refs
(AIAA PAPER 93-3325) Copyright
The objectives of this paper are to present a general mathematical framework for analyzing the numerical stability of the coupled transient aeroelastic problem, and to demonstrate that a dynamic mesh can destabilize the interacting fluid/structure system. The ability to distinguish between a numerical instability due to the moving mesh and a physical instability due to the interaction between the aerodynamic and elastic forces is crucial for flutter simulations. Author

A93-45089#
UNSTEADY FLOW SIMULATION ON A PARALLEL COMPUTER
M. FADEN, S. POKORNY, and K. ENGEL *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1037, 1038. refs
Copyright
For the simulation of the flow through compressor stages, an interactive flow simulation system is set up on an MIMD-type parallel computer. An explicit scheme is used in order to resolve the time-dependent interaction between the blades. The 2D Navier-Stokes equations are transformed into their general moving coordinates. The parallelization of the solver is based on the idea of domain decomposition. Results are presented for a problem of fixed size (4096 grid nodes for the Hakkinen case). AIAA

A93-45106
RECENT ADVANCES OF TIME DOMAIN APPROACH FOR NONLINEAR RESPONSE AND SONIC FATIGUE
RIMAS VAICAITIS (Columbia Univ., New York) *In* Structural dynamics: Recent advances; Proceedings of the 4th International Conference, Univ. of Southampton, United Kingdom, July 15-18, 1991 London and New York Elsevier Applied Science 1991 p. 84-103. refs
Copyright
Current research activities on time domain methods for nonlinear response and acoustic fatigue problems related to high-speed flight structures are reviewed. The time domain approach has been used to solve a variety of problems related to the nonlinear response and fatigue of surface panels exposed to high-intensity turbulent flow and/or engine exhaust noise. Simulation of input random pressure in the space-time domain, which is required in the formulation and solution of these problems, is examined. To illustrate the application of the time domain approach to the solution of nonlinear problems, several typical examples are discussed, including an isotropic single panel, a discretely stiffened panel, and an orthotropic composite panel. AIAA

A93-45113
THE FREE VIBRATION OF CYLINDRICALLY-CURVED RECTANGULAR PANELS
N. S. BARDELL (Southampton Univ., United Kingdom) *In* Structural dynamics: Recent advances; Proceedings of the 4th International Conference, Univ. of Southampton, United Kingdom, July 15-18, 1991 London and New York Elsevier Applied Science 1991 p. 254-263. refs
Copyright
The hierarchical finite element method is used to determine the free vibration characteristics of a cylindrically-curved rectangular panel. Natural frequencies and selected modes are presented for a variety of panels with different boundary conditions, and good agreement is obtained with the work of other investigators. Author

A93-45119
FLUTTER ANALYSIS OF COMPOSITE PANELS ON MANY SUPPORTS
LE-CHUNG SHIAU and JING-TANG CHANG (National Cheng Kung Univ., Tainan, Taiwan) *In* Structural dynamics: Recent advances; Proceedings of the 4th International Conference, Univ. of Southampton, United Kingdom, July 15-18, 1991 London and New York Elsevier Applied Science 1991 p. 377-386. refs
(Contract NSC-78-0210-D006-19)
Copyright
The flutter characteristics of finite composite panels on multiple simple supports at high supersonic Mach number have been investigated using finite element method. Linear small deflection laminated plate theory and quasi-steady aerodynamic theory are employed. Numerical results are obtained for the cases of one-, two-, three-bay running in either spanwise, streamwise or both directions. It is concluded that the number of modes required to give accurate results is mainly dependent on the number of bays under investigation. The sensitivity of the bay number in the determination of the flutter boundary is a function of the fiber orientation and aspect ratio. Author

A93-45133* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF TEMPERATURE ON NONLINEAR TWO-DIMENSIONAL PANEL FLUTTER USING FINITE ELEMENTS
CHUH MEI and DAVID Y. XUE (Old Dominion Univ., Norfolk, VA) *In* Structural dynamics: Recent advances; Proceedings of the 4th International Conference, Univ. of Southampton, United Kingdom, July 15-18, 1991 London and New York Elsevier Applied Science 1991 p. 811-821. refs
(Contract NAS1-18584)
Copyright
A finite element formulation and solution procedures is presented for limit-cycle motions of 2D panels subjected simultaneously to thermal and aerodynamic loads. The thermal load is described by a steady-state temperature distribution and the quasi-steady first-order piston theory is used for aerodynamic pressure. The von Karman nonlinear strain-displacement relationship is used for the large panel deflections. Three temperature distributions are evaluated: (1) uniform; (2) symmetric sinusoidal varying temperature along panel length; and (3) linearly varying temperature through panel thickness. The influence of these three temperature distributions on limit-cycle motions and flutter boundaries of a simply supported 2D panel is investigated. Author (revised)

A93-45148* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF STIFFNESS CHARACTERISTICS ON THE RESPONSE OF COMPOSITE GRID-STIFFENED STRUCTURES
DAMODAR R. AMBUR (NASA, Langley Research Center, Hampton, VA) and LAWRENCE W. REHFIELD (California Univ., Davis) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 541-546. AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2, p. 1349-1356. Previously cited in issue 12, p. 1994, Accession no. A91-31969 refs
Copyright

A93-45151
USE OF EIGENVECTORS IN THE SOLUTION OF THE FLUTTER EQUATION
LOUW H. VAN ZYL (South African Council for Scientific and Industrial Research, Pretoria, South Africa) Journal of Aircraft

(ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 553, 554. refs

The use of eigenvectors to assign eigenvalues to modes for the p-k formulation of the flutter equation is described. The procedure has the potential to overcome some of the problems of the determinant iteration procedure to solve the flutter equation. Advantages of the proposed procedure include the possibility of using a general eigenvalue routine capable of solving repeated eigenvalues, effective distinguishing of eigenvalues, initial frequency values requirement used only for the first calculation of reduced frequency at each speed, and reduced computation time. AIAA

A93-45175
VIBRATION ANALYSIS OF COMPOSITE WING WITH TIP MASS USING FINITE ELEMENTS
IN LEE and JUNG-JIN LEE (Korea Advanced Inst. of Science and Technology, Taejon, Republic of Korea) Computers & Structures (ISSN 0045-7949) vol. 47, no. 3 May 3, 1993 p. 495-504. refs
Copyright

The analysis of vibration characteristics, including the natural frequencies and modes for various shaped composite wings with a tip mass and an engine, has been performed using the finite element method based on the shear deformable theory. The present analysis presents the effect of tip mass, engine, sweep angle fiber orientation and aspect ratio of a composite wing, which is composed of graphite/epoxy laminate with a symmetric stacking sequence, on vibration characteristics. At a specific fiber orientation, the natural frequencies of the two modes approach each other. The natural frequencies of the wing with the tip mass and the engine are lower than those of the wing without the tip mass and the engine. However, for the wing with the tip mass, the natural frequencies of the chordwise mode increase due to the increase of the bending stiffness of the tip mass. This present finite element method, which uses eight-node quadrilateral elements, gives very accurate results. Author

A93-45451
SHOCK WAVES; PROCEEDINGS OF THE 18TH INTERNATIONAL SYMPOSIUM, SENDAI, JAPAN, JULY 21-26, 1991. VOLS. 1 & 2
KAZUYOSHI TAKAYAMA, ED. (Tohoku Univ., Sendai, Japan) Berlin and New York Springer-Verlag 1992 p. Vol. 1, 751 p.; vol. 2, 648 p. For individual items see A93-45452 to A93-45552 (ISBN 0-387-55686-9) Copyright

Various papers on shock waves are presented. The general topics addressed include: shock wave structure, propagation, and interaction; shock wave reflection, diffraction, refraction, and focusing; shock waves in condensed matter; shock waves in dusty gases and multiphase media; hypersonic flows and shock waves; chemical processes and related combustion phenomena; explosions, blast waves, and laser initiation of shock waves; shock tube technology and instrumentation; CFD of shock wave phenomena; medical applications and biological effects; industrial applications. AIAA

A93-45460
FORMATION OF SHOCK WAVES IN TRANSIENT BASE FLOW
N. SAIDA (Aoyama Gakuin Univ., Tokyo, Japan), Y. HASHIBA (Sapporo School of the Arts, Japan), and T. OZEKI (Aoyama Gakuin Univ., Tokyo, Japan) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 167-172. Research supported by MOESC refs
Copyright

The formation of shock waves behind a symmetrical body was studied in a shock tube. Three models of different afterbody shape were examined: a step, flare and boattail. The initial pressure ratio was set to 200 and optical measurements were made. It is shown that in all cases the reflected shock merges with the secondary shock and develops into the recompression shock. However, in the intermediate stage the recompression shock is unstable and asymmetric with respect to the centerline.

A93-45463
OSCILLATIONS OF CIRCULAR SHOCK WAVES WITH UPSTREAM DISTURBANCE
M. K. PARK, S. OSHIMA, and R. YAMANE (Tokyo Inst. of Technology, Japan) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 203-208. refs
Copyright

Both the oscillation state and mode of the disturbed circular shock waves by upstream nonuniformity of the velocity were investigated experimentally. Steady wake behind circular cylinders which were set up at the entrance of the nozzle. The free and forced oscillations of the shock wave mainly consist of mode 0 including other weak modes, which shows the strong influence of the wake of the upstream cylinder. The wake separates the circular shock wave into some pieces and makes their oscillation independent from each other. The resonance of forced oscillation is also weaker, and the shock wave is more stable than in the case without upstream disturbances.

A93-45476
FORMATION OF THE SHOCK REFLECTION ON A WEDGE
J. FUCHS and B. SCHMIDT (Karlsruhe Univ., Germany) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 293-298. Research supported by DFG refs
Copyright

The formation of shock reflection close to the leading edge of a wedge is investigated. Varying the wedge angle, a regular reflection or a Mach reflection can be obtained. To get a good resolution of the reflection process, measurements are performed under rarefied gas conditions. The observed flow field is definitely unsteady. The measuring method and the data reduction have to satisfy these requirements. The results are represented by the density distribution in the flow field at different time steps.

A93-45500
HUGONIOT ANALYSIS OF THE RAM ACCELERATOR
C. KNOWLEN and A. P. BRUCKNER (Washington Univ., Seattle) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 617-622. refs
Copyright

The thermodynamic properties of a combustible propellant gas, after it has been processed by a ram accelerator propulsive mode, are related by a 'ram accelerator Hugoniot' expression. These end states are determined from the 1-D conservation equations in a manner similar to that used for detonation waves, but with the addition of a force term in the momentum equation. Establishment of a region of potentially accessible thermodynamic end states that are consistent with ram accelerator operation at and above the Chapman-Jouguet detonation speed indicates that there are no fundamental constraints on accelerating projectiles over a wide range of Mach numbers in a single propellant mixture. Interpreting experimental data in the context of a generalized ram accelerator process leads to relatively simple propulsive models which can predict the projectile acceleration of any propulsive mode. The projectile velocity and acceleration histories determined by the Hugoniot analysis for the thermally choked ram accelerator mode are in excellent agreement with experiments.

A93-45504
APPLICATIONS OF LIQUID CRYSTAL SURFACE THERMOGRAPHY TO HYPERSONIC FLOW
R. A. EAST (Southampton Univ., United Kingdom) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 643-650. refs
Copyright

The use of surface coatings of microencapsulated liquid crystals for heat transfer measurements in two short running time hypersonic flow facilities is discussed. Techniques are described from which both qualitative surface flow-fields and quantitative heat transfer data may be obtained. Calibration techniques suitable for application to short duration aerothermodynamic testing are described. Applications of the techniques to the study of a variety of hypersonic flow problems are presented. These include heat transfer investigations in several hypersonic flows involving shock/boundary layer interactions, a study of the effect of sweep on boundary layer transition and an experimental assessment of the heat transfer distribution on complex shapes typical of aerospace plane configurations. Author (revised)

A93-45505

APPLICATIONS OF INFRARED MEASUREMENT TECHNIQUE IN HYPERSONIC FACILITIES

A. HENCKELS, A. F. KREINS, and F. MAURER (DLR, Cologne, Germany) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 651-656. refs
(Contract DFG-SFB-253)
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For the design of thermal protection systems for future space vehicles it is necessary to localize and quantify the thermal loads due to convective surface heating. This paper presents tunnel experiments which demonstrate how surface heating due to interaction phenomena have been visualized and measured by infrared thermovision. An impinging shock wave on a laminar boundary layer of a flat plate and an axial corner configuration under 20 deg angle of attack were studied in a 60 cm hypersonic blow down facility of DLR Cologne at Mach number 8.7 for laminar flow conditions. In addition to the shock interaction study the capability of the infrared technique as diagnostic tool for short duration measurements was tested in the shock tunnel TH2 at the Stosswellenlabor RWTH Aachen. Author (revised)

A93-45506

A LASER INDUCED FLUORESCENCE SYSTEM FOR THE HIGH ENTHALPY SHOCK TUNNEL (HEG) IN GOETTINGEN

P. ANDRESEN (La-Vision 2D Messtechnik GmbH, Germany), W. H. BECK, G. EITELBERG (DLR, Inst. fuer Experimentelle Stroemungsmechanik, Goettingen, Germany), H. HIPPLER (Goettingen Univ., Germany), T. J. MCINTYRE (DLR, Inst. fuer Experimentelle Stroemungsmechanik, Goettingen, Germany), A. RIEDL (Goettingen Univ., Germany), T. SEELEMANN (La-Vision 2D Messtechnik GmbH, Germany), and J. TROE (Goettingen Univ., Germany) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 657-662. Research supported by ESA refs
Copyright

It is planned to use the LIF technique to examine the gas flows around models located in the test section of the high enthalpy shock tunnel (HEG) in Goettingen, at present nearing the end of construction. The technique will be used to measure concentrations of NO (in 2D) and O atoms (1D) and to obtain a measure of an NO internal temperature. A complex automated apparatus consisting of two lasers and image capturing systems has been constructed and is described here. This system is at present undergoing tests in a heated cell, and will be further tested in other wind/shock tunnels before its installation at HEG in early 1992. Preliminary test results from the heated cell are presented - a spectral analysis of NO and a temperature determination. The role of quenching in applying the LIF technique to HEG gas flows (which are not in chemical equilibrium) is discussed. An ongoing study in the shock tube laboratory of the University of Goettingen addresses this problem; quenching of NO is being examined behind a shock wave. Results for quenching with argon are presented here. Author (revised)

A93-45515

RADIATIVE HEAT TRANSFER FROM NON-EQUILIBRIUM HIGH-ENTHALPY SHOCK LAYERS

A. SASOH (Tohoku Univ., Sendai, Japan), X. CHANG (Nagoya Univ., Japan), T. MURAYAMA (Toyota Motor Corp., Japan), and T. FUJIWARA (Nagoya Univ., Japan) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 1 Berlin and New York Springer-Verlag 1992 p. 723-726. refs
Copyright

Numerical calculation of radiative heat transfer from non-equilibrium, high-enthalpy shock layers generated around a blunt body has been performed. At Mach numbers from 25 to 35, the radiative heat transfer is mainly caused by strong radiative emission in a thermally and chemically non-equilibrium layer generated immediately behind the shock wave. Accordingly, as upstream Mach number increases, the intensity of the radiative emission sharply increases, resulting in sharp increase in the radiative heat transfer. In this study, the thickness of the strong emission layer is almost independent of the nose radius. Hence, the radiative heat transfer is almost unchanged with the radius.

A93-45526* National Aeronautics and Space Administration, Washington, DC.

DEVELOPMENT OF A SKIN FRICTION GAUGE FOR USE IN AN IMPULSE FACILITY

G. M. KELLY, J. M. SIMMONS, and A. PAULL (Queensland Univ., St. Lucia, Australia) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 967-972. Research supported by Australian Research Council and Zonta International Foundation refs
(Contract NAGW-674)
Copyright

Tests of a prototype skin friction gauge at Mach 3.2 in a small free piston shock tunnel demonstrate the effectiveness of the design concept and the calibration against theoretical skin friction values in a simple flow. The gauge has a rise time of about 20 microsec, sufficiently short for most shock tunnel applications and approaching the rise times needed for expansion tube applications. AIAA

A93-45537

COMPUTATION OF SHOCK DIFFRACTION IN EXTERNAL AND INTERNAL FLOWS

J. Y. YANG, C. A. HSU, C. T. JIANG (National Taiwan Univ., Taipei), and B. MUELLER (Zuerich, Eidgenoessische Technische Hochschule, Zurich, Switzerland) *In* Shock waves; Proceedings of the 18th International Symposium, Sendai, Japan, July 21-26, 1991. Vol. 2 Berlin and New York Springer-Verlag 1992 p. 1063-1068. refs
(Contract NSC-79-0401-E002-34)
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Truly nonstationary shock diffraction patterns in external and internal flows were simulated using a third order essentially nonoscillatory shock capturing scheme based on the characteristic flux difference splitting method. For external flows, shock wave diffraction by an elliptic cylinder at angle of attack was studied. Whitham's geometrical shock dynamics was applied to obtain the shock-shock standoff distance and compared with the computed results. For internal flows, the unsteady shock propagation through a convergent-divergent channel was simulated. For both cases, the complete diffraction patterns, including the transition from regular to Mach reflection and the complex shock-on-shock interactions are reported in detail.

A93-45563

EFFECTS OF NOZZLE CONTOUR ON THE AERODYNAMIC CHARACTERISTICS OF UNDEREXPANDED ANNULAR IMPINGING JETS

WATARU MASUDA and TAKAO NAKAMURA (Nagaoka Univ. of Technology, Japan) JSME International Journal, Series B: Fluids

and Thermal Engineering (ISSN 0914-8817) vol. 36, no. 2 May 1993 p. 238-244. refs
Copyright

Dependence of the flow behavior of underexpanded annular impinging jets on the nozzle contours is investigated experimentally. In the present study, five converging annular nozzles of different contours are fabricated and tested. The most important parameters of the annular nozzle contour are the ratio of the inner diameter d to the outer diameter D and the angle alpha of the ejection. The flow visualization using the shadowgraph method and the pressure measurements at the impinged surface show that the shock structure in the jets and the surface pressure strongly depend on the nozzle contour. It is demonstrated that the impinging jet issuing from an annular nozzle with large d/D and large alpha produces high surface pressure concentrated at the jet center. These results suggest that annular nozzles show great potential for assisting laser cutting.

A93-45670
PREDICTION OF FATIGUE CRACK GROWTH KINETICS IN THE PLANE STRUCTURAL ELEMENTS OF AIRCRAFT IN THE BIAXIAL STRESS STATE [PROGNOZIROVANIE KINETIKI USTALOSTNYKH TRESHCHIN V PLOSKIKH EHLEMENTAKH KONSTRUKTSII VS PRI DVUKHOSNOM NAPRYAZHENNOM SOSTOYANII]
A. A. SHANYAVSKIJ, K. Z. KARAEV, V. M. GRIGOR'EV, M. Z. KORONOV, and E. F. ORLOV *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 61-69. In RUSSIAN refs
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The kinetics of fatigue crack growth in the case of a complex stress state is investigated with particular reference to D16T aluminum alloy. By using simulation models in the form of plane cruciform specimens, the characteristics of fatigue crack growth are investigated under conditions of uniaxial and biaxial tension-compression, with the ratio of the main stresses varying from -1 to 1.5. An algorithm is developed which makes it possible to predict the kinetics of fatigue crack growth and the equivalent stress level under conditions of multiparametric loading. AIAA

A93-45684
DAMPING OF A GYRO HORIZON-COMPASS WITH ARBITRARY DISPLACEMENT OF THE SUSPENSION POINT [DEMPFIROVANIE GIROGORIZONTKOMPASA PRI PROIZVOL'NOM PEREMESHCHENII TOCHKI PODVESA]
I. A. LAPIN and L. S. RATAF'EVA *In* Mathematical methods for the analysis of instruments and control systems Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 p. 125-129. In RUSSIAN refs
Copyright

The damping of a gyro horizon-compass in the case of the arbitrary displacement of the suspension point is investigated analytically using a system of equations describing the small motions of the sensing element of the instrument. Conditions for the asymptotic stability of the gyro horizon-compass motions are determined. AIAA

A93-45740
NONLINEAR FLUTTER OF ORTHOTROPIC COMPOSITE PANEL UNDER AERODYNAMIC HEATING
JEHAD F. ABBAS, R. A. IBRAHIM, and RONALD F. GIBSON (Wayne State Univ., Detroit, MI) AIAA Journal (ISSN 0001-1452) vol. 31, no. 8 Aug. 1993 p. 1478-1488. AIAA Dynamics Specialists Conference, Dallas, TX, Apr. 16, 17, 1992, Technical Papers, p. 524-535. Previously cited in issue 14, p. 2377, Accession no. A92-35699 refs
Copyright

A93-45745
SOME MEASUREMENTS ON DEPENDENCE OF RECTANGULAR CYLINDER DRAG ON ELEVATION
R. G. BATT and S. A. PEABODY, II (TRW, Inc., Redondo Beach, CA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 8 Aug. 1993 p. 1517-1519. refs
Copyright

Recent measurements of rectangular cylinder drag on model elevation are summarized using a rectangular shaped model of 1 in and 0.0254 m base height (H) in a laboratory scale shock tube. Model elevations (HE) are from HE/H equals to 0.125 - 6.00 (freestream) at low shock overpressures about 7.5 psi/51.7 kPa. Data for both early-time diffraction loads and late-time steady-state are presented for a case of clean (dust-free) flow. AIAA

A93-45773
TOWARDS QUANTITATIVE NON-DESTRUCTIVE EVALUATION OF AGING AIRCRAFT
J. D. ACHENBACH (Northwestern Univ., Evanston, IL) and D. O. THOMPSON (Iowa State Univ. of Science and Technology, Ames) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 1-13. refs
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Nondestructive testing techniques, as they are practiced in the field of quantitative nondestructive evaluation, are at the basis of a comprehensive approach to secure the safety of aging aircraft. The applications, advantages and disadvantages of the principal NDE techniques are summarized in this paper. It is discussed that measurement models for these techniques, in conjunction with the probability of detection concept, scanning plans, and methods of graphical display, facilitate the selection of optimal procedures for specific inspection problems. These models also suggest NDE standards and calibration techniques, and they can be an important part of inspection system validation and operator training. Four major components of a comprehensive quantitative NDE program for aging aircraft are identified and briefly discussed. Author (revised)

A93-45774
COMPUTATIONAL SCHEMES FOR INTEGRITY ANALYSES OF FUSELAGE PANELS IN AGING AIRPLANES
SATYA N. ATLURI (Georgia Inst. of Technology, Atlanta) and PIN TONG (DOT, Transportation Systems Center, Cambridge, MA) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 15-35. Research supported by DOT refs
Copyright

This paper reviews some simplified computational strategies for the integrity analyses of fuselage panels in aging airplanes. The topics covered include: (i) a 'direct stiffness' method for stiffened panels (with fastener flexibility being accounted for) with multiple cracks, using the alternating technique, (ii) MSD near a row of fastener holes, (iii) analysis of cracks with bonded repair patches, (iv) weight functions for multiple cracks, and (v) bulging near crack-tips in pressurized fuselages, and equivalent domain integral methods for computing fracture parameters for bulged cracks.

A93-45775
RISK ANALYSIS FOR AGING AIRCRAFT FLEETS
A. P. BERENS (Dayton Univ., OH), J. G. BURNS, and J. L. RUDD (USAF, Wright Lab., Wright-Patterson AFB, OH) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 37-51. refs
(Contract F33615-87-C-3215)
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The objective of the USAF program presently discussed was to stochastically assess aircraft structural integrity in terms of both the probability of fracture of a population of structural details and a quantification of the anticipated number and sizes of cracks requiring repair that will be detected at a given inspection. The characterization of structural integrity may then proceed as a tool for making inspection-, replacement-, and retirement-related maintenance decisions. This methodology has been implemented in the PROF code for risk analyses, as illustrated for the case of a representative scenario. AIAA

A93-45776
ASPECTS OF AGING AIRCRAFT - A TRANSATLANTIC VIEW
JOHN W. BRISTOW (Civil Aviation Authority, Safety Regulation Group, Gatwick, United Kingdom) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 53-71. refs
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This paper discusses, from a regulatory viewpoint, some of the key technical matters in the aging aircraft issue. Attention is focused primarily on research topics of interest, for an overview of the CAA approach to aging aircraft. In general, the reader is referred to Williams (1990) and James (1990). The topics covered here are: experience with proof pressure testing; inspection reliability in relation to the task; potential effects of corrosion on fatigue crack growth and toughness; definition of corrosion inhibiting fluids; and implementation management of aging aircraft programs. Author (revised)

A93-45777
THE CIVIL DAMAGE TOLERANCE REQUIREMENTS IN THEORY AND PRACTICE
DAVID BROEK (FractuResearch, Inc., Galena, OH) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 73-86. refs
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This paper presents a brief review of the Damage Tolerance Requirements (DTR) for civil aircraft, and of their impact and significance for both newly developed and aging aircraft. Some improvements to the DTR are suggested. In principle, fracture control of aircraft is ensured by non-destructive inspection, although destructive inspection has been suggested for certain aging aircraft, as will be discussed briefly as well.

A93-45780* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN EVALUATION OF THE PRESSURE PROOF TEST CONCEPT FOR 2024-T3 ALUMINIUM ALLOY SHEET
D. S. DAWICKE (Analytical Services and Materials, Inc., Hampton, VA), C. C. POE, JR., J. C. NEWMAN, and C. E. HARRIS (NASA, Langley Research Center, Hampton, VA) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 115-129. refs
Copyright

The concept of pressure proof testing of fuselage structures with fatigue cracks to insure structural integrity was evaluated from a fracture mechanics viewpoint. A generic analytical and experimental investigation was conducted on uniaxially loaded flat panels with crack configurations and stress levels typical of longitudinal lap splice joints in commercial transport aircraft fuselages. The results revealed that the remaining fatigue life after a proof cycle was longer than that without the proof cycle because of crack growth retardation due to increased crack closure. However, based on a crack length that is slightly less than the critical value at the maximum proof stress, the minimum assured life or proof test interval must be no more than 550 pressure cycles for a 1.33 proof factor and 1530 pressure cycles for a 1.5 proof factor to prevent in-flight failures.

A93-45782* National Aeronautics and Space Administration, Washington, DC.
NASA AIRFRAME STRUCTURAL INTEGRITY PROGRAM
CHARLES E. HARRIS (NASA, Langley Research Center, Hampton, VA) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 141-152. refs
Copyright

NASA has initiated a research program with the long-term objective of supporting the aerospace industry in addressing issues related to the aging commercial transport fleet. The interdisciplinary program combines advanced fatigue crack growth prediction methodology with innovative nondestructive examination technology with the focus on multi-site damage (MSD) at riveted connections. A fracture mechanics evaluation of the concept of pressure proof testing the fuselage to screen for MSD has been completed. Also, a successful laboratory demonstration of the ability of the thermal flux method to detect disbonds at riveted lap splice joints has been conducted. All long-term program elements have been initiated and the plans for the methodology verification program are being coordinated with the airframe manufacturers.

A93-45785
REPRESENTATION AND PROBABILITY ISSUES IN THE SIMULATION OF MULTI-SITE DAMAGE
A. R. INGRAFFEA, M. D. GRIGORIU (Cornell Univ., Ithaca, NY), and D. V. SWENSON (Kansas State Univ., Manhattan) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 183-197. Research supported by Boeing Military Airplanes and USAF refs
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The types of multi-site damage which are observed in fuselage skins preclude use of common simplifications employed in simulating crack growth. Interaction of cracks with each other and with structural features causes arbitrary growth patterns. Representation of a number of arbitrarily growing cracks in a finite element model is a problem which can be addressed with new codes built on a topological data structure and employing automatic remeshing. Examples of such codes applied to problems of interacting cracks, crack interaction with rivet holes, and cracking beneath a boron/epoxy patch are presented. A technique for incorporating probability methods into simulations of arbitrary crack growth is also presented and discussed via an example problem.

A93-45787
APPLICATIONS OF ADVANCED FRACTURE MECHANICS TO FUSELAGE
M. F. KANNINEN, P. E. O'DONOGHUE, S. T. GREEN, C. P. LEUNG, S. ROY, and O. H. BURNSIDE (Southwest Research Inst., San Antonio, TX) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 213-224. refs
(Contract DTRS57-90-P-80689)
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Multi-site damage (MSD) in the form of cracking at rivet holes in lap splice joints has been identified as a serious threat to the integrity of commercial aircraft nearing their design life targets. Consequently, to assure the safety of aircraft that have accumulated large numbers of flights, flight hours and years in service requires requires inspection procedures that are based on the possibility that MSD may be present. For inspections of aircraft components to be properly focused on me defect sizes that are critical for structural integrity, fracture analyses are needed. The current methods are essentially those of linear elastic fracture mechanics (LEFM) which are strictly valid only for cracks that extend in a quasi-static manner under small-scale crack tip plasticity conditions. While LEFM is very likely to be appropriate for subcritical crack growth, quantifying the conditions for fracture instability and subsequent propagation may require advanced fracture mechanics techniques. The specific focus in this paper was to identify the conditions in which inelastic-dynamic effects occur in (1) the linking up Of local damage in a lap splice joint to form a major crack, and (2) large-scale fuselage failure by a rapidly occurring fluid structure interaction process.

A93-45788
AXIAL CRACK PROPAGATION AND ARREST IN PRESSURIZED FUSELAGE
M. KOSAI and A. S. KOBAYASHI (Washington Univ., Seattle) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 225-239. refs
(Contract DTRS56-83-C-0009; N00014-89-J-1276)
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The rapid crack propagation, crack curving and arrest mechanisms associated with a pressurized, thin-walled ductile steel tubes are used to develop a model of axial rupture of an aircraft fuselage. This model is used to replicate axial crack propagation along a line of multi-site damage (MSD) and crack curving and arrest near a tear strap of an idealized fuselage.

A93-45790
A LABORATORY STUDY OF FRACTURE IN THE PRESENCE OF LAP SPLICE MULTIPLE SITE DAMAGE
RONALD A. MAYVILLE and THOMAS J. WARREN (Arthur D. Little, Inc., Cambridge, MA) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 263-273. Research supported by FAA refs
(Contract DTRS57-88-C-00019)
Copyright
Flat coupons were tested in the laboratory to determine a fracture criterion for link-up of fuselage lap splice multiple site damage at adjacent rivet holes. Experiments were performed on 0.040 inch (1 mm) thick 2024-T3 clad aluminum sheet. Continuous and riveted lap splice coupons were tested with simulated uniform (equal crack lengths) and nonuniform MSD, and the effects of notch sharpness were also studied. A net section stress criterion was found to provide excellent predictions of fracture for uniform MSD and uniform stress distributions. This same criterion provides conservative predictions for nonuniform MSD in uniform stress fields. An overload/cyclic stress experiment was also conducted to explore the pressurized proof test scenario of ensuring structural integrity.

A93-45791
HOW LIKELY IS MULTIPLE SITE DAMAGE?
OSCAR ORRINGER (DOT, Transportation Systems Center, Cambridge, MA) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 275-292. refs
Copyright
One way to avoid multiple site damage in airframes of the future is to screen design details by means of coupon tests. A simple conceptual model for estimating the risk of multiple site damage is presented. The risk is expressed as the fraction of similar details which can be expected to form fatigue cracks at times close enough to each other to allow a fracture cascade after the damage has propagated. Examples based on an approximate representation of typical transport category fuselage skin properties and stress environments show that the risk becomes significant for details which exhibit much less fatigue life scatter than is observed in plain fatigue tests and for which the characteristic life is of the order of the service life. Results for confidence limits are also presented to show that at least 40 replicate details must be tested to obtain adequate estimates of scatter and characteristic life.

A93-45798* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OPTICAL METHODS OF STRESS ANALYSIS APPLIED TO CRACKED COMPONENTS
C. W. SMITH (Virginia Polytechnic Inst. and State Univ., Blacksburg) *In* Structural integrity of aging airplanes Berlin and New York Springer-Verlag 1991 p. 421-432. Research supported by NASA refs
Copyright
After briefly describing the principles of frozen stress photoelastic and moire interferometric analyses, and the corresponding algorithms for converting optical data from each method into stress intensity factors (SIF), the methods are applied to the determination of crack shapes, SIF determination, crack closure displacement fields, and pre-crack damage mechanisms in typical aircraft component configurations.

A93-46407* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LOW-TO-HIGH ALTITUDE PREDICTIONS OF THREE-DIMENSIONAL ABLATIVE RE-ENTRY FLOWFIELDS
BILAL A. BHUTTA and CLARK H. LEWIS (VRA, Inc., Blacksburg, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650) vol. 30, no. 4 July-Aug. 1993 p. 395-403. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0366. Previously cited in issue 09, p. 1412, Accession no. A92-26227 refs
(Contract NAS3-25450)
Copyright

A93-46488*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
FLIGHT DATA FOR THE CRYOGENIC HEAT PIPE (CRYOHP) EXPERIMENT
PATRICK J. BRENNAN (OAO Corp., Greenbelt, MD), LEE THIENEL (Jackson and Tull, Greenbelt, MD), TED SWANSON (NASA, Goddard Space Flight Center, Greenbelt, MD), and MICHAEL MORGAN (USAF, Wright Lab., Wright-Patterson AFB, OH) Jul. 1993 12 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 Research supported by USAF, SDIO, and NASA refs
(AIAA PAPER 93-2735) Copyright
This paper presents the flight test results and data correlation for the Cryogenic Heat Pipe Flight Experiment (CRYOHP). CRYOHP is a Hitchhiker Canister experiment that was flown aboard the shuttle Discovery (STS-53) in December of 1992. Two different axially grooved oxygen heat pipes were tested to determine their startup behavior and transport capability in micro-gravity. Three startup cycles were conducted with each heat pipe and transport data was obtained over the range of 60 K to 140 K. Startup in flight was repeatable but slower than observed in ground tests. The transport data shows good agreement with the theoretical model. The CRYOHP test bed, which incorporates five Stifling cycle refrigerators to provide the cryo-cooling, performed as predicted and offers a good micro-gravity test bed for cryogenic thermal devices.

A93-46529*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CONVECTIVE HEAT-TRANSFER RATE DISTRIBUTIONS OVER A 140 DEG BLUNT CONE AT HYPERSONIC SPEEDS IN DIFFERENT GAS ENVIRONMENTS
DAVID A. STEWART (NASA, Ames Research Center, Moffett Field, CA) and Y. K. CHEN (Eloret Inst., Palo Alto, CA) Jul. 1993 16 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2787) Copyright
Experiments were conducted in air, CO2, and CO2-argon gas mixtures to obtain heating distribution data over a 140 deg blunt cone with various corner radii. The effect of corner radius on the heating distribution over the forebody of the cone was included in the investigation. These experiments provide data for validation of two-dimensional axisymmetric and three-dimensional Navier-Stokes solutions. Heating distribution data and measured bow shock wave stand-off distances for 0 deg angle of attack were compared with predicted values using a two-dimensional axisymmetric Navier-Stokes code. Author (revised)

A93-46531# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SIMULATION OF ABLATION IN EARTH ATMOSPHERIC ENTRY
JAMES A. KEENAN (North Carolina State Univ., Raleigh) and GRAHAM V. CANDLER (Minnesota Univ., Minneapolis) Jul. 1993 14 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(Contract NCC1-140; NAGW-1331)
(AIAA PAPER 93-2789) Copyright
The process of ablation for Earth atmospheric entry is simulated using a computational approach that allows thermo-chemical nonequilibrium of the flow field and ablation gases. The heat pulse into the heat shield is modeled. The flowfield and graphite heat shield are coupled through surface mass and energy balances. The surface thermochemistry involves the oxidation of graphite and allows for catalytic recombination of diatomic oxygen. Steady-state simulations are performed on a one meter nose radius sphere at an altitude of 65/km and at freestream velocities of 8 km/s and 10 km/s. A transient simulation is performed at 65 km altitude and a freestream velocity of 10 km/s.

A93-46544#
NON-EQUILIBRIUM THERMAL RADIATION FROM AIR SHOCK LAYERS MODELLED WITH THE DIRECT SIMULATION MONTE CARLO METHOD
M. A. GALLIS and J. K. HARVEY (Imperial College of Science, Technology, and Medicine, London, United Kingdom) Jul. 1993 11 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 Research supported by Ministry of Defence of United Kingdom, refs
(Contract MOD-AT/2037/331)
(AIAA PAPER 93-2805) Copyright
At re-entry velocities it is generally agreed that the radiation associated with transitions between excited electronic states of atoms and molecules is responsible for the bulk of the thermal radiation emitted from the shock wave area. This paper deals with the evaluation of thermal radiation emitted from hypersonic shock waves in real air using the Direct Simulation Monte Carlo method. The calculation of electronic excitation is made without assuming equilibrium for the distribution of the energy states and measured or theoretically evaluated cross sections are used to determine the electronic excitation of atoms and molecules in the flow and the subsequent thermal radiation. The results with this new scheme are compared with available experimental data and existing numerical methods. The test cases are based on an AVCO Everett shock tube experiment and on the two dimensional flow field of a blunted Mars-net re-entry vehicle. The method is in good agreement with both experimental data and results given by other methods. Discrepancies are evaluated and discussed.

A93-46590*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THERMAL ANALYSIS OF AN ARC HEATER ELECTRODE WITH A ROTATING ARC FOOT
FRANK S. MILOS (NASA, Ames Research Center, Moffett Field, CA) and CHARLES E. SHEPARD (Eloret Inst., Palo Alto, CA) Jul. 1993 17 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2855) Copyright
A smoothly rotating arc foot and an arc foot that jumps between multiple sticking points were analyzed using analytic formulations and numerical solution procedures. For each case the temperature distribution for a copper electrode was obtained for the plausible range of operating conditions. It is shown that the smoothly rotating arc foot is an extremely safe mode of operation, whereas the jumping arc foot produces excessively high electrode surface temperatures which are not greatly alleviated by increasing the average rotational frequency of the arc foot. It is suggested to eliminate arc-foot rotation and rely on the distribution of fixed electrodes with stationary arc attachment to avoid electrode failure at high current. AIAA

A93-46796#
EFFECT OF NONAXISYMMETRIC FORCING ON A SWIRLING JET WITH VORTEX BREAKDOWN
ISMET GURSUL (Cincinnati Univ., OH) Jul. 1993 8 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 Research supported by Univ. of Cincinnati refs
(AIAA PAPER 93-3251) Copyright
Experiments were carried out to develop control techniques for swirling flows. Nonaxisymmetric forcing was applied to the vortex breakdown flowfield of a strongly swirling jet and its effects were investigated experimentally. It is shown that the spreading rate of the jet can be substantially increased due to the excitation of the helical mode instability of the breakdown flowfield. This can be achieved for extremely low amplitudes of excitation.

A93-46802
ACTIVELY COOLED PANEL TESTING PERILS, PROBLEMS, AND PITFALLS
H. N. KELLY (Analytical Services and Materials, Inc., Hampton, VA) and TIMOTHY P. SIKORA (USAF, Wright Lab., Wright-Patterson AFB, OH) Nov. 1991 8 p. SEM, Structural Testing Technology at High Temperatures Conference, Dayton, OH, Nov. 4-6, 1991, Paper refs
Some of the lessons learned from the design and testing of cooled structures for aerospace vehicles are reviewed. It is concluded that the wide range of operational temperatures and the extremely hostile environment in which the panels are expected to operate tend to enhance the criticality of each element and add new aspects to the design and development process. The material properties, including conductivity, thermal expansion, ductility, and fracture toughness, are of primary importance due to the impact of heat transfer and the wide temperature range. Current instrumentation techniques are considered to be inadequate for the hostile environment to which the hot surfaces of actively cooled panels are exposed. Generally, the studies emphasize the need for testing for the entire anticipated operating range to reveal hidden drawbacks in design logic or manufacturing. AIAA

A93-46811*. National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
KINEMATIC DOMAIN DECOMPOSITION FOR BOUNDARY-MOTION-INDUCED FLOW SIMULATIONS
OKTAY BAYSAL and GUAN-WEI YEN (Old Dominion Univ., Norfolk, VA) May 1991 10 p. SIAM, Conference on Domain Decomposition Methods for Partial Differential Equations, 5th, Norfolk, VA, May 6-8, 1991, Paper refs
(Contract NAG1-1150)
A method is developed to solve the unsteady Navier-Stokes equations on a composite grid, which consists of subdomain grids moving with respect to each other. These subdomains are structured grids with different topologies. This method eliminates assuming the moving components to be instantaneously stationary, where deciding on the particular frozen instants is difficult and affects the solution adversely. Moreover, this method captures the boundary-motion-induced flow component. The method is demonstrated through a transonic flow past an airfoil, which experiences a combined motion of pitching and plunging. An O-grid around the airfoil is overlapped on a fine Cartesian grid, which is zonally embedded in a coarse Cartesian grid. The coarse grid is stationary but the other two grids are plunging. Only the O-grid is also sinusoidally pitching. The results are compared successfully with the experimental data.

A93-46821* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THERMAL CONTROL OF A LIDAR LASER SYSTEM USING A NON-CONVENTIONAL RAM AIR HEAT EXCHANGER
BRIAN D. KILLOUGH, WILLIAM ALEXANDER, JR., and DOYLE P. SWOFFORD (NASA, Langley Research Center, Hampton, VA) Oct. 1990 10 p. SAE, Aerotech 90 Conference, Long Beach, CA, Oct. 1-4, 1990, Paper
This paper describes the analysis and performance testing of a uniquely designed external heat exchanger. The heat exchanger is attached externally to an aircraft and is used to cool a laser system within the fuselage. Estimates showed insufficient cooling capacity with a conventional staggered tube array in the limited space available. Thus, a non-conventional design wes developed with larger tube and fin area exposed to the ram air to increase the heat transfer performance. The basic design consists of 28 circular finned aluminum tubes arranged in two parallel banks. Wind tunnel tests were performed to simulate air and liquid flight conditions for the non-conventional parallel bank arrangement and the conventional staggered tube arrangement. Performance comparisons of each of the two designs are presented. Test results are used in a computer model of the heat exchanger to predict the operating performance for the entire flight profile. These analyses predict significantly improved performance over the conventional design and show adequate thermal control margins.

A93-46822* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A THREE DIMENSIONAL VIEW OF VELOCITY USING LASERS
JAMES F. MEYERS (NASA, Langley Research Center, Hampton,

VA) Jul. 1991 27 p. International Invitational Symposium on Unification of Finite Element Methods in Theory and Test, 10th, Worcester, MA, July 18, 19, 1991, Paper refs

The use of laser light sheet flow visualization, fringe-type laser velocimetry, and Doppler global velocimetry to make flow field investigations is described. The complementary nature of the techniques is demonstrated by using them to examine the vortical flow fields above a 75 deg swept delta wing and a YF-17 model in a low-speed wind tunnel. The characteristics of these systems are described and their capability to provide fundamental velocity databases for CFD validation is assessed. Author (revised)

A93-46928

TURBINE BLADE FORCES DUE TO PARTIAL ADMISSION

F. BOULBIN, N. PENNERON (Nantes, Ecole Centrale, France), J. KERMAREC (Centre Technique des Industries Mecaniques, Nantes, France), and M. PLUVIOSE (Conservatoire National des Arts et Metiers, Paris, France) Revue Francaise de Mecanique (ISSN 0373-6601) no. 3 1992 p. 203-208. Societe Francaise des Mecaniciens, SNECMA et ONERA, Progres recents en aerothermodynamique des compresseurs et turbines, Journees, Courbevoie, France, Nov. 24, 25, 1992, Communications. A93-46926 19-07 refs

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The unsteady forces and torques acting on the blades of a partial admission turbine are experimentally studied using a model turbine stage with two nozzle arcs. Results are presented for various stage pressure ratios and for practical ranges of stage velocity ratios. The transient aerodynamic peak forces on the blades due to the cyclic loading and unloading are determined as the blade enters and leaves the arc of admission. The unsteady flow in the channel is computed by the method of characteristics. A novel method yielding reasonable results is based on sudden enlargement theory is developed to address the inflow boundary conditions. AIAA

A93-46979

THE DETERMINATION OF HYBRID ANALYTICAL-NUMERICAL SOLUTIONS FOR THE THREE-DIMENSIONAL COMPRESSIBLE BOUNDARY LAYER

ADRIANA NASTASE (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) Zeitschrift fuer Angewandte Mathematik und Mechanik (ISSN 0044-2267) vol. 73, no. 6 1993 p. T 520-T 523. refs

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The determination of hybrid analytical solutions for the 3D stationary laminar compressible boundary layer equations over flattened configurations in supersonic flow is examined. The theory is illustrated for a delta wing with arbitrary camber, twist, and thickness distributions. AIAA

A93-46993

NUMERICAL SIMULATION OF LINEAR INTERFERENCE WAVE DEVELOPMENT IN THREE-DIMENSIONAL BOUNDARY LAYERS [NUMERISCHE SIMULATION DER LINEAREN STOERWELLENENTWICKLUNG IN DREIDIMENSIONALEN GRENZSCHICHTEN]

WOLFGANG MUELLER and HORST BESTEK (Stuttgart Univ., Germany) Zeitschrift fuer Angewandte Mathematik und Mechanik (ISSN 0044-2267) vol. 73, no. 6 1993 p. T 628-T 631. In GERMAN refs

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A procedure for solving the full 3D Navier-Stokes equations is presented which permits a numerical simulation of the spatial development of interference waves in the boundary layer over a sliding plate with crossflow. The results of the procedure are in good agreement with linear stability theory. AIAA

A93-47076

PROBLEMS OF THE STRENGTH AND FATIGUE OF THE ELEMENTS OF AIRCRAFT STRUCTURES [VOPROSY PROCHNOSTI I DOLGOVECHNOSTI EHLEMENTOV AVIATSIONNYKH KONSTRUKTSIJ]

KH. S. KHAZANOV, ED. Kuibyshev, Russia Kujbyshevskij Aviatsionnyj Institut 1990 145 p. In RUSSIAN For individual items see A93-47077 to A93-47095

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The papers presented in this volume focus on analytical and numerical methods for the study of the statics, dynamics, and stability of thin-walled structures, fracture mechanics, fatigue strength, and reliability of aircraft structures. Specific topics discussed include a finite element algorithm for studying the nonlinear deformation and stability of structurally orthotropic cylindrical shells, construction of stiffness matrices in nonlinear finite element analysis, and using the quadrature method for the stability analysis of rods of variable cross section. Other topics discussed include optimization of an aeroelastic structure using the dynamic stability condition, dynamic analysis of a compound elastic surface, and using the finite element method in the statistical prediction of fatigue strength. AIAA

A93-47078

COUPLING CONDITIONS FOR SUBSTRUCTURES WITH VARYING IDEALIZATION [USLOVIYA SOCHLENENIYA DLYA PODKONSTRUKTSIJ S RAZLICHNOJ IDEALIZATSIEJ]

P. D. LEVASHOV *In* Problems of the strength and fatigue of the elements of aircraft structures Kuibyshev, Russia Kujbyshevskij Aviatsionnyj Institut 1990 p. 13-19. In RUSSIAN refs

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The Lagrange variational principle is used to obtain coupling conditions for structure components of varying idealization, with interaction forces between the adjacent substructures used as independent variables. The existence of ambiguity in the problem is demonstrated. It is also shown that parameters describing the behavior of the structure are discontinuous on the dividing surface, which may disturb the stress-strain state. AIAA

A93-47084

AN ANALYTICAL-EXPERIMENTAL METHOD FOR STUDYING THE STRENGTH AND STABILITY OF THIN-WALLED STRUCTURES [RASCHETNO-EHKSPERIMENTAL'NYJ METOD ISSLEDOVANIYA PROCHNOSTI I USTOJCHIVOSTI TONKOSTENNYKH KONSTRUKTSIJ]

L. P. ZHELEZNOV and V. T. FADEEV *In* Problems of the strength and fatigue of the elements of aircraft structures Kuibyshev, Russia Kujbyshevskij Aviatsionnyj Institut 1990 p. 61-66. In RUSSIAN refs

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The paper is concerned with the problem of using strain gauge data to improve the accuracy of analytical determinations of the stress-strain state. The boundary forces and moments are used as the unknowns in solving the semiinverse problem. Results of a study of the stability of a round cylindrical shell are reported. AIAA

A93-47085

OPTIMIZATION OF AN AEROELASTIC SYSTEM USING THE DYNAMIC STABILITY CONDITION [OPTIMIZATSIYA AEHROUPRUGOJ SISTEMY PO USLOVIYAM DINAMICHESKOJ USTOJCHIVOSTI]

T. V. GRISHANINA and F. N. SHKLYARCHUK *In* Problems of the strength and fatigue of the elements of aircraft structures Kuibyshev, Russia Kujbyshevskij Aviatsionnyj Institut 1990 p. 66-72. In RUSSIAN refs

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A study is made of the natural vibrations of a linear aeroelastic system with a finite number of degrees of freedom. The dynamic characteristics of modified structures are determined by using the perturbation method. To increase the dynamic stability, the selected system parameters are varied in accordance with the gradient steepest descent method. The problem of increasing the flutter stability margin of an adjustable stabilizer in supersonic flow is considered as an example. AIAA

A93-47086
DYNAMIC ANALYSIS OF A COMPOUND ELASTIC SURFACE [O DINAMICHESKOM RASCHETE SOSTAVNOJ EHLASTICHNOJ POVERKHNOSTI]
V. G. GAJNUTDINOV and V. A. PAVLOV *In* Problems of the strength and fatigue of the elements of aircraft structures Kuibyshev, Russia Kujbyshevskij Aviatsionnyj Institut 1990 p. 72-76. In RUSSIAN refs
Copyright
A theory and an algorithm are proposed for the dynamic analysis of elastic lifting surfaces with control airfoils. Results of aeroelastic calculations are presented. The behavior of an elastic blade in gas flow is investigated as a function of the position of the center of mass of a load located at the tip of the blade. AIAA

A93-47093
LOAD RATING FOR A DELTA WING BOX BASED ON A RELIABILITY CRITERION [NORMIROVANIE NAGRUZKI NA TREUGOL'NYJ KESSON PO KRITERIYU NADEZHNOSTI]
S. N. PEROV and S. P. RASSKAZOV *In* Problems of the strength and fatigue of the elements of aircraft structures Kuibyshev, Russia Kujbyshevskij Aviatsionnyj Institut 1990 p. 118-124. In RUSSIAN refs
Copyright
A method is presented for calculating the maximum load for a wing box using a reliability criterion. The problem is solved in two versions: for an intact structure and for a damaged structure with a through crack in a stretched panel. Calculation results are presented for a delta wing box. AIAA

A93-47208*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATION OF THE SHADOWGRAPH FLOW VISUALIZATION TECHNIQUE TO A FULL-SCALE HELICOPTER ROTOR IN HOVER AND FORWARD FLIGHT
ALEXANDRA A. SWANSON (Sterling Software, Inc.; NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 77-91. Research supported by NASA refs
(AIAA PAPER 93-3411) Copyright
The wide-field shadowgraph flow visualization technique was used for the first time with a full-scale helicopter rotor. This was accomplished during testing of a Sikorsky S-76 main rotor in the NASA Ames National Full-Scale Aerodynamics Complex (NFAC) 80- by 120-Foot Wind Tunnel. Hover, low-speed forward flight, and descent operating conditions were studied. Preliminary results are very promising with rotor wake tip vortices visible up to an advance ratio of 0.25. In addition, many details of the rotor wake were visible, including tip vortex roll-up, inboard wake vorticity, and flow unsteadiness due to test section recirculation effects in hover. Shadowgraphs of blade/vortex interactions were also acquired. Simultaneous top and side view shadowgraphs of the rotor wake were acquired by a newly developed synchronized digital imaging system. The imaging system proved to be a highly successful tool which made real-time examination of selected regions of the rotor wake possible.

A93-47246*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DEVELOPMENT OF A SYSTEM FOR TRANSITION CHARACTERIZATION
ARILD BERTELRUD, SHARON GRAVES, and JOHN DIAMOND (NASA, Langley Research Center, Hampton, VA) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 510-523. refs
(AIAA PAPER 93-3465)
The present system for real-time boundary layer transition detection and characterization encompasses aerodynamic simulations, sensor characteristics, and a hybrid analog/digital system for signal analysis, verification, and compression. By using artificial, intermittently laminar/turbulent signals, in conjunction with trajectory simulation, it becomes possible to conduct algorithm development which is independent of, and in advance of, sensor buildup. Attention is given to the illustrative case of the Pegasus launch vehicle's trajectory. AIAA

N93-31110*# Ohio State Univ., Columbus. ElectroScience Lab.
OPERATION OF THE HELICOPTER ANTENNA RADIATION PREDICTION CODE
E. W. BRAEDEN, F. T. KLEVENOW, E. H. NEWMAN, R. G. ROJAS, K. S. SAMPATH, J. T. SCHEIK, and H. T. SHAMANSKY Jun. 1993 111 p
(Contract NAG1-1058)
(NASA-CR-193259; NAS 1.26:193259; REPT-722792-4) Avail: CASI HC A06/MF A02
HARP is a front end as well as a back end for the AMC and NEWAIR computer codes. These codes use the Method of Moments (MM) and the Uniform Geometrical Theory of Diffraction (UTD), respectively, to calculate the electromagnetic radiation patterns for antennas on aircraft. The major difficulty in using these codes is in the creation of proper input files for particular aircraft and in verifying that these files are, in fact, what is intended. HARP creates these input files in a consistent manner and allows the user to verify them for correctness using sophisticated 2 and 3D graphics. After antenna field patterns are calculated using either MM or UTD, HARP can display the results on the user's screen or provide hardcopy output. Because the process of collecting data, building the 3D models, and obtaining the calculated field patterns was completely automated by HARP, the researcher's productivity can be many times what it could be if these operations had to be done by hand. A complete, step by step, guide is provided so that the researcher can quickly learn to make use of all the capabilities of HARP. Author (revised)

N93-31123# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.
OPTIMAL DESIGN AND IMPERFECTION SENSITIVITY OF NONLINEAR SHELL STRUCTURES
ULF RINGERTZ Oct. 1992 34 p Sponsored by Foersvarets Materialverk, Stockholm, Sweden, and Swedish Board for Industrial and Technical Development
(FFA-TN-1992-30; ETN-93-94216) Avail: CASI HC A03/MF A01
Higher order optimality conditions used to analyze the imperfection sensitivity of thin shell structures are described. These are necessary since the structural behavior of such structures are in many cases known to be highly sensitive to small imperfections in geometry, boundary conditions, loading, and material properties. The higher order optimality conditions are given in a form suitable for large scale finite element analysis. The presentation is restricted to discretized structures for which the deformation can be described by a finite number of scalar parameters. It is well known that use of simplistic optimal design procedures may lead to structures with simultaneous buckling modes. Simultaneous buckling can in some cases lead to extremely imperfection sensitive structures. It is shown that structures with simultaneous buckling modes are not necessarily imperfection sensitive. Groebner bases are used for analyzing imperfection sensitivity when there are several simultaneous buckling modes. Numerical examples are used to illustrate some possible fallacies when analyzing the higher order optimality conditions. ESA

N93-31137 Virginia Polytechnic Inst. and State Univ., Blacksburg.
INTEGRATED STRUCTURAL DESIGN, VIBRATION CONTROL, AND AEROELASTIC TAILORING BY MULTIOBJECTIVE OPTIMIZATION Ph.D. Thesis
ROBERT ARTHUR CANFIELD 1992 172 p
Avail: Univ. Microfilms Order No. DA9310500
The integrated design of a structure and its control system was treated as a multiobjective optimization problem. Structural mass, a quadratic performance index, and the flutter speed constituted the vector objective function. The closed-loop performance index was taken as the time integral of the

Hamiltonian. Constraints on natural frequencies and aeroelastic damping were also considered. Derivatives of the objective and constraint functions with respect to structural and control design variables were derived for a finite element beam model of the structure and constant feedback gains determined by Independent Modal Space Control. Pareto optimal designs generated for a simple beam and a tetrahedral truss demonstrated the benefit of solving the integrated structural and control optimization problem. The use of quasi-steady aerodynamic strip theory with a thin-wall box beam model showed that the integrated design for a high aspect ratio, unswept, straight, isotropic wing can be separable. Finally, an efficient modal solution of the flutter equation facilitated the aeroelastic tailoring of a low aspect ratio, forward swept, composite plate wing model. Dissert. Abstr.

N93-31146# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
WBNFLOW: MULTI-GRID/MULTI-BLOCK POTENTIAL SOLVER FOR COMPRESSIBLE FLOW. USER'S GUIDE
WANG DIEGIAN Dec. 1992 16 p
(Contract NUTEK-92-01540P)
(FFA-TN-1992-43; ETN-93-94220) Avail: CASI HC A03/MF A01

The user manual for the flow solver WBNFLOW, a code that computes a full potential solution around wing/body/nacelle configurations including a propeller slipstream, is presented. The code is written in FORTRAN-77. The method for solution is based on the full approximation storage multigrid method using both the incomplete lower upper decomposition and the strongly implicit procedure as the smoothing algorithm. The code is very competitive in terms of computational efficiency. Topology, freestream conditions, slipstream condition, and computational parameters are all specified in input files. The code has capability to handle variations in these. There are two codes to prepare the main input files. One is a code JOBPRE1 to generate an input file including the freestream condition, the organization of the cycle for running the solution on a sequence of grids, and also some parameters. Another is a code WBNGRID to generate the grid input file for this code. When the user executes WBNFLOW, the input files are analyzed and obvious errors are fed out in an output file. Output files also contain configuration surface pressure distributions, number of supersonic points in the flow field, and convergence history. ESA

N93-31193*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
BLASIM: A COMPUTATIONAL TOOL TO ASSESS ICE IMPACT DAMAGE ON ENGINE BLADES
E. S. REDDY (Sverdrup Technology, Inc., Brook Park, OH.), G. H. ABUMERI (Sverdrup Technology, Inc., Brook Park, OH.), and C. C. CHAMIS Apr. 1993 24 p Presented at the 34th Structures, Structural Dynamics and Materials Conference, La Jolla, CA, 19-22 Apr. 1993; sponsored by AIAA, ASME, ASCE, AHS, and ASC
(Contract RTOP 509-10-11)
(NASA-TM-106225; E-7944; NAS 1.15:106225) Avail: CASI HC A03/MF A01

A portable computer called BLASIM was developed at NASA LeRC to assess ice impact damage on aircraft engine blades. In addition to ice impact analyses, the code also contains static, dynamic, resonance margin, and supersonic flutter analysis capabilities. Solid, hollow, superhybrid, and composite blades are supported. An optional preprocessor (input generator) was also developed to interactively generate input for BLASIM. The blade geometry can be defined using a series of airfoils at discrete input stations or by a finite element grid. The code employs a coarse, fixed finite element mesh containing triangular plate finite elements to minimize program execution time. Ice piece is modeled using an equivalent spherical objective that has a high velocity opposite that of the aircraft and parallel to the engine axis. For local impact damage assessment, the impact load is considered as a distributed force acting over a region around the impact point. The average radial strain of the finite elements along the leading edge is used as a measure of the local damage. To estimate damage at the blade root, the impact is treated as an impulse and a combined stress failure criteria is employed. Parametric studies of local and root ice impact damage, and post-impact dynamics are discussed for solid and composite blades.
Author (revised)

N93-31284# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugfuehrung.
INSTALLATIONS AND METHODS FOR MEASUREMENT OF AIRCRAFT RADIO COMPONENTS AND SYSTEMS
JUERGEN TETZLAFF *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 264-276 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 247-259 Original language document was announced as N92-25603
Avail: CASI HC A03/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany

The requirements and workings of a flight measurement system for measurement of radio frequency systems and components used in flight control and guidance are described. These systems and components consist of radio systems for communication, navigation, flight monitoring (Air Traffic Control (ATC)), and radar systems for flight monitoring (ATC); recognition and protection procedures. A range of subsystems and components for such installations requires in flight testing. In the case of radio systems, this relates primarily to aircaft antenna whose radiation patterns have to be measured in flight. In the case of radar systems for flight monitoring, it is particularly important to have knowledge of the radar cross section of whatever aircraft are involved, in order to estimate system range and probability of detection. Recognition systems (electronic support measurement) require measurement of antenna radiation diagrams and direction, finding antenna accuracy. In order to ascertain the coverage of systems operating electronic countermeasures, it is also necessary to have knowledge of the radiation patterns of the antennae involved. Although the above mentioned system characteristics can also be at least approximately determined by other methods (theoretical calculations, model measurements, and static measurements on the original on ground test rigs), flight measurements, for example for design acceptance of new aircraft types, is neccessary. These provide practical values and make it possible largely to avoid interferences and omissions which could affect the results of the other processes mentioned above. ESA

N93-31519# Technische Univ., Eindhoven (Netherlands).
ON THE VERIFICATION OF A THEORY FOR SCULLING PROPULSION Ph.D. Thesis
RUDOLF MATHIAS ROISA MUIJTJENS 1992 113 p
(Contract STW-GWI27.0277)
(ETN-93-94040) Avail: CASI HC A06/MF A02

The experimental verification of an optimization theory for sculling propulsion is described. The optimization theory models the hydrodynamics of a specific class of sculling propellers. The propeller consists of one wing or two wings moving side by side or one behind the other. An optimum motion to generate a certain prescribed mean thrust with the highest possible hydrodynamic efficiency can be calculated with this model. The optimum motion consists of a periodic sideways motion of the wing superimposed by a periodic pitching motion. The forces and the moment as a function of time for the two dimensional wing(s) can be calculated as well. The theoretical model reached a stage where a comparison with measurements was necessary. The verification of the theory is divided into three parts, namely: an introduction to the theory of sculling propulsion; an evaluation of the methods and assumptions used; a comparison of theoretical and measured results. A prototype designed for measurements was tested in towing tank, showing that the theory yields equivalent results for the mean thrust in several cases tested. ESA

N93-31584*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THREE-DIMENSIONAL ANALYSIS OF THE PRATT AND WHITNEY ALTERNATE DESIGN SSME FUEL TURBINE

K. R. KIRTLEY (Sverdrup Technology, Inc., Brook Park, OH.), T. A. BEACH (Sverdrup Technology, Inc., Brook Park, OH.), and J. J. ADAMCZYK *In its* Structural Integrity and Durability of Reusable Space Propulsion Systems p 255-262 May 1991
Avail: CASI HC A02/MF A03

The three dimensional viscous time-mean flow in the Pratt and Whitney alternate design space shuttle main engine fuel turbine is simulated using the average passage Navier-Stokes equations. The migration of secondary flows generated by upstream blade rows and their effect on the performance of downstream blade rows is studied. The present simulation confirms that the flow in this two stage turbine is highly three dimensional and dominated by the tip leakage flow. The tip leakage vortex generated by the first blade persists through the second blade and adversely affects its performance. The greatest mixing of the inlet total temperature distortion occurs in the second vane and is due to the large leakage vortex generated by the upstream rotor. It is assumed that the predominant spanwise mixing mechanism in this low aspect ratio turbine is the radial transport due to the deterministically unsteady vortical flow generated by upstream blade rows. A by-product of the analysis is accurate pressure and heat loads for all blade rows under the influence of neighboring blade rows. These aero loads are useful for advanced structural analysis of the vanes and blades. Derived from text

N93-31586*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LOCALIZATION OF AEROELASTIC MODES IN MISTUNED HIGH-ENERGY TURBINES
TODD E. SMITH (Sverdrup Technology, Inc., Brook Park, OH.), CHRISTOPHE PIERRE (Michigan Univ., Ann Arbor.), and DURBHA V. MURTHY (Toledo Univ., OH.) *In its* Structural Integrity and Durability of Reusable Space Propulsion Systems p 273-280 May 1991
Avail: CASI HC A02/MF A03

The effects of blade mistuning on the aerodynamic characteristics of a class of bladed-disk assemblies, namely high energy turbines, are discussed. The specific rotor analyzed is the first stage of turbine blades of the oxidizer turbopump in the Space Shuttle Main Engine. The common occurrence of fatigue cracks for these turbine blades indicates the possibility of high dynamic loading. Since mistuning under conditions of weak interblade coupling has been shown to increase blade response amplitudes drastically for simple structural models of blade assemblies, it provides a plausible explanation for the occurrence of cracks. The focus here is on the effects of frequency mistuning on the aeroelastic stability of the assembly and on the aeroelastic mode shapes. Derived from text

N93-31588*# Pennsylvania State Univ., University Park.
PENN STATE AXIAL FLOW TURBINE FACILITY: PERFORMANCE AND NOZZLE FLOW FIELD
B. LAKSHMINARAYANA, M. ZACCARIA, and S. ITOH (National Defence Academy, Yokosuka, Japan.) *In* NASA. Lewis Research Center, Structural Integrity and Durability of Reusable Space Propulsion Systems p 283-292 May 1991
(Contract NAG3-555)
Avail: CASI HC A02/MF A03

The objective is to gain a thorough understanding of the flow field in a turbine stage including three-dimensional inviscid and viscid effects, unsteady flow field, rotor-stator interaction effects, unsteady blade pressures, shear stress, and velocity field in rotor passages. The performance of the turbine facility at the design condition is measured and compared with the design distribution. The data on the nozzle vane static pressure and wake characteristics are presented and interpreted. The wakes are found to be highly three-dimensional, with substantial radial inward velocity at most spanwise locations. Derived from text

N93-31647*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MEASUREMENTS AND COMPUTATIONAL ANALYSIS OF HEAT TRANSFER AND FLOW IN A SIMULATED TURBINE BLADE INTERNAL COOLING PASSAGE
LOUIS M. RUSSELL, DOUGLAS R. THURMAN (Army Research Lab., Cleveland, OH.), PATRICIA S. SIMONYI (Sverdrup Technology, Inc., Brook Park, OH.), STEVEN A. HIPPENSTEELE, and PHILIP E. POINSATTE Jun. 1993 24 p Presented at the 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; sponsored by AIAA, SAE, ASME, and ASEE Original contains color illustrations
(Contract RTOP 505-62-52)
(NASA-TM-106189; E-7894; NAS 1.15:106189; AIAA PAPER 93-1797; ARL-MR-91) Avail: CASI HC A03/MF A01; 5 functional color pages

Visual and quantitative information was obtained on heat transfer and flow in a branched-duct test section that had several significant features of an internal cooling passage of a turbine blade. The objective of this study was to generate a set of experimental data that could be used to validate computer codes for internal cooling systems. Surface heat transfer coefficients and entrance flow conditions were measured at entrance Reynolds numbers of 45,000, 335,000, and 726,000. The heat transfer data were obtained using an Inconel heater sheet attached to the surface and coated with liquid crystals. Visual and quantitative flow field results using particle image velocimetry were also obtained for a plane at mid channel height for a Reynolds number of 45,000. The flow was seeded with polystyrene particles and illuminated by a laser light sheet. Computational results were determined for the same configurations and at matching Reynolds numbers; these surface heat transfer coefficients and flow velocities were computed with a commercially available code. The experimental and computational results were compared. Although some general trends did agree, there were inconsistencies in the temperature patterns as well as in the numerical results. These inconsistencies strongly suggest the need for further computational studies on complicated geometries such as the one studied. Author

N93-31846*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EFFICIENT FAULT DIAGNOSIS OF HELICOPTER GEARBOXES
H. CHIN (Massachusetts Univ., Amherst.), K. DANAI (Massachusetts Univ., Amherst.), and D. G. LEWICKI Jul. 1993 6 p Proposed for presentation at the 12th World Congress International Federation of Automatic Control, Sydney, Australia 19-23 Jul. 1993
(Contract DA PROJ. 1L1-62211-A-47-A; RTOP 505-62-10)
(NASA-TM-106253; E-7975; NAS 1.15:106253; AVSCOM-TR-92-C-034) Avail: CASI HC A02/MF A01

Application of a diagnostic system to a helicopter gearbox is presented. The diagnostic system is a nonparametric pattern classifier that uses a multi-valued influence matrix (MVIM) as its diagnostic model and benefits from a fast learning algorithm that enables it to estimate its diagnostic model from a small number of measurement-fault data. To test this diagnostic system, vibration measurements were collected from a helicopter gearbox test stand during accelerated fatigue tests and at various fault instances. The diagnostic results indicate that the MVIM system can accurately detect and diagnose various gearbox faults so long as they are included in training. Author (revised)

N93-31860*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HYPERSONIC ENGINE COMPONENT EXPERIMENTS IN HIGH HEAT FLUX, SUPERSONIC FLOW ENVIRONMENT
HERBERT J. GLADDEN and MATTHEW E. MELIS Jul. 1993 21 p Presented at the International Symposium on Optical Applied Science and Engineering, San Diego, CA, 11-16 Jul. 1993; sponsored by SPOIE
(Contract RTOP 505-62-52)
(NASA-TM-106273; E-8002; NAS 1.15:106273) Avail: CASI HC A03/MF A01

A major concern in advancing the state-of-the-art technologies for hypersonic vehicles is the development of an aeropropulsion system capable of withstanding the sustained high thermal loads expected during hypersonic flight. Even though progress has been made in the computational understanding of fluid dynamics and the physics/chemistry of high speed flight, there is also a need for experimental facilities capable of providing a high heat flux environment for testing component concepts and verifying/calibrating these analyses. A hydrogen/oxygen rocket engine heat source was developed at the NASA Lewis Research Center as one element in a series of facilities at national laboratories designed to fulfill this need. This 'Hot Gas Facility' is capable of providing heat fluxes up to 450 w/sq cm on flat surfaces and up to 5,000 w/sq cm at the leading edge stagnation point of a strut in a supersonic flow stream. Gas temperatures up to 3050 K can also be attained. Two recent experimental programs conducted in this facility are discussed. The objective of the first experiment is to evaluate the erosion and oxidation characteristics of a coating on a cowl leading edge (or strut leading edge) in a supersonic, high heat flux environment. Macrophotographic data from a coated leading edge model show progressive degradation over several thermal cycles at aerothermal conditions representative of high Mach number flight. The objective of the second experiment is to assess the capability of cooling a porous surface exposed to a high temperature, high velocity flow environment and to provide a heat transfer data base for a design procedure. Experimental results from transpiration cooled surfaces in a supersonic flow environment are presented.
Author (revised)

N93-31876# Analytic Power Corp., Boston, MA.
ELECTROPNEUMATIC ACTUATOR, PHASE 1
D. P. BLOOMFIELD 26 Oct. 1989 37 p Sponsored by NSF, Washington, DC
(Contract NSF ISI-88-60898)
(PB93-174951; NSF/ISI-89032) Avail: CASI HC A03/MF A01

The program demonstrated the feasibility of an electropneumatic actuator which can be used in manufacturing applications. The electropneumatic actuator, an alternative to the electric, hydraulic, and pneumatic actuators used in industry, consists of an electrochemical compressor, a power supply, and an actuator. The electrochemical compressor working fluid is hydrogen and a solvent such as water or ammonia. The compressor has no moving parts and runs on low voltage DC. The actuator is a conventional, commercially available unit. Researchers designed, constructed, and tested the electrochemical compressor in conjunction with the actuator, power supply, and computerized control. The one inch actuator can lift a fifty pound weight a distance of ten inches in about 1.5 minutes. The electrochemically powered system is capable of driving its loaded actuator to a prescribed location at a controlled rate. A defined set of design changes will combine the compressor and actuator in the same housing, and will develop two orders of magnitude increased actuator speed at the same or higher force levels. NTIS

N93-32028# Army Research Lab., Aberdeen Proving Ground, MD.
NAVIER-STOKES COMPUTATIONS FOR KINETIC ENERGY PROJECTILES IN STEADY CONING MOTION: A PREDICTIVE CAPABILITY FOR PITCH DAMPING Final Report, Sep. 1989 - Jan. 1992
PAUL WEINACHT and WALTER B. STUREK Apr. 1993 37 p
(AD-A264111; ARL-TR-112) Avail: CASI HC A03/MF A01

Previous theoretical investigations have proposed that the side force and moment acting on a body of revolution in steady coning motion could be related to the pitch damping force and moment. In the current research effort, this approach has been applied to produce the first known Navier-Stokes predictions of the pitch damping for finned projectiles. The flow field about pinned kinetic energy projectiles in steady coning motion has been successfully computed using a parabolized Navier-Stokes computational approach. The computations make use of a rotating coordinate frame in order to solve the steady flows equations. From the computed flow field, the side moment due to coning motion is used to determine the pitch-damping coefficient. The computational predictions of the slope of the side moment coefficient with coning rate normalized by the sine of the angle of attack have been compared with pitch damping coefficients determined from range firings for two finned projectile configurations. The predictions show good agreement with the range data. This computational approach provides a significant predictive capability for the design of kinetic energy projectiles whose terminal ballistic performance can be degraded by moderate levels of yaw at the target. DTIC

N93-32212*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATIONS OF STRUCTURAL OPTIMIZATION METHODS TO FIXED-WING AIRCRAFT AND SPACECRAFT IN THE 1980S
HIROKAZU MIURA and DOUGLAS J. NEILL (Northrop Corp., Hawthorne, CA.) May 1992 42 p
(Contract RTOP 505-69-50)
(NASA-TM-103939; A-92099; NAS 1.15:103939) Avail: CASI HC A03/MF A01

This report is the summary of a technical survey on the applications of structural optimization in the U.S. aerospace industry through the 1980s. Since applications to rotary wing aircraft will be covered by other literature, applications to fixed-wing aircraft and spacecraft were considered. It became clear that very significant progress has been made during this decade, indicating this technology is about to become one of the practical tools in computer aided structural design. Author

N93-32279# Eidgenoessische Technische Hochschule, Zurich (Switzerland). Inst. of Robots.
DESIGN AND APPLICATION OF ACTIVE MAGNETIC BEARINGS (AMB) FOR VIBRATION CONTROL
ROLAND SIEGWART *In* VKI, Vibration and Rotor Dynamics 64 p 1992
Copyright Avail: CASI HC A04/MF A04

The basic principles and applications of Active Magnetic Bearing (AMB) presented give an introduction to magnetic bearing technology. The results of 15 years of research in AMB are summarized. An AMB can support a body by magnetic forces without any mechanical contact. The ferromagnetic forces are generated by permanent magnets or actively controlled electromagnets. The basic equations and control configurations of the AMB actuator are given. The efficiency of the displacement sensors used in an AMB is discussed. The importance in an AMB system's design of the rotor design and modeling are underlined.
ESA

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A93-44862
A COMPARISON OF WIND SPEED MEASURED BY THE SPECIAL SENSOR MICROWAVE IMAGER (SSM/I) AND THE GEOSAT ALTIMETER
J. A. NYSTUEN, J. E. LILLY (U.S. Naval Postgraduate School, Monterey, CA), and A. K. GOROCH (U.S. Navy, Naval Oceanographic and Atmospheric Research Lab., Monterey, CA) International Journal of Remote Sensing (ISSN 0143-1161) vol. 14, no. 4 March 10, 1993 p. 745-756. refs
Copyright

Wind speed data have been routinely acquired at the Fleet Numerical Oceanography Center in near-real time from the SSM/I on board the DMSP satellite, and the radar altimeter on board the Geosat satellite. Both of these instruments use empirical algorithms which have been independently verified to measure wind speed in oceanic regions with an accuracy of +/- 2m/s. A comparison is made of the SSM/I and altimeter wind speed measurement from four regions with different environmental conditions present. Areas of variable atmospheric water vapor content do not appear to reduce the high correlation between the SSM/I and altimeter measured wind speeds, suggesting that, in the formulation of the regression algorithms, adequate sensitivity to, and variation of, water-vapor concentration allowed the algorithm to compensate for this environmental factor. Whereas areas with liquid cloud water or rain present showed SSM/I wind speed estimates higher than the Geosat wind speed estimates, indicating that further refinement of algorithms is required. Author (revised)

A93-45139* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PLUME AND WAKE DYNAMICS, MIXING, AND CHEMISTRY BEHIND A HIGH SPEED CIVIL TRANSPORT AIRCRAFT
R. C. MIAKE-LYE, M. MARTINEZ-SANCHEZ, R. C. BROWN, and C. E. KOLB (Aerodyne Research, Inc., Billerica, MA) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 467-479. AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Baltimore, MD, Sept. 23-25, 1991, AIAA Paper 91-3158. Previously cited in issue 23, p. 4092, Accession no. A91-54072 refs
(Contract NAS1-19161)
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A93-45176
BEHAVIOR OF PRECIPITATING WATER DROPS UNDER THE INFLUENCE OF ELECTRICAL AND AERODYNAMICAL FORCES
SYLVAIN COQUILLAT and SERGE CHAUZY (Toulouse III, Univ., France) Journal of Geophysical Research (ISSN 0148-0227) vol. 98, no. D6 June 20, 1993 p. 10,319-10,329. refs
Copyright
The present work performs a realistic modeling of precipitating charged water drops under the influence of electrical and dynamical forces in the vertical and downward electric field of a thundercloud. The following factors which control the shape of an individual raindrop are taken into account: surface tension, internal hydrostatic pressure, aerodynamic pressure, and electrostatic pressure. Unlike a recent work by Chuang and Beard (1990), our model considers simple local pressure balance to determine the drop shape. This computation aims at characterizing drop distortion, failing speed modification, and disruption. The present results are similar to those of Chuang and Beard's more sophisticated model, and the predicted critical fields are even closer to wind tunnel measurements by Richards and Dawson (1971). The disruption of positively charged drops requires lower ambient fields than that of the negatively charged drops, and, for highly charged and large drops, they are of the order of those commonly measured within thunderclouds. Author (revised)

A93-45699* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
MAPPING NEW AND OLD WORLDS WITH LASER ALTIMETRY
JAMES B. GARVIN (NASA, Goddard Space Flight Center, Greenbelt, MD) Photonics Spectra (ISSN 0731-1230) vol. 27, no. 4 April 1993 p. 89-94. refs
Copyright
Spaceborne laser altimeter systems intended to operate at lunar and Martian orbits are reviewed. Laser altimeter systems capable of long lifetimes with centimeter precision ranging electronics are considered to be essential components of NASA's EOS. AIAA

A93-46780* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
REMOTE SENSING CLOUD PROPERTIES FROM HIGH SPECTRAL RESOLUTION INFRARED OBSERVATIONS
WILLIAM L. SMITH, XIA L. MA, STEVEN A. ACKERMAN, H. E. REVERCOMB, and R. O. KNUTESON (Cooperative Inst. for Meteorological Satellite Studies, Madison, WI) Journal of the Atmospheric Sciences (ISSN 0022-4928) vol. 50, no. 12 June 15, 1993 p. 1708-1720. refs
(Contract NAG1-1177; DE-FG02-90GR-61057)
Copyright
A technique for estimating cloud radiative properties (spectral emissivity and reflectivity) in the IR is developed based on observations at a spectral resolution of approximately 0.5/cm. The algorithm uses spectral radiance observations and theoretical calculations of the IR spectra for clear and cloudy conditions along with lidar-determined cloud-base and cloud-top pressure. An advantage of the high spectral resolution observations is that the absorption effects of atmospheric gases are minimized by analyzing between gaseous absorption lines. The technique is applicable to both ground-based and aircraft-based platforms and derives the effective particle size and associated cloud water content required to satisfy, theoretically, the observed cloud IR spectra. The algorithm is tested using theoretical simulations and applied to observations made with the University of Wisconsin's ground-based and NASA ER-2 aircraft High-Resolution Infrared Spectrometer instruments. Author (revised)

N93-31202# National Oceanic and Atmospheric Administration, Boulder, CO. Forecast Systems Lab.
PRELIMINARY EVALUATION OF AVIATION-IMPACT VARIABLES DERIVED FROM NUMERICAL MODELS
M. M. CAIRNS, R. J. MILLER, S. C. ALBERS, D. L. BIRKENHEUER, and B. D. JAMISON Apr. 1993 180 p
(PB93-190197; NOAA-TM-ERL-FSL-5) Avail: CASI HC A09/MF A02
The report describes the Aviation Division's Verification Program, located in the Forecast Systems Laboratory, and the results of the first evaluation of four analysis and forecast model systems. The impetus for the evaluation is to get baseline statistics of forecasts of aviation-impact variables (AIVs; e.g., clouds and visibility), which are commonly not forecast or verified in numerical weather prediction models. The results of the study are very preliminary. They are intended to serve as a baseline for future evaluations, not as judgments about the current model capabilities. In general, it was found that all systems produced good analyses and forecasts of state-of-the-atmosphere variables (SAVs) in all areas, except that the surface winds were too strong and wind directions were commonly 30 degrees off. Also, all models were too dry. For AIVs, detection was good for ceiling, visibility, and cloud amount, but the ability to distinguish categories (e.g., scattered or broken clouds) was poor. NTIS

N93-31258# Institut fuer Angewandte Geodaesie, Frankfurt am Main (Germany).
AERIAL CARTOGRAPHY USING SICAD NAV-AIR [AERONAUTISCHE KARTOGRAPHIE MIT SICAD NAV-AIR]
GUENTHER CADA and ALOIS HENDGES *In its* Reports on Cartography and Topography, Series 1, Report No. 103 p 11-25 1989 In GERMAN
Avail: CASI HC A03/MF A02
The use of the graphical system SICAD (Siemens Computer Aided Design) together with its component NAV-AIR is described. The systems allows for improvement and considerable acceleration of existing procedures for processing, estimating, and evaluating graphical and non-graphical information for aeronautical charts. SICAD NAV-AIR is shown to guarantee the correctness, completeness, and up to date information contained in ratio navigation charts, area charts, and airfield charts. The design complies with an update cycle of 28 days as is required by the air traffic control authority. ESA

N93-31925 Gesellschaft fuer Strahlenforschung m.b.H., Munich (Germany). Projekt Information Umwelt.
AIR TRAFFIC AND ENVIRONMENT [FLUGVERKEHR UND UMWELT]
H.-J. HAURY, U. KOLLER, and G. ASSMANN Nov. 1991 52 p In GERMAN Journalistenseminar der Information Umwelt held in Neuherberg, Germany, Nov. 1991
(ISSN 0940-3469)

(GSF-BAND-8; ETN-93-93532) Copyright Avail: Issuing Activity (Fachinformationszentrum Karlsruhe, 7514 Eggenstein-Leopoldshafen 2, Germany)

The following topics are included: climatic effects of harmful emissions from high altitude air traffic; climatic effects of turbofan emissions in the stratosphere; radiation exposure in commercial aircraft; effects on health of noise disturbance during commercial flight; ecological balance by Swissair: waste management as an example; effects of pollution due to commercial flights on the human health and effects of air traffic on nature and environment in the neighborhood of airports, with the example of the Munich2 airport.

ESA

N93-31927 Ludwig-Maximilians-Univ., Munich (Germany). Lehrstuhl fuer Bioklimatologie und Angewandte Meteorologie.

CLIMATIC EFFECTS OF TURBOFAN EMISSIONS IN THE STRATOSPHERE AND THE HIGHER TROPOSPHERE [KLIMATISCHE AUSWIRKUNGEN VON TRIEBWERKSEMISSIONEN IN DER OBEREN TROPOSPHAERE UND IN DER STRATOSPHAERE]

PETER FABIAN *In* Gesellschaft fuer Strahlenforschung m.b.H., Air Traffic and Environment p 11-14 Nov. 1991 In GERMAN

Copyright Avail: Issuing Activity (Fachinformationszentrum Karlsruhe, 7514 Eggenstein-Leopoldshafen 2, Germany)

Aircraft emission influence is estimated in order to characterize the effects of nitrogen oxides, taking into account that they can be accumulated over the months in the tropopause. Combustion products were identified and their increase with air traffic extension was calculated. Emission distribution in the atmosphere is noticed to be not very well ascertained and models with coupling of photochemical reactions must be achieved in order to obtain good predictions of future aircraft emissions. ESA

N93-31928 Gesellschaft fuer Strahlenforschung m.b.H., Munich (Germany). Inst. fuer Strahlenschutz.

RADIATION EXPOSURE IN AIRCRAFT [STRAHLENBELASTUNG IN FLUGZEUGEN]

H. G. PARETZKE and W. HEINRICH (Siegen Univ.,, Germany.) *In its* Air Traffic and Environment p 15-23 Nov. 1991 In GERMAN

Copyright Avail: Issuing Activity (Fachinformationszentrum Karlsruhe, 7514 Eggenstein-Leopoldshafen 2, Germany)

The components of high altitude radiation are identified and its effect on human mortality is examined. Mechanisms of production and motion of primary and secondary high radiation particles and their dependence on the Earth's magnetic field are described. Altitude dependence of cosmic radiation of protons, electrons, and muons are estimated. Radiation risks in aircraft are deduced from stochastic probability reports, and curves of age versus total death probability rate are established, with and without chronic radiation exposure, to show that differences are hardly noticeable. ESA

N93-31929 Dortmund Univ. (Germany). Inst. fuer Arbeitsphysiologie.

EFFECTS ON HEALTH OF NOISE DISTURBANCES DUE TO AIR TRAFFIC [GESUNDHEITLICHE AUSWIRKUNGEN FLUGVERKEHRSBEDINGTER LAERMBELASTUNGEN]

BARBARA GRIEFAHN *In* Gesellschaft fuer Strahlenforschung m.b.H., Air Traffic and Environment p 25-28 Nov. 1991 In GERMAN

Copyright Avail: Issuing Activity (Fachinformationszentrum Karlsruhe, 7514 Eggenstein-Leopoldshafen 2, Germany)

Side effects of sound propagation on ears, vegetative nervous system, and psychosocial relations are examined. Military aircraft noise is reported as possibly damaging to people who live near air force bases. Noise emissions are shown to be disturbing for population rest and sleep and child learning capacities. These psychological and sociological effects can modify human behavior, while they reduce social activities and communications. Noise is depicted as a stress for humans since it accelerates heart frequency and increases blood pressure. ESA

N93-31930 Swissair, Zurich (Switzerland).

THE ECOLOGICAL BALANCE OF SWISSAIR: AN EXAMPLE OF WASTE MANAGEMENT [OEKOBILANZ DER SWISSAIR: BEISPIEL ABFALLBEWAELTIGUNG]

PETER GUTKNECHT *In* Gesellschaft fuer Strahlenforschung m.b.H., Air Traffic and Environment p 29-34 Nov. 1991 In GERMAN

Copyright Avail: Issuing Activity (Fachinformationszentrum Karlsruhe, 7514 Eggenstein-Leopoldshafen 2, Germany)

A global analysis of environment related tasks in aeronautical activities is performed as an information base for airline employees and external people. Technical activities and facilities, aircraft, vehicles, wastes, and material stockrooms involved in Swissair tasks were examined from an environmental point of view, as well as aircraft propulsion and maintenance, passengers and employees, energy supply, organization and administration activities and catering, by considering loads of air, water, noise, and wastes. ESA

N93-31931 Hygiene-Inst. des Ruhrgebiets, Gelsenkirchen (Germany).

EFFECTS OF COMMERCIAL FLIGHT POLLUTION ON HUMAN HEALTH [WIRKUNGEN VON FLUGVERKEHRSBEDINGTEN SCHADSTOFFBELASTUNGEN AUF DIE MENSCHLICHE GESUNDHEIT]

THOMAS EIKMANN *In* Gesellschaft fuer Strahlenforschung m.b.H., Air Traffic and Environment p 35-41 Nov. 1991 In GERMAN

Copyright Avail: Issuing Activity (Fachinformationszentrum Karlsruhe, 7514 Eggenstein-Leopoldshafen 2, Germany)

Effects of exhaust gases on human people are examined. The study is based on a measurement program, in the neighborhood of two German airports, established for estimating the influence of hydrocarbons and nitrogen oxides on air pollution. The effects of carbon monoxide and nitrogen oxides on respiration was characterized. A relationship between ozone concentration increase and lung diseases was established. Polycyclic aromatic hydrocarbons and benzol were shown to be involved in leukemia and cancer. Biological monitoring is concluded to be necessary for estimation of risks for human beings from aircraft exhaust gases. ESA

N93-31932 Fachhochschule, Munich (Germany). Fachbereich Landschaftspflege.

EFFECTS OF AIR TRAFFIC ON NATURE AND ENVIRONMENT IN THE NEIGHBORHOOD OF AIRPORTS BY EXAMPLE OF THE MUNICH 2 AIRPORT (GERMANY) [AUSWIRKUNGEN DES FLUGVERKEHRS AUF NATUR UND UMWELT IM NAHBEREICH VON FLUGHAEFEN AM BEISPIEL DES FLUGHAFENS MUENCHEN 2]

CHRISTIAN MAGERL *In* Gesellschaft fuer Strahlenforschung m.b.H., Air Traffic and Environment p 43-51 Nov. 1991 In GERMAN

Copyright Avail: Issuing Activity (Fachinformationszentrum Karlsruhe, 7514 Eggenstein-Leopoldshafen 2, Germany)

The consequences for nature and landscape of the building of the new Munich airport are examined. From an economic point of view, the airport is seen to have created employment but needed widespread surfaces for infrastructures. Noise and ground water reduction has caused the disappearance of numerous birds. It is pointed out that no studies were performed for assessment of ecological damage when the airport design phase started. The risks of bird aircraft collisions are highlighted and it is explained why a biotope dedicated to birds in the airport neighborhood is undesirable. ESA

N93-32089# Battelle Columbus Labs., OH.

IN-SITU BIOVENTING: TWO US EPA AND AIR FORCE SPONSORED FIELD STUDIES

G. D. SAYLES (Environmental Protection Agency, Cincinnati, OH.), R. E. HINCHEE, R. C. BRENNER (Environmental Protection Agency, Cincinnati, OH.), C. M. VOGEL (Air Force Engineering and Services Center, Tyndall AFB, FL.), and R. N. MILLER (Air

Force Center for Environmental Excellence, Brooks AFB, TX.) 1992 13 p
(Contract EPA-68-C0-0003)
(PB93-194231; EPA/600/A-93/116) Avail: CASI HC A03/MF A01

Bioventing is the process of delivering oxygen by forced air movement through organically contaminated unsaturated soils in order to stimulate in situ biodegradation in an otherwise oxygen-limited environment. The paper is a report on progress of two ongoing bioventing field studies involving JP-4 jet fuel contamination. The first investigation, at Eielson AFB near Fairbanks, Alaska, is a study of bioventing in shallow soils and cold climates in conjunction with an evaluation of soil warming techniques. The second study, at Hill AFB near Salt Lake City, Utah, is examining bioventing of large volumes of soil and determining biodegradation and volatilization rates as a function of air injection rate. NTIS

N93-32191 Geological Survey, Sacramento, CA. Water Resources Div.
LAND SUBSIDENCE AND PROBLEMS AFFECTING LAND USE AT EDWARDS AIR FORCE BASE AND VICINITY, CALIFORNIA, 1990
JAMES C. BLODGETT and J. S. WILLIAMS 1992 32 p Prepared in cooperation with Department of the Air Force, Washington, DC Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(PB93-182236; USGS/WRI-92-4035) Avail: Issuing Activity (National Technical Information Service (NTIS))

Land subsidence in Antelope Valley, which includes Edwards Air Force Base, was first reported in the 1950's; by 1967, about 200 square miles of Antelope Valley were affected by as much as 2 feet of subsidence. The purpose of the report is to present the results to date of recent studies done by the U.S. Geological Survey, in cooperation with the U.S. Department of the Air Force, to determine the cause and areal extent of land subsidence and surface deformation on Rogers Lakebed and vicinity, and the effects of surface deformation on runways used for aircraft landings at Edwards AFB in southern California. Because of the time-related effects of land subsidence, several years of data collection will be needed to establish subsidence trends and evaluate those factors causing land subsidence. Author

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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.

A93-44150
DYNAMIC COMPENSATOR DESIGN IN NONLINEAR AEROSPACE SYSTEMS
HEBERTT SIRA-RAMIREZ, PABLO LISCHINSKY-ARENAS, and ORESTES LLANES-SANTIAGO (Univ. des Los Andes, Merida, Venezuela) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251) vol. 29, no. 2 April 1993 p. 364-379. Research supported by Universidad des Los Andes refs
Copyright

Based on recently developed differential algebraic results, dynamic controllers are proposed for the feedback regulation of typical aerospace systems. Fliess' generalized observability canonical form (GOCF) is used for specifying a dynamic compensator that smoothly regulates the plant dynamics. The synthesis approach is also applicable to the design of nonlinear pulsewidth-modulation (PWM) controllers, as well as to sliding mode control strategies. The three underlying nonlinear control techniques, explored with the aid of illustrative examples, are commonly encountered in aerospace control system design problems. Simulations are also included. Author

A93-44452
DEAS - A PROGRAMMING SYSTEM FOR DATA PROCESSING AND SYSTEM CONTROL: NEW SOFTWARE DEVELOPMENTS FOR WIND TUNNEL OPERATION [DEAS - EIN PROGRAMMSYSTEM ZUR DATENERFASSUNG UND ANLAGENSTEUERUNG: NEUENTWICKLUNG VON SOFTWARE FUER DEN WINDKANALBETRIEB]
WERNER SACHS (DLR, Hauptabteilung Windkanaele, Goettingen, Germany) DLR-Nachrichten (ISSN 0937-0420) no. 71 May 1993 p. 2-7. In GERMAN
Copyright

The automation of the transonic wind tunnel in Goettingen has involved the automation of the installation using memory-programmable control and a new programming system. Emphasis is given to a discussion of the software. AIAA

A93-45006#
SOLUTION OF THE EULER AND NAVIER STOKES EQUATIONS ON PARALLEL PROCESSORS USING A TRANSPOSED/THOMAS ADI ALGORITHM
THOMAS S. CHYCZEWSKI (Pennsylvania State Univ., University Park), FRANK MARCONI (Grumman Corporate Research Center, Bethpage, NY), RICHARD B. PELZ, and ENRIQUE N. CURCHITSER (Rutgers Univ., New Brunswick, NJ) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 144-154. refs
(AIAA PAPER 93-3310) Copyright

The Euler and Navier Stokes equations are discretized and numerically solved on distributed memory parallel processors for airfoil geometries. The spatial derivatives are evaluated to second order accuracy with upwind differencing and the equations are solved implicitly using ADI factorization. The Thomas Algorithm is used to solve the block tridiagonal matrices that result from the implicit ADI scheme. The recursion inherent in this method is dealt with by transposing the domain amongst the processors so that there is no communication required in order to solve the tridiagonals once the transpose is done. A couple of transpose schemes were considered and results are presented for the most efficient. Very good times are achieved for realistic problems when run on a coarse to medium grain machine. The method is compared with other parallel schemes. The code was developed and run on an nCUBE/2 and also run on a Thinking Machines CM-5 for a performance comparison and to illustrate portability of the code. Author

A93-45007*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DYNAMIC OVERSET GRID COMMUNICATION ON DISTRIBUTED MEMORY PARALLEL PROCESSORS
ERIC BARSZCZ, SISIRA K. WEERATUNGA, and ROBERT L. MEAKIN (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 155-166. refs
(AIAA PAPER 93-3311) Copyright

A parallel distributed memory implementation of intergrid communication for dynamic overset grids is presented. Included are discussions of various options considered during development. Results are presented comparing an Intel iPSC/860 to a single processor Cray Y-MP. Results for grids in relative motion show the iPSC/860 implementation to be faster than the Cray implementation. Author

A93-45046#
VISUAL GRID QUALITY ASSESSMENT FOR 3D UNSTRUCTURED MESHES
ROBERT HAIMES (MIT, Cambridge, MA), STUART D. CONNELL

(GE Corporate Research and Development Center, Schenectady, NY), and SABINE A. VERMEERSCH (MIT, Cambridge, MA) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 598-605. Research supported by General Electric Co refs
(AIAA PAPER 93-3352) Copyright

A method for displaying elements of a 3D unstructured mesh in order to obtain data on grid quality and topology is presented. These data make it possible to modify the input to the grid generator to produce a better mesh. These visual techniques may be used by authors of mesh generation codes to further automate the meshing. If a mesh refinement scheme is employed where cells are tagged for refinement, these cells may be displayed. This procedure can be used to help select adaptation criteria. AIAA

A93-45047#
TECHNIQUES FOR THE VISUAL EVALUATION OF COMPUTATIONAL GRIDS
KELLY L. PARMLEY, JOHN F. DANNENHOFFER, III, and NIGEL P. WEATHERILL (Mississippi State Univ., Mississippi State) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 606-614. refs
(AIAA PAPER 93-3353) Copyright

A novel approach for the visual evaluation of computational grids is presented. The method employs a visualization hierarchy to display and highlight various aspects of grid quality: a new qualitative point cloud mode to assess the overall distribution of grid points; a new quantitative grid weathermap mode to present 'at a glance' an overall measure of grid quality and to help isolate regions of poor grids; and a new grid browsing egg carton display for visualizing and stepping through the grid planes. Results for a variety of block-structured and unstructured grids are discussed and displayed. The hierarchical visualization techniques are very simple, owing to their close connection to real-world situations and metaphors. AIAA

A93-45150
VISUALIZATION AND VIEW SIMULATION BASED ON TRANSPUTERS
KLAUS ALVERMANN (DLR, Inst. fuer Flugmechanik, Braunschweig, Germany) Journal of Aircraft (ISSN 0021-8669) vol. 30, no. 4 July-Aug. 1993 p. 550-553. refs
Copyright

A real time transputer-based visualization system aimed at showing a 3D view of the flight vehicles and their movement in space is described. The system can be implemented on a scalable transputer architecture with different numbers of transputers thus allowing to adjust the cost and complexity of the system to the application. Transputers make it possible to show the flight vehicle moving in a landscape with texturing and fog simulation. Viewing from the cockpit of the flight vehicle results in a view simulation. Real-time visualization requirements include a high image rate of about 16-24 images/s and a time lag of up to half a second. AIAA

A93-45431
OPTIMIZATION USING FUZZY SET THEORY
S. S. RAO (Purdue Univ., West Lafayette, IN) *In* Structural optimization: Status and promise Washington American Institute of Aeronautics and Astronautics, Inc. 1993 p. 637-661. refs
Copyright

An account is given of the application of fuzzy set theories to the formulation and solution of structural and mechanical design problems of both single-objective and multiple-objective type. The first illustrative example presented seeks the minimum weight design of a three-bar truss; the second attempts to arrive at the multiple-objective optimum design of a helicopter main rotor. Fuzzy approaches are judged superior to 'crisp' optimization wherever there is uncertainty concerning the precision of permissible parameters, the degree of credibility, and the correctness of statements and judgments. AIAA

A93-45661
A SET OF IBM PC SOFTWARE FOR PROCESSING HELICOPTER FLIGHT TESTS DATA TO DETERMINE THE FLIGHT PERFORMANCE CHARACTERISTICS [KOMPLEKS PROGRAMM DLYA PERSONAL'NOJ EHVM IBM PC DLYA OBRABOTKI REZUL'TATOV LETNYKH ISPYTANIJ VERTOLETOV PO OPREDELENIYU LETNO-TEKHNICHESKIKH KHARAKTERISTIK /LTKH/]
A. YU. RUDAKOV and I. L. YASTREBOV *In* Problems in the aerodynamics, strength, and flight operations of aircraft Moscow Gosudarstvennyj NII Grazhdanskoj Aviatsii 1991 p. 6-10. In RUSSIAN refs
Copyright

A set of computer software for the IBM PC has been developed which provides an efficient way to determine the flight performance characteristics of helicopters. The approach used is based on the similarity theory, aerodynamic analysis, and multidimensional regression analysis. The programs provide for the entire cycle of procedures that are necessary to determine the flight performance characteristics, from primary data processing to the calculation and optimization of flight regimes. AIAA

A93-46834#
ACTIVE FLOW CONTROL WITH NEURAL NETWORKS
XUETONG FAN, LORENZ HOFMANN, and THORWALD HERBERT (Ohio State Univ., Columbus) Jul. 1993 11 p. AIAA, Shear Flow Conference, Orlando, FL, July 6-9, 1993 refs
(Contract AF-AFOSR-91-0262; F49620-93-J-0135; F49620-92-J-0339)
(AIAA PAPER 93-3273) Copyright

We conduct a conceptual study of active laminar flow control with neural networks to evaluate the feasibility of a 'smart wall' which would combine micro-electro-mechanical sensors and actuators with an artificial neural network in a single layer of silicon. This first phase of our study shows that properly trained neural networks can establish the complex nonlinear relationships between multiple inputs and outputs which are characteristic of an active flow-control system. Numerical simulations of flow-control systems with pretrained neural networks demonstrate almost complete cancellation of single and multiple artificial wave disturbances as they occur in transitional boundary layers. A natural disturbance signal with developing wave packets from a wind-tunnel experiment is also successfully attenuated. We conclude that active flow-control systems based on neural networks hold great promise for real-world implementation of transition control and ultimately can be extended to drag reduction in turbulent flow.

A93-47237#
UNSTRUCTURED GRID GENERATION USING INTERACTIVE THREE-DIMENSIONAL BOUNDARY AND EFFICIENT THREE-DIMENSIONAL VOLUME METHODS
TIMOTHY D. GATZKE (McDonnell Douglas Corp., Saint Louis, MO) and NIGEL P. WEATHERILL (Swansea, Univ. College, United Kingdom) *In* AIAA Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 409-419. refs
(AIAA PAPER 93-3452) Copyright

An account is given of the integration of an unstructured grid-generation capability into an interactive graphical grid system for the generation of 3D boundary grids and an efficient 3D volume grid generation method; these methods are based on a Delaunay approach, with an automatic point-creation algorithm. A major advantage of the method is the computational speed with which 3D unstructured volume grids can be generated. It is possible to generate a million tetrahedral elements in minutes of workstation CPU time, as demonstrated by interactive work on complete aircraft configurations. AIAA

N93-31442*# Tokyo Inst. of Tech. (Japan).
CURRENT PROJECTS IN FUZZY CONTROL
MICHIO SUGENO *In* McDonnell-Douglas Space Systems Co., Workshop on Fuzzy Control Systems and Space Station Applications p 65-77 Nov. 1990
Avail: CASI HC A03/MF A04

Viewgraphs on current projects in fuzzy control are presented. Three projects on helicopter flight control are discussed. The projects are (1) radio control by oral instructions; (2) automatic autorotation entry in engine failure; and (3) unmanned helicopter for sea rescue. CASI

N93-31649*# Old Dominion Univ., Norfolk, VA. Dept. of Electrical and Computer Engineering.
DESIGN AND IMPLEMENTATION OF FUZZY LOGIC CONTROLLERS Thesis Final Report, 27 Jul. 1992 - 1 Jan. 1993
OSAMA A. ABIHANA and OSCAR R. GONZALEZ Jul. 1993 173 p
(Contract NASA ORDER L-20278-D)
(NASA-CR-193268; NAS 1.26:193268) Avail: CASI HC A08/MF A02

The main objectives of our research are to present a self-contained overview of fuzzy sets and fuzzy logic, develop a methodology for control system design using fuzzy logic controllers, and to design and implement a fuzzy logic controller for a real system. We first present the fundamental concepts of fuzzy sets and fuzzy logic. Fuzzy sets and basic fuzzy operations are defined. In addition, for control systems, it is important to understand the concepts of linguistic values, term sets, fuzzy rule base, inference methods, and defuzzification methods. Second, we introduce a four-step fuzzy logic control system design procedure. The design procedure is illustrated via four examples, showing the capabilities and robustness of fuzzy logic control systems. This is followed by a tuning procedure that we developed from our design experience. Third, we present two Lyapunov based techniques for stability analysis. Finally, we present our design and implementation of a fuzzy logic controller for a linear actuator to be used to control the direction of the Free Flight Rotorcraft Research Vehicle at LaRC. Author (revised)

N93-32224*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A PC-BASED SIMULATION OF THE NATIONAL TRANSONIC FACITITY'S SAFETY MICROPROCESSOR
J. J. THIBODEAUX, W. A. KILGORE (Vigyan Research Associates, Inc., Hampton, VA.), and S. BALAKRISHNA (Vigyan Research Associates, Inc., Hampton, VA.) Jul. 1993 76 p
(Contract RTOP 505-59-85-01)
(NASA-TM-109003; NAS 1.15:109003) Avail: CASI HC A05/MF A01

A brief study was undertaken to demonstrate the feasibility of using a state-of-the-art off-the-shelf high speed personal computer for simulating a microprocessor presently used for wind tunnel safety purposes at Langley Research Center's National Transonic Facility (NTF). Currently, there is no active display of tunnel alarm/alert safety information provided to the tunnel operators, but rather such information is periodically recorded on a process monitoring computer printout. This does not provide on-line situational information nor permit rapid identification of safety operational violations which are able to halt tunnel operations. It was therefore decided to simulate the existing algorithms and briefly evaluate a real-time display which could provide both position and trouble shooting information. Author

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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.

A93-44458
OPTICAL CORRELATOR FIELD TEST RESULTS
T. D. HUDSON, DON A. GREGORY, JAMES C. KIRSCH, JEFFREY A. LOUDIN, and W. M. CROWE (U.S. Army, Missile Command, Redstone Arsenal, AL) *In* Optical information processing systems and architectures III; Proceedings of the Meeting, San Diego, CA, July 23-26, 1991 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1991 p. 54-64. refs
Copyright

A first phase demonstration of the capabilities and limitations of an optical correlator in a realistic environment has been completed. The testing was divided into several areas, from laboratory data gathering to a fully functional helicopter-delivered demonstration airframe. The basic research performed has led to three fully fieldable test units which have proven to be rugged and dependable under normal test range conditions. The units were transportable and required no realignment of the optics. Two of the test systems were modular in construction while the third was a 'solid optic' design having optical paths and components contained within a solid glass construction. Two flights have been completed so far, and in both cases the target was identified and tracked, and an airframe guided to target impact. Author

A93-45556
FAST DESIGN OF CIRCULAR-HARMONIC FILTERS USING SIMULATED ANNEALING
GUY PREMONT and YUNLONG SHENG (Univ. Laval, St. Foy, Canada) Applied Optics (ISSN 0003-6935) vol. 32, no. 17 June 10, 1993 p. 3116-3121. refs
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Attention is given to a novel method for determining the proper center of the circular-harmonic (CH) filter which employs an analytical expression for circular-harmonic expansion around an arbitrary center and simulated annealing for the automatic search for the maximum. The new method is two orders of magnitude faster than the previous method and requires no human intervention. The theory of the CH filter and the proper center is reviewed. An analytical expression for the CH energy map is provided. An automated search for the proper center with a simulated-annealing algorithm is described. A CH energy map for an image of the Space Shuttle with the order $m = 4$, and a weighted energy map are shown. AIAA

A93-45561
ANALYTICAL STUDY ON PLATE EDGE NOISE (NOISE GENERATION FROM TANDEMLY SITUATED TRAILING AND LEADING EDGES)
KOJI TAKAHASHI and SHOJIRO KAJI (Tokyo Univ., Japan) JSME International Journal, Series B: Fluids and Thermal Engineering (ISSN 0914-8817) vol. 36, no. 2 May 1993 p. 214-221. refs
Copyright

The problem of noise generation due to the interaction between flows and plate edges is treated analytically. In uniform flow containing vorticity waves, two semiinfinite flat plates are placed with the trailing edge of one plate and leading edge of the other being tandemly situated a finite distance apart. This flow is considered to be a simplified model for self-excited tones such as edge tone and cavity noise. An approximate solution to the sound pressure is obtained by the Wiener-Hopf technique, and the calculated acoustic field shows the characteristics of the trailing edge noise and the leading edge noise. The sound pressure level varies with peaks and troughs as the wave number increases, especially in the region upstream from both edges, and these peaks show a frequency dependence similar to edge tones. Such a selective response mechanism will be explained by the phase relationship between vortex and sound.

A93-46482#

INVESTIGATION OF THE RADIANCE FROM THE LEADING EDGE OF A WING

WILLIAM A. BELL and JOHN S. DIMARCO (Georgia Inst. of Technology, Atlanta) Jul. 1993 11 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2728) Copyright

The present analysis of wing leading-edge radiance assumes that the optical axis of the sensor aligns with the chord line of the wing, and that the leading edge falls within the instantaneous field-of-view of the sensor. Wing radiance rapidly decreases with increasing angular dependence of surface emissivity. A sharp leading edge and a wedgelike shape minimize grey-body radiation from a wing. IR radiation is shown to strongly depend on the angular dependence of emissivity. AIAA

A93-46682*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SURVEY OF NONEQUILIBRIUM RE-ENTRY HEATING FOR ENTRY FLIGHT CONDITIONS

THOMAS A. GALLY and LELAND A. CARLSON (Texas A & M Univ., College Station) Jul. 1993 15 p. AIAA, Plasmadynamics and Lasers Conference, 24th, Orlando, FL, July 6-9, 1993 refs
(Contract NAG1-1003)
(AIAA PAPER 93-3230) Copyright

A viscous shock layer method has been developed which includes the effects of chemical and thermal nonequilibrium and is coupled with a radiation analysis which includes thermodynamic nonequilibrium effects. This code has been used to obtain solutions for a wide variety of nonequilibrium re-entry conditions in air. The results are tabulated and displayed graphically. Comparisons are made to similar results obtained for radiatively coupled equilibrium flow and conclusions drawn on the effect of nonequilibrium and in particular thermodynamic nonequilibrium on the radiative environment about re-entry vehicles.

A93-46701

SOUND GENERATION BY ROTATING STALL IN CENTRIFUGAL TURBOMACHINES

L. MONGEAU, D. E. THOMPSON, and D. K. MCLAUGHLIN (Pennsylvania State Univ., University Park) Journal of Sound and Vibration (ISSN 0022-460X) vol. 163, no. 1 May 8, 1993 p. 1-30. Research supported by NSERC refs
(Contract N00014-87-K-0837)
Copyright

The mechanism responsible for the generation of low-frequency acoustic noise in centrifugal turbomachines was investigated using an experimental facility consisting of a centrifugal water pump impeller (with no diffuser or casing) with various discharge configurations and a specially designed inlet duct which provided a controlled quiet inflow to the impeller. Air was used as the fluid medium. The acoustic noise radiated in the pump surroundings was measured in parallel with fluid dynamic measurements to establish correlations. The results of measurements indicate that a form of rotating stall dominated the low-frequency noise production in all the open pump configurations used. A hypothesis is proposed that the prominent peaks in the acoustic signature of the diffuserless impeller represent rotating stall noise, generated by aerodynamic interaction between the rotating stall pattern and the impeller blades. AIAA

A93-46706

PROPELLER NOISE REDUCTION BY MEANS OF UNSYMMETRICAL BLADE-SPACING

W. DOBRZYNSKI (DLR, Inst. fuer Entwurfsaerodynamik, Braunschweig, Germany) Journal of Sound and Vibration (ISSN 0022-460X) vol. 163, no. 1 May 8, 1993 p. 123-136. refs
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The noise reduction potential of propellers with circumferentially unsymmetrical blade-spacing is predicted on theoretical grounds and substantiated through both aerodynamic and aeroacoustic full scale wind tunnel experiments. To avoid potential balancing problems such propellers have two (or several) pairs of opposite blades, each such pair constituting a symmetrical two-blade propeller. Spacing angles between these individual blade pairs are optimized towards achieving minimum A-weighted noise radiation in the plane of rotation. The result is then compared with the corresponding noise level from a symmetrical reference propeller with the same total number of geometrically identical blades. The study reveals that the value of the optimum spacing angle depends almost entirely on the operational helical blade-tip Mach number, assuming values of about 40 deg at a Mach number of O.5 and decreasing to 15 deg at a Mach number of 0.8. The noise reduction to be achieved from such unsymmetrical blade-spacing is limited to about 4 dB(A) in the direction of maximum noise radiation since the related acoustic effect is due to interference between the sound pressure signatures of the individual blades. It is found that both the harmonic sound pressure level spectrum and the acoustic directivity pattern is affected. Author (revised)

A93-46805* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ON THE POSSIBILITY OF SINGULARITIES IN THE ACOUSTIC FIELD OF SUPERSONIC SOURCES WHEN BEM IS APPLIED TO A WAVE EQUATION

E. DE BERNARDIS (Italian Aerospace Research Center, Capua, Italy) and F. FARASSAT (NASA, Langley Research Center, Hampton, VA) Oct. 1989 8 p. International Symposium on Boundary Element Methods, East Hartford, CT, Oct. 2-4, 1989, Paper refs

Using a time domain method based on the Ffowcs Williams-Hawkings equation, a reliable explanation is provided for the origin of singularities observed in the numerical prediction of supersonic propeller noise. In the last few years Tam and, more recently, Amiet have analyzed the phenomenon from different points of view. The method proposed here offers a clear interpretation of the singularities based on a new description of sources, relating to the behavior of lines where the propeller blade surface exhibit slope discontinuity.

A93-47450

HELICOPTER EXTERNAL NOISE PREDICTION AND REDUCTION

SERGE LEWY (ONERA, Chatillon, France) ONERA, TP no. 1993-48 1993 7 p. Internal Noise and Vibration Control Conference, St. Petersburg, Russia, May 31-June 3, 1993 Research supported by DRET and Service Technique des Programmes Aeronautiques refs
(ONERA, TP NO. 1993-48)

Helicopter external noise is a major challenge for the manufacturers, both in the civil domain and in the military domain. The strongest acoustic sources are due to the main rotor. Two flight conditions are analyzed in detail because radiated sound is then very loud and very impulsive: (1) high-speed flight, with large thickness and shear terms on the advancing blade side; and (2) descent flight, with blade-vortex interaction for certain rates of descent. In both cases, computational results were obtained and tests on new blade designs have been conducted in wind tunnels. These studies prove that large noise reduction can be achieved. It is shown in conclusion, however, that the other acoustic sources (tail rotor, turboshaft engines) must not be neglected to define a quiet helicopter. Author (revised)

N93-31051# Aeronautical Research Inst. of Sweden, Stockholm.

MODAL MEASUREMENTS AND PROPELLER FIELD EXCITATION ON ACOUSTIC FULL SCALE MOCKUP OF SAAB 340 AIRCRAFT

LARS GUSTAVSSON Jun. 1992 293 p Sponsored by Swedish National Board for Industrial and Technical Development
(FFA-TN-1992-08; ETN-93-94213) Avail: CASI HC A13/MF A03

The acoustic mockup of the cabin SAAB 340 aircraft was measured in an anechoic chamber concerning modal parameters and operating deflection shapes. The mockup was excited with vibration shakers at the fuselage for modal estimation and with a ring of loudspeakers around the fuselage to generate propeller fields for operating deflection shapes. Two cases of structure configuration were used at the measurements; one consisting of only the fuselage, without trimpanels and floorpanels and one case with trimpanels and floorpanels. Modal measurements were done with excitation on a frame of the fuselage at the propeller plane. The modes were estimated for the individual components; fuselage, trimpanels, floorpanels, and soundfield in the cabin. The modes of the fuselage were compared with the acoustic models in the cabin concerning possible coupling effects. With the loudspeakering, the sound field from the left and the right propeller were generated at a blade passage frequency of 81.9 Hz and its first harmonic. Operating deflection shapes of fuselage, panels, and cabin acoustic were estimated. The results from the measurements could be used to verify a finite element model and as a tool for developing acoustic noise control systems. ESA

N93-31283# Deutsche System-Technik G.m.b.H., Bremen (Germany).
TESTING OF AN EXPERIMENTAL SYSTEM FOR IMAGE RECONNAISSANCE
H. KEIL and P. SCHULZ (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick, Germany.) *In* ESA, Flight Test of Avionic and Air-Traffic Control Systems p 249-263 Jan. 1993 Transl. into ENGLISH from Flugerprobung von Avionik und Flugsicherungssystemen (Brunswick, Germany, DLR) Jul. 1991 p 233-246 Original language document was announced as N92-25602
Avail: CASI HC A03/MF A03; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany

Operations performed in the context of an experimental study entitled 'experimental system for image data reduction, storage, and interference resistant transmission for Remotely Piloted Vehicle (RPV) application' (image reconnaissance) are described. The goal was to produce a complete functional system for interference resistant air image transmission from the IR camera on the aircraft to ground station up to 100 km away where it could be viewed on a monitor, in order to be able to investigate the complex, interactive influences and dependencies of individual image processing and data saving processes, and to check out individual results in aircraft testing in a realistic scenario. The special features of the system are its installations for image illustration and storage, for analysis on the ground, the control of the system and image sensor from the ground station and the interference resistant duplex radio transmission between the flying test platform and the ground station. In order to optimize the applied methods, there is also the facility of varying a multitude of system parameters even during operation. This is particularly important with regard to optimum adaptation of the transmission mode to interference arising at a given time. The operations performed so far consisted of proposing, constructing, and flight testing the experimental system. A further operation will involve the planning of a modern process for reduction of image data, in order to make it possible to perform comparative testing with the existing process, in flight operations. There is investigation of hybrid solutions for both processes. ESA

N93-31653# Technische Univ., Delft (Netherlands). Faculty of Technical Mathematics and Informatics.
ON THE DYNAMICS OF AEROELASTIC OSCILLATORS WITH ONE DEGREE OF FREEDOM
T. I. HAAKER and A. H. P. VANDERBURGH 1992 26 p
(ISSN 0922-5641)
(REPT-92-96; ETN-93-94285) Copyright Avail: CASI HC A03/MF A01

Two aeroelastic oscillators in crossflow with one degree of freedom are considered. The first oscillator is a special mass-spring system which is able to oscillate in crossflow, that is perpendicular to the direction of a one dimensional uniform flowing medium. The second oscillator is a seesaw type oscillator in crossflow. The geometry of the oscillators is such that for both oscillators an axis of symmetry can be defined. The interesting difference between the two oscillators is the difference between the dynamical behavior of this axis. For the first oscillator the slope of the axis of symmetry with the horizontal plane does not change with time, whereas for the seesaw type oscillator this slope is time dependent. By using a quasi steady theory as model equations a Lienard and a generalized Lienard equation are obtained. For the first equation a global and for the second equation a local analysis is presented resulting in conditions for the existence and uniqueness of limit cycles. ESA

N93-32221*# University of Southern California, Los Angeles. Dept. of Aerospace Engineering.
CONTROL OF JET NOISE Final Report, 1 Feb. 1991 - 31 Jan. 1992
STEFAN SCHRECK 1992 6 p
(Contract NAG1-1096)
(NASA-CR-193552; NAS 1.26:193552) Avail: CASI HC A02/MF A01

To investigate the possibility of active control of jet noise, knowledge of the noise generation mechanisms in natural jets is essential. Once these mechanisms are determined, active control can be used to manipulate the noise production processes. We investigated the evolution of the flow fields and the acoustic fields of rectangular and circular jets. A predominant flapping mode was found in the supersonic rectangular jets. We hope to increase the spreading of supersonic jets by active control of the flapping mode found in rectangular supersonic jets. Author (revised)

N93-32339 Institute of Sound and Vibration Research, Southampton (England). Fluid Dynamics and Acoustics Group.
THE PREDICTION OF NOISE FROM CO-AXIAL JETS
M. J. FISHER and G. A. PRESTON Mar. 1993 60 p
(ISVR-TR-215) Copyright Avail: Issuing Activity (Institute of Sound and Vibration Research, University of Southampton, Southampton SO9 5NH, England)

A portion of an on-going fundamental study of co-axial jet noise both statically and in flight is reported. Three principal noise producing regions are identified and their mean flow and turbulence characteristics classified from published data. The noise production from each region is then calculated using single jet prediction methods for flows of similar mean velocity and turbulence profiles. The initial test of this prediction scheme was conducted by comparison with data from a cold, co-planar co-axial jet configuration. Agreement, in terms of 1/3 octave spectral prediction, is significantly better than 1 dB over a wide range of both angle of observation and velocity ratio. Author (revised)

N93-32377 Civil Aviation Authority, London (England). Directorate of Operational Research and Analysis.
REACTION TO AIRCRAFT NOISE NEAR GENERAL AVIATION AIRFIELDS
Jun. 1992 95 p
(DORA-8203; ETN-93-93933) Copyright Avail: Issuing Activity (Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, England, HC)

The results of a social survey and noise measurement program around five United Kingdom General Aviation (GA) airfields at Coventry, Kidlington, Leavesden, Shoreham, and Staverton are presented. The fieldwork was carried out during the Summer and early Autumn of 1981. The aims of the study were as follows: to establish the nature and scale of disturbance through noise from GA operations at a number of representative GA airfields; to determine how adequate existing noise indices, in particular NNI (Noise and Number Index) and Leq, (measure of sound energy experienced during a specified period), are in describing disturbance due to GA operations, and what modification, if any, might be necessary to make them appropriate. The NNI is found to show a reasonable correlation with disturbance around the airfields.

Reaction above 35 NNI appears stronger than for public transport operations at major airports. ESA

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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.

A93-44996# National Aeronautics and Space Administration, Washington, DC.

THE NASA COMPUTATIONAL FLUID DYNAMICS (CFD) PROGRAM - BUILDING TECHNOLOGY TO SOLVE FUTURE CHALLENGES

PAMELA F. RICHARDSON (NASA, Washington), DOUGLAS L. DWOYER (NASA, Langley Research Center, Hampton, VA), PAUL KUTLER (NASA, Ames Research Center, Moffett Field, CA), and LOUIS A. POVINELLI (NASA, Lewis Research Center, Cleveland, OH) *In* AIAA Computational Fluid Dynamics Conference, 11th, Orlando, FL, July 6-9, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 16-20.
(AIAA PAPER 93-3292) Copyright

This paper presents the NASA Computational Fluid Dynamics program in terms of a strategic vision and goals as well as NASA's financial commitment and personnel levels. The paper also identifies the CFD program customers and the support to those customers. In addition, the paper discusses technical emphasis and direction of the program and some recent achievements. NASA's Ames, Langley, and Lewis Research Centers are the research hubs of the CFD program while the NASA Headquarters Office of Aeronautics represents and advocates the program. Author

N93-31045# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Hubschrauber und Flugzeuge.

TECHNOLOGY TRANSFER: POTENTIAL OF BMFT CONCEPT FOR HYPERSONICS [TECHNOLOGIETRANSFER: OTENTIALE DES BMFT-FOERDERKONZEPTES HYPERSCHALLTECHNOLOGIE]

E. H. HIRSCHEL, P. W. SACHER, P. KRAMMER (Motoren- und Turbinen-Union Muenchen G.m.b.H., Germany.), W. UHSE (Dornier System G.m.b.H., Friedrichshafen, Germany.), and F. HORMANN (Deutsche Airbus G.m.b.H., Hamburg, Germany.) 22 Sep. 1992 16 p In GERMAN Presented at DGLR Deutsche Luft- und Raumfahrtkongress, Bremen, Germany, 29 Sep. - 2 Oct. 1992
(MBB-LME-202-S-PUB-0505; DGLR-92-03-087; ETN-93-94195)
Avail: CASI HC A03/MF A01

The structure of the BFMT requirement concept for hypersonics technology is outlined. Objectives are presented in key technologies such as propulsion, aerothermodynamics, materials, structures, flight management, and subsystems, which are selected as a concept for the Saenger two stage space transportation system. Supercomputers, ground simulation facilities, and experimental flight instruments are the key technologies to be developed. The technology transfer potential is identified for each technology area. Possible addresses for technology transfer are presented and mechanisms for transmission of extracted technologies are discussed. ESA

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GENERAL

N93-31734# Groupement des Industries Francaises Aeronautiques et Spatiales, Paris (France).

FRENCH AEROSPACE EQUIPMENT [EQUIPMENTS AEROSPATIAUX FRANCAIS]

1993 566 p In ENGLISH and FRENCH
Avail: CASI HC A24/MF A04

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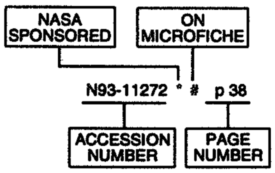

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