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October 1991

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

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NASA SP-7037 (270)
October 1991

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Program
Washington, DC 1991

INTRODUCTION

This issue of *Aeronautical Engineering—A Continuing Bibliography* (NASA SP-7037) lists 600 reports, journal articles, and other documents originally announced in September 1991 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

Accession numbers cited in this issue are:

STAR (N-10000 Series)	N91-25100 — N91-27119
IAA (A-10000 Series)	A91-40567 — A91-44484

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 1991 will be published in early 1992.

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

CONTENTS

Category 01 Aeronautics (General) 693

Category 02 Aerodynamics 694
Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

Category 03 Air Transportation and Safety 733
Includes passenger and cargo air transport operations; and aircraft accidents.

Category 04 Aircraft Communications and Navigation 734
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 738
Includes aircraft simulation technology.

Category 06 Aircraft Instrumentation 742
Includes cockpit and cabin display devices; and flight instruments.

Category 07 Aircraft Propulsion and Power 743
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 756
Includes aircraft handling qualities; piloting; flight controls; and autopilots.

Category 09 Research and Support Facilities (Air) 759
Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.

Category 10 Astronautics 763
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 764
Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.

Category 12 Engineering 767
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 779
Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

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

Category 15 Mathematical and Computer Sciences 780
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 783
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

Category 17 Social Sciences 785
Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

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

Category 19 General 785

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

TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → N91-10010*# Institute for Computer Applications in Science and Engineering, Hampton, VA. ← CORPORATE SOURCE

TITLE → **TURBULENT FLOW CALCULATIONS USING UNSTRUCTURED AND ADAPTIVE MESHES Final Report**

PUBLICATION DATE

AUTHOR → DIMITRI J. MAVRIPLIS Sep. 1990 32 p Submitted for publication

CONTRACT NUMBER → (Contract NAS1-18605)

REPORT NUMBERS → (NASA-CR-182102; NAS 1.26:182102; ICASE-90-61) Avail: NTIS ← AVAILABILITY SOURCE

HC/MF A03 CSCL 01A ← COSATI CODE

PRICE CODE

A method of efficiently computing turbulent compressible flow over complex two dimensional configurations is presented. The method makes use of fully unstructured meshes throughout the entire flow-field, thus enabling the treatment of arbitrarily complex geometries and the use of adaptive meshing techniques throughout both viscous and inviscid regions of flow-field. Mesh generation is based on a locally mapped Delaunay technique in order to generate unstructured meshes with highly-stretched elements in the viscous regions. The flow equations are discretized using a finite element Navier-Stokes solver, and rapid convergence to steady-state is achieved using an unstructured multigrid algorithm. Turbulence modeling is performed using an inexpensive algebraic model, implemented for use on unstructured and adaptive meshes. Compressible turbulent flow solutions about multiple-element airfoil geometries are computed and compared with experimental data. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → A91-11198*# Oklahoma State Univ., Stillwater. ← CORPORATE SOURCE

TITLE → **FLOW AND ACOUSTIC PROPERTIES OF LOW REYNOLDS NUMBER UNDEREXPANDED SUPERSONIC JETS**

AUTHORS → TIEH-FENG HU and D. K. MCLAUGHLIN (Oklahoma State University, Stillwater) Journal of Sound and Vibration (ISSN 0022-460X), vol. 141, Sept. 22, 1990, p. 485-505. refs ← AUTHORS' AFFILIATION

JOURNAL TITLE

CONTRACT NUMBERS → (Contract NAG1-10; NAG1-159)

Copyright

An experimental program to investigate the flow and acoustic properties of model underexpanded supersonic jets was conducted. In particular, the role played by large-scale organized fluctuations in the flow evolution and acoustic production processes was examined in detail. The experimental conditions were chosen as low-Reynolds-number (Re = 8000) Mach 1.4 and 2.1 underexpanded jets exhausting from convergent nozzles. A consequence of performing the experiments at low Reynolds number is that the broad and shock-associated noise is suppressed. The focus of the present study is on the generation of noise by large-scale instabilities in the presence of strong shock cell structures. It is demonstrated that the production of screech is related to the modulation and decay of large-scale turbulence structures. Author

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 270)

OCTOBER 1991

ABSTRACTS

01

AERONAUTICS (GENERAL)

A91-41643#

TRENDS IN AIRCRAFT ENGINE MATERIALS

J. C. WILLIAMS (GE Aircraft Engines, Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 5 p.
(AIAA PAPER 91-1890) Copyright

The consequences of changing aircraft engine material requirements are discussed as well as various approaches taken to address these changes. A list of engine programs through 2005 is presented. It is suggested that a balanced allocation of resources between evolutionary, improved value, and revolutionary materials is necessary to retain the competitiveness of the airline industry.
K.K.

A91-41710#

SUMMARY OF TECHNOLOGY NEEDS FOR HIGH SPEED ROTORCRAFT STUDY

MARK W. SCOTT (Sikorsky Aircraft, Stratford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 28 p. refs
(AIAA PAPER 91-2148) Copyright

A comparative analytical study has been conducted to ascertain the most meritorious among configurations capable of both VTOL and helicopterlike hover, on the one hand, and 350-450 knot cruise speeds, on the other, for various mission scenarios. For transport missions, tilt-wing and variable-diameter tilt-rotor (VDTR) concepts were demonstrably superior; for the military scout/attack role, VDTR was deemed best, although a shrouded-rotor concept was noted to be promising in the event of a future structural weight reduction. The key technologies requiring advancement for tilt-wing and VDTR concepts to become fully viable lie in the areas of wing and proprotor aerodynamics, airframe design, and flight controls.
O.C.

A91-41711*# Bell Helicopter Co., Fort Worth, TX.

CONCLUSIONS FROM HIGH-SPEED ROTORCRAFT STUDIES

SCOTT CONWAY (Bell Helicopter Textron, Inc., Fort Worth, TX) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. NASA-supported research. refs
(AIAA PAPER 91-2149) Copyright

Under the tutelage of NASA-Ames, evaluations have been made of the technology required for high-speed rotorcraft flight with a view to the performance potential and development risks of several candidate configurations. Configurational performance limitations were associated with rotor performance at high Mach numbers and advance ratios, nacelle interference effects on rotor flow, and wing/rotor aeroelastic stability requirements. Attention is given to tiltwing, tilt-for-VTOL/fold-for-cruise rotor, and conventional tiltrotor configurations capable of carrying 30 passengers for the intercity commuter market.
O.C.

A91-41765#

THE IMPORTANCE OF MAINTAINABILITY AND RELIABILITY IN THE DESIGN PROCESS - AN AIRLINE PERSPECTIVE

ROBERT E. MATSON (USAir, Inc., Pittsburgh, PA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p.
(AIAA PAPER 91-2374) Copyright

An examination is conducted of the reliability and maintainability criteria that are essential to the airline operational environment, giving attention to access issues, borescope provisions, and field experience. It is recommended that all engine designs for airline use have easy access to components, the fewest possible number of parts consistent with the requisite performance, highly modular construction for ease of disassembly and maintenance, and avoid electronics that do not possess built-in test equipment. Also imortant are the incorporation of borescope access wherever possible for ease of inspection, high commonality with existing systems, inherent 'overdesign' for the given level of performance, avoidance of repetitive maintenance tasks, and a maximization of component lives rather than performance wherever feasible.
O.C.

A91-43009

REPAIR OF F-104 AIRCRAFT NOSEDOME BY COMPOSITE PATCHING

C. L. ONG and S. B. SHEN (Aero Industry Development Center, Taichung, Republic of China) Theoretical and Applied Fracture Mechanics (ISSN 0167-8442), vol. 15, May 1991, p. 75-83. refs
Copyright

Repair of thin-walled structures with cracks by composite patching has been established as a reliable technology by the aircraft and aerospace industry. Application of this method requires a knowledge of the design stress and know-how in adhesive bonding. This work is concerned with the repair of the F-104 aircraft nosedome by using the boron/epoxy patch and the structural component was restored to its normal service condition. Emphasized is the process of bonding where the mechanical adhesion properties would depend on the chemical reactions. Appropriate combinations of temperature and pressure must be selected to achieve the desired curing cycle. This was found to be 90 C at 483 kPa for 4 hours for the boron/epoxy composite. The repaired nosedome was tested statically to the equivalent of 4.5g while strain gage measurements were taken at several critical locations to assure that the design limits are satisfied. Ultrasonic inspection of the repaired section was made after the proof test and no defects were found. The nosedome was certified and returned to service.
Author

A91-43077#

AGING FLEET - MAINTAINING AIRWORTHINESS

B. A. COSGROVE (Boeing Commercial Airplanes, Seattle, WA) IN: Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Collection of Papers. Haifa, Israel, Technion - Israel Institute of Technology, 1990, p. 1-4.

The authors propose that, with proper maintenance and inspection, airplanes can be flown indefinitely. A system that keeps aircraft structures safe is described as well as measures that have been taken in response to aging aircraft. Particular attention is given to the concerns that arose following the explosive decompression experienced by an Aloha Airlines 737 on April 28, 1988. K.K.

A91-43273

SUB-CONTRACTORS PLAY NEW STRATEGIC ROLES

PHILIP BUTTERWORTH-HAYES and J. R. WILSON Interavia Aerospace Review (ISSN 0020-6512), vol. 46, July 1991, p. 30-32, 34, 36-38.

Copyright

An overview is presented of the manner in which U.S. aircraft manufacturers have approached their outside suppliers, though sharply different from each other, reflecting the recognition they have given to the changing nature of international manufacturing and marketing. A breakdown of major civilian transport aircraft by component parts and subcontracting manufacturers is provided. The relationship between the major civil airline airframe manufacturers and their suppliers is evolving into growing complex structures, with suppliers themselves making intricate arrangements with their own subcontractors. Specific examples of contractual arrangements are described for European, Asian, and other international manufacturers as well as those in the U.S.A. R.E.P.

A91-44340#

SIMULATING A NEW SPECIES OF BIRD

BRUCE FRISCH Aerospace America (ISSN 0740-722X), vol. 29, July 1991, p. 22-24.

Copyright

Simulator design and development for the instruction of helicopter pilots who will be transitioning to the Osprey tilt-rotor aircraft is presented. The simulator specifications call for significant requirements for size, brightness and density of the visual scene; responsiveness of the motion system; and instructional capability. These requirements are met by mounting the instructor station, cockpit, and projectors inside a 24 ft dome, all contained on a motion system. To limit inertia and weight, the dome is made of a composite sandwich of aircraft honeycomb aluminum between graphite composite skins. The scene projected inside the dome will stretch 220 deg horizontally, 70 deg upward, and 45 deg downward. Areas up to 600 by 600 n mi are modeled utilizing texture maps with varying amounts of detail. R.E.P.

N91-25100# Federal Aviation Administration, Atlantic City, NJ.

NAS OPERATIONAL TEST AND EVALUATION/INTEGRATION OF THE MAINTENANCE MANAGEMENT SYSTEM (MMS) TEST PROCEDURES

FRANCES M. BAYNE, CHERYL KROUSE, COREY BOLLING, EDWARD PALKA, JOSEPH POINTKOWSKI, and EDWARD SZYDLOWSKI Jun. 1991 426 p

(DOT/FAA/CT-TN90/63) Avail: NTIS HC/MF A19

The Maintenance Management System (MMS) is an integral part of the Maintenance Processor Subsystem (MPS) which is a major component of the Remote Maintenance Monitoring System (RMMS). The RMMS provides the means for centralized processing and storage of maintenance-related data. The MMS is the major tool for managing the maintenance and operations functions of National Airspace System (NAS) facilities and equipment. The NAS Operational Test and Evaluation (OT and E)/Integration of the MMS Test Procedures are given. The test location, test schedule, manning and responsibilities, test configurations, test assumptions and interdependencies, and test operational instructions are defined. The NAS OT and E/Integration of the MMS Test Procedures was developed to validate the Phase 1 functions of the MMS. Phase 1 includes Periodic Maintenance/Certification (PM/CERT) Scheduling, Report Generation, Facility/Service/-Equipment Profiles (FSEP), Logging, and Administration, together with interfaces to the interim Monitor and Control Software (IMCS), TRANSFER/MAIL application of Tandem Computers Incorporated, and the National Airspace Performance Reporting System (NAPRS). ACN-230 personnel will conduct the NAS OT and E/Integration of the MMS on the ACN-230 MPS located at the Federal Aviation Administration (FAA) Technical Center, Atlantic City International Airport, New Jersey. The MMS versions to be tested will be A03, A03.01, A03.1, and A03.2. The MMS performance requirements will not be verified during this test effort but will be verified during the MPS Performance Test, as outlined in the MPS Performance Test Plan. Author

N91-25102*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

APPLICATIONS OF HIGHER HARMONIC CONTROL TO HINGELESS ROTOR SYSTEMS

KHANH NGUYEN and INDERJIT CHOPRA (Maryland Univ., College Park.) Mar. 1991 15 p Previously announced in IAA as A91-28471 Submitted for publication

(NASA-TM-103846; A-90263; NAS 1.15:103846) Avail: NTIS HC/MF A03 CSCL 01B

A comprehensive analytical formulation was developed to predict the vibratory hub loads of a helicopter rotor system in forward flight. This analysis is used to calculate the optimal higher harmonic control inputs and associated actuator power required to minimize these hub loads. The present formulation is based on a finite element method in space and time. A nonlinear time domain, unsteady aerodynamic model is used to obtain the airloads, and the rotor induced inflow is calculated using a nonuniform inflow model. Predicted vibratory hub loads are correlated with experimental data from a scale model rotor. Results of a parametric study on a hindgeless rotor show that blade flap, lag and torsion vibration characteristics, offset of blade center of mass from elastic axis, offset of elastic axis from quarter-chord axis, and blade thrust greatly affect the higher harmonic control actuator power requirement. Author

N91-26113*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

DEVELOPMENT OF AN INTEGRATED AEROSERVOELASTIC ANALYSIS PROGRAM AND CORRELATION WITH TEST DATA

K. K. GUPTA, M. J. BRENNER, and L. S. VOELKER Washington May 1991 105 p

(NASA-TP-3120; H-1543; NAS 1.60:3120) Avail: NTIS HC/MF A06 CSCL 01/2

The details and results are presented of the general-purpose finite element STructural Analysis RoutineS (STARS) to perform a complete linear aeroelastic and aeroservoelastic analysis. The earlier version of the STARS computer program enabled effective finite element modeling as well as static, vibration, buckling, and dynamic response of damped and undamped systems, including those with pre-stressed and spinning structures. Additions to the STARS program include aeroelastic modeling for flutter and divergence solutions, and hybrid control system augmentation for aeroservoelastic analysis. Numerical results of the X-29A aircraft pertaining to vibration, flutter-divergence, and open- and closed-loop aeroservoelastic controls analysis are compared to ground vibration, wind-tunnel, and flight-test results. The open- and closed-loop aeroservoelastic control analyses are based on a hybrid formulation representing the interaction of structural, aerodynamic, and flight-control dynamics. Author

02

AERODYNAMICS

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

A91-40569#

AN APPLICATION OF TOPOLOGICAL METHOD TO ANALYSING THE THREE-DIMENSIONAL FLOW IN CASCADES. II - TOPOLOGICAL ANALYSIS ON THE VECTOR FIELD PATTERNS OF SKIN-FRICTIONS AND SECTION STREAMLINES

SHUN KANG and ZHONG-QI WANG (Harbin Institute of Technology, People's Republic of China) Applied Mathematics and Mechanics (English Edition) (ISSN 0253-4827), vol. 11, Dec. 1990, p. 1119-1127. NNSFC-supported research. refs

The skin-friction line patterns related to compressor and turbine cascade surfaces are described by means of a topological analysis, and the cross sections of a curved pipe and a turbine cascade are considered by means of the streamline patterns of their secondary flow fields. Flow patterns are qualitatively inferred by applying previously derived topological rules which describe the nature and classification of some singular points. The suction surfaces and the endwalls of compressor cascades are characterized by spiral nodes which are not usually found on the surfaces of turbine cascades. Spiral nodes and saddles are identified in the secondary flow fields of turbine cascades. In this case, the spiral node is found where the cores of the concentrated vortices develop in the cascade passage. Topological rules are found to be adequate means for depicting directions of movement and single-point distributions of both skin-friction lines and streamlines for cascade sections. C.C.S.

A91-40575

A NUMERICAL ANALYSIS OF THE FLOW PASSING THROUGH A CASCADE WITH TIP CLEARANCE - SUBSONIC FLOW THROUGH A LINEAR CASCADE COMPOSED OF FLAT PLATES

TOSHINORI WATANABE (Tokyo University of Agriculture and Technology, Koganei, Japan), ISAO KANAZAWA (NASDA, Tsukuba, Japan), OSAMU NOZAKI, and ATSUHIRO TAMURA (National Aerospace Laboratory, Chofu, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 34, May 1991, p. 134-140. refs

Copyright

The three-dimensional flow field through a linear cascade with tip clearance was numerically studied by solving Navier-Stokes equations. A fundamental cascade model composed of flat plates, for which corresponding experimental data were available, was adopted to develop the appropriate solution method for the flow through the tip clearance. The computed normal force distributions on blades and velocity vectors in the downstream flow field showed good agreement with the experimental data. The detailed flow phenomena around the blade tip, such as the formation of separation bubbles on the tip surface, were clearly described. The spanwise distributions of the normal force on the blade were investigated for various tip clearances, and it was found that the normal force on the extremity of the blade did not diminish in the case of small clearances of less than 0.6 percent of the blade span because of the blockage of leakage flow due to the effect of viscosity. Author

A91-40578

SOME ASPECTS OF SHOCK-WAVE BOUNDARY LAYER INTERACTION AT HYPERSONIC SPEEDS

JOHN L. STOLLERY (Cranfield Institute of Technology, Bedford, England) IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 12-22. refs

Copyright

A brief overview of the interaction been shock waves and boundary layers is given, concentrating on flow past a compression corner, glancing interaction, and viscous interaction. Glancing interaction involving sharp straight fins, sharp swept fins, blunt straight fins, and blunt swept fins are addressed. For flow past a compression corner and glancing interaction, the main effects are caused by the shock wave altering the behavior of the boundary layer. In viscous interaction the boundary layer initiates significant changes in the development of the shock wave. C.D.

A91-40604

EXPERIMENTAL INVESTIGATION OF THE SHOCK WAVE AND TURBULENT BOUNDARY LAYER INTERACTION INDUCED BY A CYLINDRICAL PROTUBERANCE

GUI-MING TANG and HONG-RU YU (Chinese Academy of Sciences, Institute of Mechanics, Beijing, People's Republic of China) IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 264-269. refs

Copyright

Detailed distributions of aerodynamic heating were measured in the interaction region caused by a long cylinder on a flat plate in shock tunnel. Oil flow patterns and schlieren photographs were taken. The results were discussed and approximate methods were given for determining separation shock angle, heating peak values and their locations on both the cylinder leading edge and the plate. Author

A91-40646

LAMINAR HEAT TRANSFER TO SPHERICALLY BLUNTED CONES IN HIGH ENTHALPY HYPER VELOCITY FLOWS

S. L. GAI (Australian Defence Force Academy, Canberra, Australia) and W. JOE (Australian National University, Canberra, Australia) IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 624-629. refs

Copyright

Measurements of heat transfer on spherically blunted cones of various bluntness ratios in high-enthalpy hypervelocity air flows using the Australian National University free-piston driven Shock Tunnel T3 are described. The stagnation enthalpies considered were in the range 3-20 MJ/kg (equivalent to flight velocities 2-6 km/s). The corresponding equilibrium stagnation temperatures were in the range 2000-9000 K. Author

A91-40647

SURFACE HEAT TRANSFER CHANGE INDUCED BY UNSTEADY SHOCK REFLECTIONS AND NUMERICAL SIMULATIONS ON SHOCK REFLECTION

SHIGERU ASO (Kyushu University, Fukuoka, Japan), MASANORI HAYASHI (Nishinippon Institute of Technology, Fukuoka, Japan), ANZHONG TAN (Chinese Academy of Sciences, Institute of Mechanics, Beijing, People's Republic of China), and YOSHIHARU TANAHASHI (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan) IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 630-635.

Copyright

Experimental and numerical investigations of unsteady aerodynamic heating in shock reflections were performed, and heat flux changes induced by unsteady shock impingement were measured. An additional increase in surface heat transfer owing to slip-layer impingement is observed in complex Mach reflection and double Mach reflection. Numerical simulations of unsteady shock reflections by a ramp were also conducted, using an orthogonal curvilinear grid system generated by conformal mapping. The two-dimensional Euler equations and thin-layered Navier-Stokes equations are solved numerically by a TVD scheme to simulate unsteady shock reflections and unsteady aerodynamic heating by shock reflections. Substantial agreement with the experiments is shown. The detailed flow structure and parametric change of the slip layer's shape with the incident Mach number are simulated correctly. The calculated additional increase in surface heat flux induced by slip-layer impingement exhibits a high level of agreement with experiments. P.D.

A91-40656

WAVE PROCESSES OCCURRING IN SUPERSONIC MOTION OF BLUNTED BODY THROUGH DUST LAYER

V. L. BELOUSOV, M. S. RAMM, and A. A. SCHMIDT (AN SSSR, Fiziko-Tekhnicheskii Institut, Leningrad, USSR) IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 726-731. refs

Copyright

Numerical simulation is made of unsteady structure of a two-phase shock layer in front of a sphere flying through a dusted region. Effect of the dispersed particles rebounded by the sphere surface is taken into account. Simulation is based on modified Eulerian-Lagrangian description of the two-phase flow. Analysis shows that in the case under study the structure of the shock layer is characterized by the dispersed phase concentration fronts and internal pressure jumps interaction with the bow shock and the sphere surface. It is shown that when the sphere enters the dust layer the surface heat flux and friction increase significantly.
Author

A91-40672 Texas Univ., Arlington.
THE PEAK SURFACE PRESSURE IN FIN-GENERATED SHOCK-WAVE BOUNDARY-LAYER INTERACTIONS
FRANK K. LU (Texas, University, Arlington) IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 867-872. refs
(Contract AF-AFOSR-86-0082; NCA2-192; NAG1-891)
Copyright
Recent experimental evidence has shown that for separated swept shock turbulent boundary-layer interactions, the freestream inviscid shock is bifurcated into a lambda-foot structure. The fluid through this foot impinges the surface as an energetic, supersonic jet that results in overpressures. This overpressure can be understood using inviscid theory.
Author

A91-40703#
AREAS FOR FUTURE CFD DEVELOPMENT AS ILLUSTRATED BY TRANSPORT AIRCRAFT APPLICATIONS
P. L. GARNER, P. T. MEREDITH, and R. C. STONER (Boeing Commercial Airplanes, Seattle, WA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 10-20. refs
(AIAA PAPER 91-1527) Copyright
New capabilities in computer codes available to the aerodynamic designer are discussed. A course of future work in CFD is suggested, from the perspective of the engineers responsible for developing and applying new aerodynamics technology to future aircraft programs. The need for improved understanding of basic flow physics issues is stressed.
Author

A91-40705*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF A MULTI-DIMENSIONAL FLUX FUNCTION ON THE MONOTONICITY OF EULER AND NAVIER-STOKES COMPUTATIONS
CHRISTOPHER L. RUMSEY (NASA, Langley Research Center, Hampton, VA), BRAM VAN LEER, and PHILIP L. ROE (Michigan, University, Ann Arbor) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 32-46. refs
(AIAA PAPER 91-1530) Copyright
A limiting method has been devised for a grid-independent flux function for use with the two-dimensional Euler and Navier-Stokes equations. This limiting is derived from a monotonicity analysis of the model and allows for solutions with reduced oscillatory behavior while still maintaining sharper resolution than a grid-aligned method. In addition to capturing oblique waves sharply, the grid-independent flux function also reduces the entropy generated over an airfoil in an Euler computation and reduces pressure distortions in the separated boundary layer of a viscous-flow airfoil computation. The model has also been extended to three dimensions, although no angle-limiting procedure for improving monotonicity characteristics has been incorporated.
Author

A91-40706# North Carolina State Univ., Raleigh.
AN EXPLICIT, ROTATED UPWIND ALGORITHM FOR SOLUTION OF THE EULER/NAVIER-STOKES EQUATIONS
D. A. KONTINOS and D. S. MCRAE (North Carolina State University, Raleigh) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 47-59. refs
(Contract NAGW-1331; NCA2-540)
(AIAA PAPER 91-1531) Copyright
An explicit, finite difference, rotated upwind algorithm for solution of the two-dimensional Euler/Navier-Stokes equations is developed. This scheme, with the upwind direction determined from flow field properties, is compared to an algorithm where the upwinding is performed in each coordinate direction (grid-aligned). The solver is a MacCormack-like scheme with upwind flux modifiers. First- and second-order inviscid results are generated for the test case of a Mach 3.2 compression channel. Also, first-order viscous results of a Mach 3.0, 10 deg compression corner are presented. In computations to first-order accuracy, the rotated scheme is shown to have a significant improvement over the grid aligned scheme. The second-order results show only slight improvement in the shock capturing ability. Finally, the compression corner case demonstrates the significant differences in a solution that can devleop as a result of the upwind orientation.
Author

A91-40708#
UPWIND IMPLICIT RESIDUAL SMOOTHING METHOD FOR MULTI-STAGE SCHEMES
J. BLAZEK, N. KROLL, R. RADESPIEL, and C.-C. ROSSOW (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 70-80. refs
(AIAA PAPER 91-1533) Copyright
The present upwind-biased form for the implicit residual-smoothing method's operator improves both the damping and convergence characteristics of explicit multistage time-stepping schemes, relative to the commonly employed residual smoothing with central implicit-operator form. The properties of the novel approach are studied for the case of the scalar-advection equation using Fourier analysis for various space discretizations. The suitability of the method in multigrid computations is demonstrated, and numerical results for the one- and two-dimensional Euler equations are presented. Outstanding performance characteristics are confirmed.
O.C.

A91-40712# Computer Sciences Corp., Moffett Field, CA.
IMPLICIT SOLVERS FOR UNSTRUCTURED MESHES
V. VENKATAKRISHNAN (Computer Sciences Corp., Moffett Field, CA) and DIMITRI J. MAVRIPLIS (NASA, Langley Research Center; ICASE, Hampton, VA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 115-124. refs
(Contract NAS2-12961)
(AIAA PAPER 91-1537) Copyright
Implicit methods for unstructured mesh computations are developed and tested. The approximate system which arises from the Newton-linearization of the nonlinear evolution operator is solved by using the preconditioned generalized minimum residual technique. These different preconditioners are investigated: the incomplete LU factorization (ILU), block diagonal factorization, and the symmetric successive over-relaxation (SSOR). The preconditioners have been optimized to have good vectorization properties. The various methods are compared over a wide range of problems. Ordering of the unknowns, which affects the convergence of these sparse matrix iterative methods, is also investigated. Results are presented for inviscid and turbulent viscous calculations on single and multielement airfoil configurations using globally and adaptively generated meshes.
Author

A91-40715#
A VERTEX-CENTROID SCHEME FOR IMPROVED FINITE-VOLUME SOLUTION OF THE NAVIER-STOKES EQUATIONS
M. G. HALL (Royal Aerospace Establishment, Farnborough, England) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 146-154. refs
(AIAA PAPER 91-1540) Copyright

A new spatial discretization is proposed for the finite-volume solution of the Navier-Stokes equations. The aim is to combine improved accuracy with improved robustness, relative to the best of the current cell-centered and cell-vertex schemes. For the new scheme the dependent variables are specified at the vertices of the grid cells but a control volume defined by cell centroids is used for the integration of all the fluxes. Numerical results from a solution for transonic flow past an aerofoil are presented to demonstrate feasibility. Author

A91-40717*# Michigan Univ., Ann Arbor.
AN ADAPTIVELY-REFINED CARTESIAN MESH SOLVER FOR THE EULER EQUATIONS
DARREN DE ZEEUW and KENNETH G. POWELL (Michigan, University, Ann Arbor) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 166-180. refs
(Contract NSF EET-88-57500; NAG1-869)
(AIAA PAPER 91-1542) Copyright

A method for adaptive refinement of a Cartesian mesh for the solution of the steady Euler equations is presented. The algorithm creates an initial uniform mesh and cuts the body out of that mesh. The mesh is then refined based on body curvature. Next, the solution is converged to a steady state using a linear reconstruction and Roe's approximate Riemann solver. Solution-adaptive refinement of the mesh is then applied to resolve high-gradient regions of the flow. The numerical results presented show the flexibility of this approach and the accuracy attainable by solution-based refinement. Author

A91-40718*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HIGHER ORDER ACCURACY FOR UPWIND METHODS BY USING THE COMPATIBILITY EQUATIONS
PETER M. GOORJIAN and SHIGERU OBAYASHI (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 181-189. refs
(AIAA PAPER 91-1543) Copyright

A new algorithm has been developed for obtaining higher order accuracy in upwind schemes for the Euler and Navier-Stokes equations. In this method, the compatibility relations for the Euler equations are used to construct formulas for the higher order interpolates. Using these formulas, computed results are obtained for steady, inviscid flow through a nozzle and also steady, inviscid and viscous flow over an airfoil. These results are compared with results obtained by using a minmod limiter function. The comparisons show improved accuracy throughout the flow field with the use of the compatibility equations. Author

A91-40719#
DISSIPATION ADDITIONS TO FLUX-DIFFERENCE SPLITTING
HONG-CHIA LIN (Cranfield Institute of Technology, England) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 190-198. Dassault Aviation-supported research. refs
(AIAA PAPER 91-1544) Copyright

Although the flux-difference splitting methods for solving the Euler equations are generally very robust and no explicit dissipation is required. There are situations where explicit dissipation is needed. Two cases, a slowly-moving shock problem and a blunt body calculation, are discussed in this paper. The slowly-moving shock problem is tested extensively by the Roe's Riemann solver and a cure for Roe's Riemann solver is proposed. For the second-order scheme it is found necessary to reduce the second-order accuracy to first-order accuracy inside the shock layer. For supersonic blunt body calculation adding dissipation in the linear waves in Roe's Riemann solver can prevent numerical instability in the subsonic pocket. The drawback of Yee's formula to cure the instability when used on viscous flow calculation is demonstrated. A better solution based on pressure gradient is proposed. Author

A91-40721*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A NEW LAGRANGIAN RANDOM CHOICE METHOD FOR STEADY TWO-DIMENSIONAL SUPERSONIC/HYPERSONIC FLOW
C. Y. LOH (NASA, Lewis Research Center, Cleveland, OH) and W. H. HUI (Waterloo, University, Canada) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 209-216. Research supported by NASA and NSERC. refs
(AIAA PAPER 91-1546) Copyright

Glimm's (1965) random choice method has been successfully applied to compute steady two-dimensional supersonic/hypersonic flow using a new Lagrangian formulation. The method is easy to program, fast to execute, yet it is very accurate and robust. It requires no grid generation, resolves slipline and shock discontinuities crisply, can handle boundary conditions most easily, and is applicable to hypersonic as well as supersonic flow. It represents an accurate and fast alternative to the existing Eulerian methods. Many computed examples are given. Author

A91-40722#
HODOGRAPH SOLUTION FOR COMPRESSIBLE FLOW PAST A CORNER AND COMPARISON WITH EULER NUMERICAL PREDICTIONS
A. VERHOFF, D. STOOKESBERRY, and T. MICHAL (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 217-227. refs
(AIAA PAPER 91-1547) Copyright

An iterative procedure for solving the two-dimensional compressible hodograph equation is presented which is applicable for flows where the variation in local Mach number is not large. Solutions are constructed for shock-free flow past compression and expansion corners for various turning angles and free stream Mach numbers. Numerical predictions of surface Mach number and pressure provided by several Euler flowfield codes are compared with the hodograph solutions. Even when extremely fine grids are used near a singular corner point, wiggles still tend to appear locally in the numerical solutions, indicating inconsistent boundary condition models. The analytic solutions provide a detailed description of flow characteristics near corners. Using this information, accurate surface boundary conditions to be applied near geometric singularities, such as airfoil trailing edges, can then be developed which will reduce the need for tight grid clustering in Euler numerical prediction methods. Author

A91-40723*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A 3-D UPWIND EULER SOLVER FOR UNSTRUCTURED MESHES
TIMOTHY J. BARTH (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 228-238. refs
(AIAA PAPER 91-1548) Copyright

A three-dimensional finite-volume upwind Euler solver is developed for unstructured meshes. The finite-volume scheme solves for solution variables at vertices of the mesh and satisfies the integral conservation law on nonoverlapping polyhedral control volumes surrounding vertices of the mesh. The schene achieves improved solution accuracy by assuming a piecewise linear variation of the solution in each control volume. This improved spatial accuracy hinges heavily upon the calculation of the solution gradient in each control volume given pointwise values of the solution at vertices of the mesh. Several algorithms are discussed for obtaining these gradients. Details concerning implementation procedures and data structures are discussed. Sample calculations for inviscid Euler flow about isolated aircraft wings at subsonic and transonic speeds are compared with established Euler solvers as well as experiment. Author

A91-40727#
THE EFFECT OF ARTIFICIAL VORTICITY ON THE DISCRETE SOLUTION OF EULER EQUATIONS
M. HAFEZ and D. BRUCKER (California, University, Davis) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 283-296. refs
(AIAA PAPER 91-1553) Copyright

Numerical solutions of Euler equations in primitive variables are usually contaminated with the effect of artificial viscosity and the numerical treatment of boundary conditions. Due to these discretization errors, artificial vorticity is generated and leads to erroneous answers. For example, a substantial lift is produced over a cylinder at angle of attack, in an inviscid incompressible steady flow calculation. In this paper, a finite difference scheme is constructed to minimize (in some cases eliminate) the amount of artificial vorticity. Sample calculations for two dimensional geometries such as flow over an ellipse at angle of attack are presented. Results are compared with the exact and numerical potential solutions on coarse and fine meshes. Concluding remarks, as well as, further investigations are suggested. Author

A91-40729*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN IMPLICIT THREE-DIMENSIONAL NAVIER-STOKES SOLVER FOR COMPRESSIBLE FLOW
SEOKKWAN YOON and DOCHAN KWAK (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 308-318. refs
(AIAA PAPER 91-1555) Copyright

A three-dimensional numerical method based on the lower-upper symmetric-Gauss-Seidel implicit scheme in conjunction with the flux-limited dissipation model is developed for solving the compressible Navier-Stokes equations. A new computer code which is based on this method requires only 9 microsec per grid-point per iteration on a single processor of a Cray YMP computer and executes at the sustained rate of 170 MFLOPS. A reduction of 4 orders of magnitude in the residual for a high Reynolds number flow using 230 K grid points is obtained in 24 minutes. The computational results compare well with available experimental data. Author

A91-40730*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
GENERALIZED CONJUGATE-GRADIENT METHODS FOR THE NAVIER-STOKES EQUATIONS
KUMUD AJMANI, WING-FAI NG (Virginia Polytechnic Institute and State University, Blacksburg), and MENG-SING LIOU (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 319-327. refs
(AIAA PAPER 91-1556) Copyright

A generalized conjugate-gradient method is used to solve the two-dimensional, compressible Navier-Stokes equations of fluid flow. The equations are discretized with an implicit, upwind finite-volume formulation. Preconditioning techniques are incorporated into the new solver to accelerate convergence of the overall iterative method. The superiority of the new solver is demonstrated by comparisons with a conventional line Gauss-Siedel Relaxation solver. Computational test results for transonic flow (trailing edge flow in a transonic turbine cascade) and hypersonic flow (M = 6.0 shock-on-shock phenoena on a cylindrical leading edge) are presented. When applied to the transonic cascade case, the new solver is 4.4 times faster in terms of number of iterations and 3.1 times faster in terms of CPU time than the Relaxation solver. For the hypersonic shock case, the new solver is 3.0 times faster in terms of number of iterations and 2.2 times faster in terms of CPU time than the Relaxation solver. Author

A91-40732#
UNIFIED ZONAL METHOD BASED ON THE FORTIFIED NAVIER-STOKES CONCEPT
KOZO FUJII, YOSHIAKI TAMURA (Institute of Space and Astronautical Science, Sagamihara, Japan), and SHINICHI KURODA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 339-349. refs
(AIAA PAPER 91-1558) Copyright

A generalized zonal method for flow simulations is developed which improves the local grid resolution and makes it possible to handle complex body configurations. The method is based on the fortified Navier-Stokes (FNS) concept, making it possible to unite several types of zonal methods (such as a zonal method with slightly overlapped grid, a zonal method with overset grid, a multiblock method, and an implementation of additional boundary conditions) under one concept. It is shown that this unified method is simple and that its implementation into existing implicit or explicit single-zone codes is easy. Several application examples are presented. I.S.

A91-40733#
VISCOUS AIRFOIL COMPUTATIONS USING RICHARDSON EXTRAPOLATION
D. W. ZINGG (Toronto, University, Canada) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 350-359. Research supported by NSERC and Cray Canada, Inc. refs
(AIAA PAPER 91-1559) Copyright

An investigation of the use of Richardson extrapolation in the computation of viscous airfoil flowfields is presented. The Richardson extrapolation procedure uses a numerical solution obtained on a coarsened grid to improve the accuracy of a given solution. Computational results are presented for subsonic flow about the NACA 0012 airfoil and transonic flow about the NACA 0012 and the RAE 2822 airfoils. The cases studied exhibit a variety of flow features, including shock-induced separation and trailing-edge separation. The transonic flow conditions correspond to cases from the Viscous Transonic Airfoil Workshop. The computations were performed using ARC2D, a well-established Navier-Stokes code, with the Baldwin-Lomax turbulence model. The results show that Richardson extrapolation can reduce the grid requirements for a given level of accuracy, especially in the prediction of drag, for a wide range of flow conditions. In addition, Richardson extrapolation produces estimates of truncation error. Author

A91-40740*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NUMERICAL FLUX FORMULAS FOR THE EULER AND NAVIER-STOKES EQUATIONS. II - PROGRESS IN FLUX-VECTOR SPLITTING
WILLIAM J. COIRIER (NASA, Lewis Research Center, Cleveland, OH) and BRAM VAN LEER (Michigan, University, Ann Arbor) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American

Institute of Aeronautics and Astronautics, 1991, p. 422-438. Previously announced in STAR as N91-22084. refs
(AIAA PAPER 91-1566) Copyright

The accuracy of various numerical flux functions for the inviscid fluxes when used for Navier-Stokes computations is studied. The flux functions are benchmarked for solutions of the viscous, hypersonic flow past a 10 degree cone at zero angle of attack using first order, upwind spatial differencing. The Harten-Lax/Roe flux is found to give a good boundary layer representation, although its robustness is an issue. Some hybrid flux formulas, where the concepts of flux-vector and flux-difference splitting are combined, are shown to give unsatisfactory pressure distributions; there is still room for improvement. Investigations of low diffusion, pure flux-vector splittings indicate that a pure flux-vector splitting can be developed that eliminates spurious diffusion across the boundary layer. The resulting first-order scheme is marginally stable and not monotone. Author

A91-40745*# Cornell Univ., Ithaca, NY.
DIAGONAL IMPLICIT MULTIGRID SOLUTION OF COMPRESSIBLE TURBULENT FLOWS
R. R. VARMA and D. A. CAUGHEY (Cornell University, Ithaca, NY) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 487-500. McDonnell Douglas Corp.-supported research. refs
(Contract NAG2-665)
(AIAA PAPER 91-1571) Copyright

The Caughey (1988) multigrid diagonal implicit algorithm for Euler equations is extended to solve the two-dimensional thin layer Navier-Stokes equations for turbulent transonic flows. To further accelerate convergence to a steady state, the implicit scheme is used within the multigrid method. Results are presented for transonic flows past airfoils, and the flow-field results are compared with other computational data and experiments demonstrating the accuracy of the method. I.S.

A91-40746*# Tel-Aviv Univ. (Israel).
MULTIGRID FOR HYPERSONIC VISCOUS TWO- AND THREE-DIMENSIONAL FLOWS
E. TURKEL (Tel Aviv University, Israel), R. C. SWANSON, V. N. VATSA (NASA, Langley Research Center, Hampton, VA), and J. A. WHITE (Analytical Services and Materials, Inc., Hampton, VA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 501-517. refs
(AIAA PAPER 91-1572) Copyright

The use of a multigrid method with central differencing to solve the Navier-Stokes equations for hypersonic flows is considered. The time-dependent form of the equations is integrated with an explicit Runge-Kutta scheme accelerated by local time stepping and implicit residual smoothing. Variable coefficients are developed for the implicit process that remove the diffusion limit on the time step, producing significant improvement in convergence. A numerical dissipation formulation that provides good shock-capturing capability for hypersonic flows is presented. This formulation is shown to be a crucial aspect of the multigrid method. Solutions are given for two-dimensional viscous flow over a NACA 0012 airfoil and three-dimensional viscous flow over a blunt biconic. Author

A91-40747#
LU IMPLICIT TVD SCHEME FOR THE SOLUTION OF VISCOUS TWO DIMENSIONAL HIGH SPEED FLOWS
FRANCESCO GRASSO (Roma I, Universita, Rome, Italy) and MARCO MARINI IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 518-528. refs
(AIAA PAPER 91-1573) Copyright

This paper describes an accurate finite-volume implicit scheme developed for solving both the laminar and the Reynolds-averaged Navier-Stokes equations for high-speed perfect-gas flows. The numerical algorighm is based on a symmetric discretization of viscous terms and uses an upwind-biased second-order TVD scheme for the inviscid terms. Results are presented for the supersonic boundary layer, the laminar shock wave-boundary layer interaction on a flat plate, and flows over compression ramps at hypersonic Mach numbers. I.S.

A91-40748*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
COMPUTATIONAL ASPECTS OF CHEMICALLY REACTING FLOWS
C. P. LI (NASA, Johnson Space Center, Houston, TX) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 529-540. refs
(AIAA PAPER 91-1574) Copyright

An implicit, time-dependent approach is taken to solve the inviscid conservative equations in a vertex-based finite-volume formulation. The convective fluxes are estimated by a modified Riemann solver, and higher-order accuracy is obtained by means of the MUSCL. Implicit techniques are adopted to deal with the equation stiffness as a result of the clustered grid and chemical source term. The real-gas Roe matrix and the ADI and LU schemes have been tested on the sample problems: hypersonic flow over blunt configurations, such as the forebody of a double ellipse, and the near wake of a conic aerobrake. Temperature distribution and standoff distance are validated against the shock-fitting, central-differencing results. Equilibrium temperature may be recovered by artificially increasing the chemical rates at the wall. The present method satisfactorily resolves the flow structure, including the strong expansion behind the flat base. The relative merits and performance of the real-gas TVD and implicit schemes are discussed briefly. Author

A91-40749*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A RUNGE-KUTTA DISCONTINUOUS FINITE ELEMENT METHOD FOR HIGH SPEED FLOWS
KIM S. BEY (NASA, Langley Research Center, Hampton, VA) and J. T. ODEN (Texas, University, Austin) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 541-555. refs
(AIAA PAPER 91-1575) Copyright

A Runge-Kutta discontinuous finite element method is developed for hyperbolic systems of conservation laws in two space variables. The discontinuous Galerkin spatial approximation to the conservation laws results in a system of ordinary differential equations which are marched in time using Runge-Kutta methods. Numerical results for the two-dimensional Burger's equation show that the method is $(p+1)$-order accurate in time and space, where p is the degree of the polynomial approximation of the solution within an element and is capable of capturing shocks over a single element without oscillations. Results for this problem also show that the accuracy of the solution in smooth regions is unaffected by the local projection and that the accuracy in smooth regions increases as p increases. Numerical results for the Euler equations show that the method captures shocks without oscillations and with higher resolution than a first-order scheme. Author

A91-40751*# Old Dominion Univ., Norfolk, VA.
AERODYNAMIC SHAPE OPTIMIZATION USING SENSITIVITY ANALYSIS ON THIRD-ORDER EULER EQUATIONS
OKTAY BAYSAL, MOHAMED E. ELESHAKY, and GREG W. BURGREEN (Old Dominion University, Norfolk, VA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 573-583. refs
(Contract NAG1-1188)
(AIAA PAPER 91-1577) Copyright

Two major advancements of an aerodynamic optimization method with two design variables are described. The first is represnted by an improved flow prediction method that uses the third-order accurate discretization of the Euler equations. This method makes it possible to predict the flowfield of a perturbed shape which generates shocks and other large gradients without intermediate CFD analysis. The second advancement is the use of every surface grid point as a design variable in the aerodynamic shape optimization problem. The improved algorithm is demonstrated by optimizing the ramp shape of a scramjet-afterbody configuration for maximum axial thrust. It is concluded that the improved flow-field prediction method eliminates most of the flow analysis and a priori guessing of all possible shapes from which the optimum is to be selected. O.G.

A91-40753*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ASYNCHRONOUS, MACROTASKED RELAXATION STRATEGIES FOR THE SOLUTION OF VISCOUS, HYPERSONIC FLOWS

PETER A. GNOFFO (NASA, Langley Research Center, Hampton, VA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 591-607. refs

(AIAA PAPER 91-1579) Copyright

A point-implicit, asynchronous macrotasked relaxation of the steady, thin-layer, Navier-Stokes equations is presented. The method employs multidirectional, single-level storage Gauss-Seidel relaxation sweeps, which effectively communicate perturbations across the entire domain in 2n sweeps, where n is the dimension of the domain. In order to enhance convergence the application of relaxation factors to specific components of the Jacobian is examined using a stability analysis of the advection and diffusion equations. Attention is also given to the complications associated with asynchronous multitasking. Solutions are generated for hypersonic flows over blunt bodies in two and three dimensions with chemical reactions, utilizing single-tasked and multitasked relaxation strategies. O.G.

A91-40754#

A COMPARISON OF IMPLICIT MULTIGRID EULER SOLVERS IMPLEMENTED ON A MULTIPROCESSOR COMPUTER

J. A. O'CALLAHAN and D. S. THOMPSON (Texas, University, Arlington) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 608-618. Research supported by Texas Advanced Research Program. refs

(AIAA PAPER 91-1580) Copyright

Several smoothing schemes are incorporated into a Full Approximation Storage multigrid algorithm to examine the rate of convergence to the steady-state solution of the two-dimensional Euler equations for a transonic flow problem. Comparisons between convergence rates and CPU times are shown for both single grid and multigrid Approximate Factorization, Line Gauss-Seidel and Zebra smoothing schemes (with several variations of LGS and Zebra). Roe's flux difference splitting is used for evaluating the fluxes required by the discrete form of the Euler equations. Results for both first-order and second-order solutions are presented. Author

A91-40758*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

SURFACE RECONSTRUCTION FROM SCATTERED DATA THROUGH PRUNING OF UNSTRUCTURED GRIDS

C. M. MAKSYMIUK and M. L. MERRIAM (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 648-653. refs

(AIAA PAPER 91-1584) Copyright

This paper describes an algorithm for reconstructing a surface from a randomly digitized object. Scan data (treated as a cloud of points) is first tesselated out to its convex hull using Delaunay triangulation. The line-of-sight between each surface point and the scanning device is traversed, and any tetrahedra which are pierced by it are removed. The remaining tetrahedra form an approximate solid model of the scanned object. Due to the inherently limited resolution of any scan, this algorithm requires two additional procedures to produce a smooth, polyhedral surface: one process removes long, narrow tetrahedra which span indentations in the surface between digitized points; the other smooths sharp edges. The results for a moderately resolved sample body and a highly resolved aircraft are displayed. Author

A91-40759#

COMPUTER-AIDED BLOCK-STRUCTURING THROUGH THE USE OF OPTIMIZATION AND EXPERT SYSTEM TECHNIQUES

JOHN F. DANNENHOFFER, III (United Technologies Research Center, East Hartford, CT) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 654-661. United Technologies Corp.-supported research. refs

(AIAA PAPER 91-1585) Copyright

One of the most labor-intensive aspects of performing computational simulations of the flow over aerospace configurations is the design and generation of appropriate computational grids, especially of the block-structured variety. A major difficulty with current systems is the need to design a suitable blocking plan, or flowfield decomposition, for a given configuration. Presented herein is a new approach for the automatic design of suitable blocking plans which is based upon the use of a rule-based expert system. A domain decomposition knowledge base is used by the expert system to analyze a given configuration, set up an appropriate baseline blocking plan, and perform a nonlinear integer optimization to 'fine-tune' the blocking plan and the resulting computational grid. It is shown that this new approach efficiently generates near-optimal block-structured grids over a variety of multi-body configurations. Author

A91-40761# Lockheed Engineering and Sciences Co., Houston, TX.

COLLAR GRIDS FOR INTERSECTING GEOMETRIC COMPONENTS WITHIN THE CHIMERA OVERLAPPED GRID SCHEME

STEVEN J. PARKS (Lockheed Engineering and Sciences Co., Houston, TX), PIETER G. BUNING, WILLIAM M. CHAN (NASA, Ames Research Center, Moffett Field, CA), and JOSEPH L. STEGER (California, University, Davis) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 672-682. NASA-supported research. refs

(AIAA PAPER 91-1587) Copyright

A method for overcoming problems with using the Chimera overset grid scheme in the region of intersecting geometry components is presented. A 'collar grid' resolves the intersection region and provides communication between the component grids. This approach is validated by comparing computed and experimental data for a flow about a wing/body configuration. Application of the collar grid scheme to the Orbiter fuselage and vertical tail intersection in a computation of the full Space Shuttle launch vehicle demonstrates its usefulness for simulation of flow about complex aerospace vehicles. O.G.

A91-40763#

GRID RESTRUCTURING FOR MOVING BOUNDARIES

AVIJIT GOSWAMI and IJAZ H. PARPIA (Texas, University, Arlington) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 696-704. Research supported by Texas Higher Education Coordinating Board. refs

(AIAA PAPER 91-1589) Copyright

A grid restructuring scheme is presented for unstructured grids on domains whose boundaries are in relative motion. The aim is

to provide the user with a valid and superior quality grid at every time step in a time accurate flow calculation. The grid generator provides a Delaunay triangulation of the nodes. The position of the interior nodes are adjusted to the boundary motion and the required local node densities by using successive smoothing operations. This is done using the spring analogy, where the forces acting on a node are in equilibrium. The final step is to delete nodes which get too close to the boundary or where the triangle area gets too small, and insert nodes to refine triangles with large area or bad aspect ratio. Since the restructuring scheme is local in nature, there is a substantial saving in computational time compared to a complete regeneration of the grid at every time step. Results are presented for movement of an airfoil inside a circular domain and the extension of a flap from a wing section.
Author

A91-40765#
UNSTRUCTURED MESHES AND SURFACE FIDELITY FOR COMPLEX SHAPES
TIMOTHY J. BAKER (Princeton University, NJ) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 714-728. IBM Corp.-supported research. refs
(AIAA PAPER 91-1591) Copyright
Unstructured mesh generation based on the Delaunay triangulation can produce good quality meshes around highly complicated shapes. The reconstruction of a solid surface from a series of cross-sections is a necessary prerequisite that still poses a number of difficulties. The relationship is discussed between point distribution and triangle quality for planar triangulations and it is indicated how this provides some guidance on the distribution of points over a curved surface. An approach to the surface reconstruction problem that has proved effective in numerous applications is described.
Author

A91-40766*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
GRID CONVERGENCE FOR ADAPTIVE METHODS
GARY P. WARREN, W. K. ANDERSON, JAMES L. THOMAS, and SHERRIE KRIST (NASA, Langley Research Center, Hampton, VA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 729-741. refs
(AIAA PAPER 91-1592) Copyright
The ability of adaptive methods to obtain accurate results is examined using two different Euler solvers for a near-sonic flow containing several important flow features. It is shown that the accuracy obtained can be greatly affected by the lack of resolution of smooth portions of the flow caused by adapting only to the more prevalent flow features such as discontinuities. In particular, common methods of adaptation can lead to results in which shocks are well resolved but whose locations are highly inaccurate due to the lack of resolution of the smoother regions. An explanation for this behavior is given and a correction is proposed. Author

A91-40767#
ADAPTIVE EAGLE - SOLUTION-ADAPTIVE AND QUALITY-ENHANCING MULTI-BLOCK GRIDS FOR ARBITRARY DOMAINS
PHU V. LUONG, JOE F. THOMPSON, and BOYD GATLIN (Mississippi State University, Mississippi State) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 742-755. refs
(AIAA PAPER 91-1593) Copyright
A straightforward and effective procedure for the conversion of any CFD flow code that operates on a block-structured grid (or single-block grid) into a dynamically adaptive code is presented. The development and application of several grid quality measures for use in the static adaptive grid generation is discussed, and a means of analysis and control of grid quality through static and dynamic adaptive grid generation is given. Results of static adaption to quality measures by the EAGLE grid code shows improvement in some of the grid properties. Results of dynamic adaption by adaptive EAGLE installed in the INS3D incompressible flow code of NASA Ames, and the Whitfield Euler code of MSU, show significant improvement in quality of aerodynamics simulation.
Author

A91-40768*# Sterling Software, Palo Alto, CA.
APPLICATION OF A SOLUTION ADAPTIVE GRID SCHEME, SAGE, TO COMPLEX THREE-DIMENSIONAL FLOWS
CAROL B. DAVIES (Sterling Software, Inc., Palo Alto, CA) and ETHIRAJ VENKATAPATHY (Eloret Institute, Sunnyvale, CA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 756-779. refs
(Contract NCC2-420)
(AIAA PAPER 91-1594) Copyright
A new three-dimensional (3D) adaptive grid code based on the algebraic, solution-adaptive scheme of Nakahashi and Deiwert is developed and applied to a variety of problems. The new computer code, SAGE, is an extension of the same-named two-dimensional (2D) solution-adaptive program that has already proven to be a powerful tool in computational fluid dynamics applications. The new code has been applied to a range of complex three-dimensional, supersonic and hypersonic flows. Examples discussed are a tandem-slot fuel injector, the hypersonic forebody of the Aeroassist Flight Experiment (AFE), the 3D base flow behind the AFE, the supersonic flow around a 3D swept ramp and a generic, hypersonic, 3D nozzle-plume flow. The associated adapted grids and the solution enhancements resulting from the grid adaption are presented for these cases. Three-dimensional adaption is more complex than its 2D counterpart, and the complexities unique to the 3D problems are discussed. Author

A91-40769#
A THREE-DIMENSIONAL NAVIER-STOKES/FULL-POTENTIAL COUPLED ANALYSIS FOR VISCOUS TRANSONIC FLOW
L. N. SANKAR, FU-LIN TSUNG (Georgia Institute of Technology, Atlanta), and BALA K. BHARADVAJ (Douglas Aircraft Co., Long Beach, CA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 780-787. Research supported by U.S. Army and McDonnell Douglas Corp. refs
(AIAA PAPER 91-1595) Copyright
A novel technique for the prediction of three-dimensional steady and unsteady viscous flows past arbitrary configurations is described. Details of the coupling procedure are described, along with numerical validation of the coupled formulation. Computational results are presented for an airplane wing as well as for a helicopter rotor in hover; these are compared with experimental data, and other CFD data. It is demonstrated that the present coupled analysis requires only about 50 percent of the CPU time required by a standard Navier-Stokes analysis while generating equally accurate data.
Author

A91-40770#
COMPUTATION OF UNSTEADY VISCOUS FLOW USING AN EFFICIENT ALGORITHM
B. LAKSHMINARAYANA (Pennsylvania State University, University Park) and Y. H. HO IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 788-799. refs
(Contract N00014-90-J-1182)
(AIAA PAPER 91-1597) Copyright
The objective of this research is to develop efficient, accurate numerical analysis for the prediction of unsteady turbulent flows using a Navier-Stokes solver. The technique developed is for incompressible flow and is an extension of the pressure based method. The finite volume approach and a nonstagger grid formulation is used in this analysis. A predictor-corrector type

algorithm is applied to the governing equations to ensure the time accuracy. The low Reynolds form of two-equation turbulence model is used to simulate the turbulent flow. The scheme proved to be both accurate and efficient. The code is first calibrated against the existing analytical solution of an oscillating flat plate. In order to test the two-equation model, a steady state flow calculation is made and compared with the available experimental data for a turbine stator. Good agreement is obtained between the prediction and the experimental results. The prediction of unsteady viscous flow for a flat plate cascade subjected to a transverse gust is presented. The aerodynamic parameters agree well with the analytical solution. The viscous effects are discussed in terms of time dependent momentum thickness variation. Finally, unsteady flow through a practical compressor cascade subjected to gust is predicted and compared with the experimental data. The unsteady blade pressure distribution and the time dependent wakes are captured well. Author

A91-40771#
ON THE VALIDITY OF LINEARIZED UNSTEADY EULER EQUATIONS WITH SHOCK CAPTURING
DANA R. LINDQUIST and MICHAEL B. GILES (MIT, Cambridge, MA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 800-813. refs
(AIAA PAPER 91-1598) Copyright
An alternative shock capturing approach based on the linearization of the standard, unsteady, nonlinear shock-capturing Euler methods is presented. This approach can be applied to a much larger class of flow fields than linearized potential and linearized Euler methods. The validity of the approach is proved analytically and computationally for a quasi-one-dimensional duct case. O.G.

A91-40775#
QUASI-3-D NON-REFLECTING BOUNDARY CONDITIONS FOR EULER EQUATIONS CALCULATIONS
ANDRE P. SAXER and MICHAEL B. GILES (MIT, Cambridge, MA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 845-857. Rolls-Royce, PLC-supported research. refs
(AIAA PAPER 91-1603) Copyright
This paper presents a theory for the construction of steady-state quasi-three-dimensional non-reflecting boundary conditions for the Euler equations. These allow calculations to be performed on truncated domains without the generation of spurious non-physical reflections at the far-field boundaries. The theory is based upon Fourier analysis and eigenvectors applied to the linearized Euler equations. It is presented within the context of transonic axial flow turbomachinery computations. The effectiveness of the new boundary conditions is demonstrated by comparing results obtained using this new formulation and calculations performed with the standard one-dimensional approach. Author

A91-40776#
ACCELERATED CONVERGENCE TO STEADY STATE BY GRADUAL FAR-FIELD DAMPING
SMADAR KARNI (Michigan, University, Ann Arbor) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 858-868. refs
(AIAA PAPER 91-1604) Copyright
Reflections from artificial boundaries inhibit convergence of transient solutions to their steady limit. Far-field damping operators to suppress such reflections are presented for general first order hyperbolic systems, and particular reference is made to the compressible Euler equations. The damping operator has the following properties: (1) no reflections are generated due to the introduction of the damping terms and (2) different wave systems may be damped at different rates. Feature (1) enables the attenuation of waves over relatively short length scales, while feature (2) enables the damping operator to act selectively on the outgoing waves alone, leaving the incoming waves unharmed. This property is desirable in genuine time-dependent problems where consistent information should be allowed to propagate from the artificial boundaries. Results for compressible Euler flows past aerofoils show the potential of far-field damping in substantially accelerating, particularly in fully subsonic problems. Author

A91-40778#
A NUMERICAL METHOD FOR PREDICTING TRANSITION IN THREE-DIMENSIONAL FLOWS BY SPATIAL AMPLIFICATION THEORY
TUNCER CEBECI and HSUN H. CHEN (California State University, Long Beach) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 878-889. refs
(AIAA PAPER 91-1606) Copyright
An efficient second-order-accurate numerical method, based on Keller's box scheme, is used to solve the Orr-Sommerfeld equation for three-dimensional incompressible flows. Transition is computed with the e exp n-method and with an eigenvalue formulation based on the saddle-point method of Cebeci and Stewartson. The frequencies needed in transition calculations are obtained from zarfs which correspond to three-dimensional neutral stability curves. The calculation method is evaluated in terms of experimental data on a swept wing and a prolate spheroid at an angle of incidence. In general, the results are in good agreement with measured values. Author

A91-40779*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DIRECT NUMERICAL SIMULATION OF TRANSITION AND TURBULENCE IN A SPATIALLY EVOLVING BOUNDARY LAYER
MAN M. RAI (NASA, Ames Research Center, Moffett Field, CA) and PARVIZ MOIN (NASA, Ames Research Center, Moffett Field; Stanford University, CA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 890-914. refs
(AIAA PAPER 91-1607) Copyright
A high-order-accurate finite-difference approach to direct simulations of transition and turbulence in compressible flows is described. Attention is given to the high-free-stream disturbance case in which transition to turbulence occurs close to the leading edge. In effect, computation requirements are reduced. A method for numerically generating free-stream disturbances is presented. K.K.

A91-40792#
PARALLEL BLOCK MULTIGRID SOLUTION OF THE COMPRESSIBLE NAVIER-STOKES EQUATIONS
YORAM YADLIN, DAVID CAUGHEY (Cornell University, Ithaca, NY), and THOMAS L. TYSINGER IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 965, 966. NSF-supported research. refs
Copyright
The development of an efficient parallel algorithm for the simulation of compressible viscous flow over complex geometries is described. The present algorithm is modeled on the algorithm used for the solution of Euler equations as well as on the extension of that algorithm for the implicit solution of Navier-Stokes equations. The efficiency of the present algorithm is obtained via an implicit formulation suitable for highly stretched grids, a diagonalization procedure that reduces the operation count significantly, and a multigrid algorithm for rapid convergence acceleration. K.K.

A91-40795#
HIGH RESOLUTION NONOSCILLATORY SCHEMES FOR UNSTEADY GAS DYNAMICS

J. Y. YANG and C. A. HSU (National Taiwan University, Taipei, Republic of China) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 971, 972. Sponsorship: National Science Council of the Republic of China. refs
(Contract NSC-78-0210-D002-11)
Copyright

High-resolution explicit finite-difference nonscillatory shock-capturing schemes based on Harten's essentially nonscillatory schemes using reconstruction via primitive function approach are described for simulating unsteady compressible flows. For two-dimensional problems, Strang-type dimensional splitting is adopted. Numerical simulations of unsteady shock diffraction by an elliptic cylinder and shock wave propagating through a convergent-divergent nozzle are included to illustrate the performance of the schemes. Author

A91-40796#
A NOVEL IMPLEMENTATION OF AN IMPLICIT K-EPSILON TURBULENCE MODEL COUPLED WITH AN EXPLICIT NAVIER-STOKES SOLVER
MARK G. TURNER and IAN K. JENNIONS (GE Aircraft Engines, Cincinnati, OH) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 973, 974. refs
Copyright

A method which couples an implicit k-epsilon turbulence model with an explicit Runge-Kutta Navier-Stokes solver is presented. A solution of this method is presented for a transonic fan rotor. This solution shows good agreement with data and better results than predicted with the Baldwin-Lomax algebraic turbulence model. K.K.

A91-40797#
PRESSURE-BASED FLUX VECTOR SPLITTING FOR BLUNT GEOMETRIES
P. K. KHOSLA and S. G. RUBIN (Cincinnati, University, OH) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 975, 976.
(Contract AF-AFOSR-90-0096)
Copyright

A technique for the computation of incompressible flow past a circular cylinder and a blunt-nosed cylinder is presented. Both inviscid and viscous flows are computed. It is shown that the stagnation line behavior can be obtained as part of the overall solution if a direct solver is utilized for the stagnation region computations. K.K.

A91-40799*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A NUMERICAL INVESTIGATION OF TURBULENT BASEFLOW
DENNY S. CHAUSSEE (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 979, 980.
Copyright

The turbulent base flow of a cone with a sting in hypersonic flow is investigated using a time-dependent Navier-Stokes code called UWIN. A PNS solver provides the upstream flow conditions which drive the development of the base flow. The computational method is described along with its application to the base flow problem. The grid generation and boundary conditions are described. The results and the summary conclude this note. Author

A91-40802#
THREE-DIMENSIONAL NAVIER-STOKES CALCULATIONS USING SOLUTION-ADAPTIVE GRIDS
J. M. LOELLBACH, W. C. HUANG, and K. D. LEE (Illinois, University, Urbana) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 985, 986.
Copyright

A solution-adaptive grid technique for Navier-Stokes solutions in three dimensions is presented. The method involves the use of a grid redistribution scheme for structured grids. The method is presented using two different flow problems. The first is a supersonic symmetric corner flow with dual wedge angles of 9.5 deg, while the second is a leading-edge vortex flow over a zero-thickness delta wing at a high angle of attack. K.K.

A91-41148*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL ROTORCRAFT FLOWFIELD RESEARCH AT THE U.S. ARMY AEROSTRUCTURES DIRECTORATE
JOHN D. BERRY and SUSAN L. ALTHOFF (NASA, Langley Research Center; U.S. Army, Aviation Systems Command, Hampton, VA) ARO Workshop on Rotorcraft Interactional Aerodynamics, 2nd, Atlanta, GA, Mar. 26, 27, 1990, Paper. 7 p.

Rotorcraft aerodynamic interaction investigations conducted experimentally and computationally by the U.S. Army at the NASA Langley subsonic tunnel are described. Consideration is given to fuselage velocity computation, an interactional aerodynamics method, a rotor/wake/fuselage method, predicted wake geometry, views of tip vortex trajectory, and an inflow velocity study. Calculations were found to predict the periodic geometry of a rotor wake. Details of its interactions with the fuselage surface are not well modeled with inviscid panel methods. For the cases investigated in the present study, the overall effects of the fuselage are relatively small. However, increasing the size of the fuselage or decreasing the fuselage-rotor space will amplify these effects. P.D.

A91-41157
GASDYNAMIC INTERACTION OF FLOW WITH AN OSCILLATING SHELL [GAZODINAMICHESKOE VZAIMODEISTVIE POTOKA S KOLEBLIUSHCHEISIA OBOLOCHKOI]
A. A. SERGIENKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1991, p. 15-19. In Russian.
Copyright

The energy and strength interaction between a homogeneous flow and an oscillating corrugated shell is investigated analytically. Flow regimes are determined in the cases where the flow of mechanical energy is directed from the shell to the gas or from the gas to the shell. The frequency characteristics of panel flutter are determined for the case where the mechanical energy required to maintain shell oscillations is supplied by the flow. V.L.

A91-41218
THE LEVEL OF SELF-OSCILLATIONS OF AERODYNAMIC CONTROL SURFACES UNDER NONSEPARATING TRANSONIC GAS FLOW [UROVEN' AVTOKOLEBANII AERODINAMICHESKIKH POVERKHNOSTEI UPRAVLENIIA PRI BEZOTRYVNOM OBTEKANII OKOLOZVUKOVYM POTOKOM GAZA]
A. V. SAFRONOV (Kievskoe Vysshee Voenno-Aviatsionnoe Inzhenernoe Uchilishche, Kiev, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), April 1991, p. 51-55. In Russian. refs
Copyright

This paper examines the feasibility of determining the amplitude of the limiting cycle of self-oscillations of aerodynamic-control surfaces under nonseparating transonic gas flow in the presence of shock waves. It is shown that the level of self-oscillations depends on both the transonic-flow parameters and the characteristics of the aerodynamic control surface. An analytical relationship is developed for estimating the level of self-oscillations of the aerodynamic-control surfaces, which takes into account all the factors affecting the formation and the evolution of self-oscillations. I.S.

A91-41320
DETERMINATION OF THE STRESS-STRAIN STATE OF A SOFT LIFTING SYSTEM [K OPREDELENIIU NAPRIAZHENNO-DEFORMIROVANNOGO SOSTOIANIIA MIAGKOI NESUSHCHEI SISTEMY]
I. V. DNEPROV, A. T. PONOMAREV, A. V. RADCHENKO, and O. V. RYSEV Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela (ISSN 0572-3299), Mar.-Apr. 1991, p. 140-148. In Russian. refs
Copyright
The aeroelastic characteristics and the stress-strain state of soft lifting surfaces of the single-shell parachute airfoil type are investigated analytically in the case of steady subsonic flow. A mathematical model of the static aeroelasticity of the parachute is developed on the basis of the synthesis of data produced by combined integration of equations of nonlinear aerodynamics and geometrically and physically nonlinear relations of the soft shell theory. Three-dimensional flow is treated in the context of a nonideal incompressible fluid model and the discrete vortex method; the initial equilibrium shape of the parachute for a given load is determined from a one-dimensional model. A specific example is presented. V.L.

A91-41462
AN INVESTIGATION OF A HOVERING ROTOR IN GROUND EFFECT
A. GRABER, A. ROSEN, and A. SEGINER (Technion - Israel Institute of Technology, Haifa) Aeronautical Journal (ISSN 0001-9240), vol. 95, May 1991, p. 161-169. refs
Copyright
A free-wake aerodynamic model of a rotor hovering ground effect is presented, and the numerical characteristics of the model are investigated. The ground influence on the required torque was found to be much less than on the thrust coefficient, as it is the result of contradicting effects. The numerical model shows good convergence characteristics within the range investigated of all the variables and parameters that define the numerical model. It is shown that eight cells along the blade and 15 vortex rings in the far wake provide sufficiently accurate results after up to 20 iterations. R.E.P.

A91-41644*# Purdue Univ., West Lafayette, IN.
ACTIVE UNSTEADY AERODYNAMIC SUPPRESSION OF ROTATING STALL IN AN INCOMPRESSIBLE FLOW CENTRIFUGAL COMPRESSOR WITH VANED DIFFUSER
PATRICK B. LAWLESS and SANFORD FLEETER (Purdue University, West Lafayette, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 15 p. NASA-supported research. refs
(AIAA PAPER 91-1898) Copyright
A mathematical model is developed to analyze the suppression of rotating stall in an incompressible flow centrifugal compressor with a vaned diffuser, thereby addressing the important need for centrifugal compressor rotating stall and surge control. In this model, the precursor to to instability is a weak rotating potential velocity perturbation in the inlet flow field that eventually develops into a finite disturbance. To suppress the growth of this potential disturbance, a rotating control vortical velocity disturbance is introduced into the impeller inlet flow. The effectiveness of this control is analyzed by matching the perturbation pressure in the compressor inlet and exit flow fields with a model for the unsteady behavior of the compressor. To demonstrate instability control, this model is then used to predict the control effectiveness for centrifugal compressor geometries based on a low speed research centrifugal compressor. These results indicate that reductions of 10 to 15 percent in the mean inlet flow coefficient at instability are possible with control waveforms of half the magnitude of the total disturbance at the inlet. Author

A91-41645*# Purdue Univ., West Lafayette, IN.
FLUTTER CONTROL OF INCOMPRESSIBLE FLOW TURBOMACHINE BLADE ROWS BY SPLITTER BLADES
HSIAO-WEI D. CHIANG and SANFORD FLEETER (Purdue University, West Lafayette, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. NASA-sponsored research. refs
(AIAA PAPER 91-1900) Copyright
Splitter blades as a passive flutter control technique is investigated by developing a mathematical model to predict the stability of an aerodynamically loaded splittered-rotor operating in an incompressible flow field. The splitter blades, positioned circumferentially in the flow passage between two principal blades, introduce aerodynamic and/or combined aerodynamic-structural detuning into the rotor. The two-dimensional oscillating cascade unsteady aerodynamics, including steady loading effects, are determined by developing a complete first-order unsteady aerodynamic analysis together with an unsteady aerodynamic influence coefficient technique. The torsion mode flutter of both uniformly spaced tuned rotors and detuned rotors are predicted by incorporating the unsteady aerodyamic influence coefficients into a single-degree-of-freedom aeroelastic model. This model is then utilized to demonstrate that incorporating splitters into unstable rotor configurations results in stable splittered-rotor configurations. Author

A91-41673#
INLET TURBULENCE DISTORTION AND VISCOUS FLOW DEVELOPMENT IN A CONTROLLED-DIFFUSION COMPRESSOR CASCADE AT VERY HIGH INCIDENCE
G. V. HOBSON and R. P. SHREEVE (U.S. Naval Postgraduate School, Monterey, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. U.S. Navy-supported research. refs
(AIAA PAPER 91-2004) Copyright
Detailed two-component laser Doppler velocimeter (LDV) measurements of the flow through a controlled-diffusion (CD) compressor cascade at a Reynolds number of about 700,000 and at a low Mach number are reported in this paper. A very high incidence angle (8 degrees above design) was considered throughout this investigation, which included the full experimental characterization of the turbulence field. The LDV measurements were fully automated and were all taken in co-incidence mode, thus turbulent flow correlations could be determined. Of most significance was the measurement of the distortion of the inlet freestream turbulence upstream of the blade leading edges. Such information is important in assessing viscous codes which incorporate transport equations to describe the turbulence within the flowfield. The laminar leading edge separation bubble, which reattached turbulent, was enlarged on the suction surface of the blade. Consistent with measurements at lower incidence angles, the suction surface boundary layer remained attached over the rear part of the blade. The pressure side boundary layer initially showed little or no growth, however, it finally developed into a profile similar to a wall jet. The wake profiles showed significant asymmetry due to the high loading on the blades at the increased incidence angle. Author

A91-41704#
THE EFFECT OF SQUARE TRAILING EDGES ON TURBINE BLADE PERFORMANCE
J. C. COLLIE, H. L. MOSES, and T. KISS (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. Research supported by General Electric Co. refs
(AIAA PAPER 91-2130) Copyright
An experimental investigation was conducted on the aerodynamic performance of transonic gas turbine blades with blunt and round trailing edges. All work was performed at the recently-developed transonic cascade facility of Virginia Polytechnic Institute & State University. This paper provides a brief description of the equipment and testing procedures used, a summary of the various test parameters, a description of data reduction techniques, figures containing collected data, and a discussion of the results. Tests were conducted on both the blunt and round trailing edged blades at blade row exit Mach numbers from 0.7 to 1.35. Total

and static pressure measurements were taken at two locations downstream of the cascade. Performance of the two trailing edge geometries was compared using a total pressure loss coefficient and also with shadowgraph photos. Results of the testing indicate that overall performance of the two trailing edge geometries was similar, with slightly greater losses for the blunt blades varying as a function of exit Mach number. Author

A91-41713*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

USE OF THE PARC CODE FOR GENERIC NASP NOZZLES OPERATING AT OFF-DESIGN TRANSONIC CONDITIONS

STEVEN F. YAROS (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 7 p. refs
(AIAA PAPER 91-2154) Copyright

A three-dimensional Navier-Stokes solver, PARC3D, has been investigated for applications to the wind tunnel testing of high-speed nozzle configurations, particularly with extended expansion ramps, operating at transonic off-design conditions. Numerous cases have been run and compared with existing wind tunnel data. The code has been shown to be an efficient and robust tool in the analysis of complex nozzle configurations whose flows are substantially determined by three-dimensional effects. Although the method requires that a grid, generated independently of the code, be supplied to it, the robust nature of the code does not require that this grid be excessively detailed, nor does it seem to require that the grid be fine-tuned for individual cases. The directness and flexibility of the boundary condition specifications allow a variety of configurations and flow conditions to be handled very efficiently. Author

A91-41734#

MEASURED THRUST LOSSES ASSOCIATED WITH SECONDARY AIR INJECTION THROUGH NOZZLE WALLS

DAVID AZEVEDO (Pratt and Whitney Group, West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 16 p. refs
(AIAA PAPER 91-2244) Copyright

An experimental program has attempted to ascertain the aerodynamic effects of auxilliary air injection on the thrust of a scaled, two-dimensional converging/diverging nozzle, in order to (1) validate analytical and CFD models developed for the thrust loss associated with such cooling air injection and (2) establish a data base for nozzle-performance sensitivities to various secondary air-injection parameters. Divergent-section pressure distributions obtained in the presence of injection across the flaps indicate that the injected flow constricts the primary flow, thereby reducing the effective expansion ratio; also noted is a dependence of performance on the angle at which the secondary air is injected. A simple one-dimensional formulation, corrected for certain two-dimensional effects, reasonably predicted thrust coefficient changes due to injection. O.C.

A91-41735*# Lockheed Engineering and Sciences Co., Hampton, VA.

PERIODIC BLADE LOADS OF A HIGH SPEED PROPELLER AT SMALL ANGLE OF ATTACK

M. A. TAKALLU (Lockheed Engineering and Sciences Co., Hampton, VA) and V. R. LESSARD (Vigyan Research Associates, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 13 p. refs
(Contract NAS1-19000; NAS1-18585)
(AIAA PAPER 91-2250) Copyright

A code has been developed to predict the periodic aerodynamic loads of an advanced turboprop propeller. The analytical formulation accounts for flow three-dimensionality and flow periodicity due to the propeller inclination. The flow past the blade sections is computed using a thin layer Navier-Stokes solver. An iterative procedure is used to account for the induced axial and rotational velocities. The viscous periodic results are obtained for an eight-bladed Hamilton Standard SR-7L advanced propeller at a cruise Mach number of 0.813 and 35,000 ft. altitude. The results are shown for flow field quantities and performance parameters during the blade passage in the plane of rotation illustrating the periodic nature of blade flow separation and shocks. The time averaged coefficients of thrust and power are computed and compared with available flight test data. The results obtained show excellent agreement at cruise conditions for small nacelle angles of attack. Author

A91-41738*# Ohio State Univ., Columbus.

SUPERSONIC JET MIXING ENHANCEMENT BY VORTEX GENERATORS

M. SAMIMY, M. F. REEDER (Ohio State University, Columbus), and K. B. M. Q. ZAMAN (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 13 p. refs
(AIAA PAPER 91-2263) Copyright

Experiments were conducted to explore the effects of vortex generators, in the form of tabs projecting normally into the jet, on the mixing and the far-field noise characteristics of a jet. A converging-diverging nozzle with a design Mach number of 1.36 was used in the experiments. The flow regimes from subsonic to highly underexpanded supersonic conditions were studied. One, two, and four tabs were used and some of the findings of previous investigators were examined and confirmed. The tabs eliminated screech noise from moderately overexpanded cases to highly underexpanded cases. Detailed flow visualizations and measurements showed that two tabs bifurcated the jet at all Mach numbers. While the effect of two tabs was persistent and the jet remained bifurcated, the distortions produced by one and four tabs disappeared by a streamwise distance of approximately 16 jet diameters. Two and four tabs significantly increased the entrainment of ambient air into the jet. Author

A91-41739*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

MIXING STUDIES OF HELIUM IN AIR AT MACH 6

R. H. THOMAS, J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg), E. J. FULLER, and R. B. MAYS AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 16 p. NASA-supported research. refs
(AIAA PAPER 91-2268) Copyright

Concentration and mean flow measurements with nanoshadowgraphs and surface flow visualization have been obtained by a study of mixing phenomena during gas injection into hypersonic flow. At Mach 6, a comparison of the matched-pressure injection case with the underexpanded case indicated a greater injectant core penetration rate and a greater concentration-decay rate, leading to a shorter distance for the injectant core to reach an H2-air stoichiometric ratio. The entire injectant plume remained supersonic, and only moderate pressure losses were found. While injector yaw did not increase the mixing rates, it led to an increase in overall injectant plume cross-section, with consequent increase in the size of the mixing region. O.C.

A91-41740#

AERODYNAMIC FREE-JET NOZZLE PERFORMANCE AUGMENTATION USING AN EXHAUST DIFFUSER

R. W. MCAMIS and C. R. BARTLETT (Sverdrup Technology, Inc., Arnold AFB, TN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 6 p. refs
(AIAA PAPER 91-2270)

The Arnold Engineering Development Center has successfully demonstrated significant static pressure recovery for an exhaust diffuser configuration having a free jet 1.4 times the primary jet nozzle diameter. One subsonic and three supersonic aerodynamicnozzles were operated over a range of total pressure and total temperature conditions and were configured with a constant are diffuser to provide static pressure recovery. Maximum diffuser exit pressure to diffuser inlet pressure ratios varied from 1.2 during subsonic operation to 10.7 during supersonic operation. The percent of normal shock recovery was 72, 83, and 87 percent for the Mach 1.6, 2.0, and 3.0 nozzles, respectively. In addition to diffuser performance, aerodynamic nozzle exit lip static pressure measurement confirmed a full flowing nonseparated nozzle. The onset of nozzle separation agreed well with theoretical predictions. Author

A91-41760#

VISCOUS/INVISCID METHOD FOR PRELIMINARY DESIGN OF TRANSONIC CASCADES

HAROLD YOUNGREN and MARK DRELA (MIT, Cambridge, MA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. NSF-supported research. refs

(Contract AF-AFOSR-89-0373)

(AIAA PAPER 91-2364) Copyright

A new computational method, MISES, developed for blade-to-blade design and analysis of axial stators and rotors with optional splitter vanes is presented. The method extends the ISES airfoil code, a two-dimensional viscous/inviscid method, and includes quasi-three-dimensional effects for streamtube thickness, radius, and rotational effects. The steady Euler equations and the integral boundary layer equations are used for modeling the flow. The fully-coupled nonlinear equations are solved simultaneously with a Newton-Raphson technique, making it possible to model flows with strong viscous/inviscid interactions, such as shock-induced separated flows or transitional separation bubbles. Advantages of this methodology for design applications include speed, accuracy, and a natural inverse design capability. O.G.

A91-41762*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PREDICTION OF INTERNAL PERFORMANCE FOR TWO-DIMENSIONAL CONVERGENT-DIVERGENT NOZZLES

JOHN R. CARLSON (NASA, Langley Research Center, Hampton, VA) and KHALED S. ABDOL-HAMID (Analytical Services and Materials, Inc., Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 13 p. refs

(AIAA PAPER 91-2369) Copyright

A three-dimensional code (PAB3D) has been under development to simulate underexpanded and overexpanded supersonic jet exhaust effects on a nonaxisymmetric nozzle/afterbody. The code is a multiblock/multizone technique solving the simplified Navier-Stokes equations. This method was applied to the solution of two nozzle configurations to verify the recent implementation of a nozzle performance calculation package. Static pressure distributions, discharge coefficient and thrust ratio quantities were calculated for on-design and off-design operating conditions for rectangular convergent-divergent nozzles with different throat designs. Approaches involved in computing the flows for these nozzles are presented. Computation of performance parameters were typically within 1 percent of experimental on-design and off-design data. Author

A91-42094#

CONTROL OF VORTEX STRUCTURE ON A DELTA WING BY SMALL AMPLITUDE PERTURBATIONS OF ANGLE-OF-ATTACK

CHENG-HSIUNG KUO (China Steel Corp., Research and Development Dept., Kaohsiung, Republic of China) and DONALD O. ROCKWELL (Lehigh University, Bethlehem, PA) Chinese Society of Mechanical Engineers, Journal (ISSN 0257-9731), vol. 12, Feb. 1991, p. 1-7. USAF-supported research. refs

The vortical flow structure upstream and downstream of vortex breakdown of a generic delta wing subjected to the controlled wind motion is investigated through qualitative flow visualization in conjunction with quantitative velocity measurements. Modifications of mean flow structure above the pitching delta wing are closely related to (1) visualized changes in the instability of the separating shear layer that feeds into large scale, leading-edge vortex at different exciting frequencies; (2) variations of the magnitude and phase distributions of the fluctuating axial and swirl velocity components across vortex core; and (3) alteration of spectral content of the vortex core in the pre-and postbreakdown region. Author

A91-42096#

A BLOCK-STRUCTURED SOLUTION SCHEME WITH THE MULTIGRID METHOD FOR THREE-DIMENSIONAL INVISCID TRANSONIC FLOWS

DUN C. LIU (Chung Shan Institute of Science and Technology, Lung-Tan, Republic of China) Chinese Society of Mechanical Engineers, Journal (ISSN 0257-9731), vol. 12, Feb. 1991, p. 15-25. refs

A block-structured solution scheme with the multigrid method is developed for the solution of the unsteady three-dimensional Euler equations using finite volume discretization in space and the multistage Runge-Kutta time stepping. Different blocks of the multiblock mesh system are patched together to fit a complex configuration. As a result, it simplifies grid generation problems in dealing with a complex geometry. By using local time stepping, total enthalpy damping, and implicit residual smoothing, results are computed for transonic flows past a wing-body configuration to demonstrate the feasibility of the presented block-structured solution scheme. In multigrid calculations, the studies are emphasized on the influence of renewing either all block solutions after a complete multigrid cycle is finished or each block right after its latest solutions are available. Comparing the two, the results show that the later strategy accelerates the convergence. Author

A91-42098#

MULTIGRID SOLUTIONS OF THE THREE-DIMENSIONAL GRID EQUATIONS

DUN C. LIU (Chung Shan Institute of Science and Technology, Lung-Tan, Republic of China) Chinese Society of Mechanical Engineers, Journal (ISSN 0257-9731), vol. 12, Feb. 1991, p. 91-95.

The present study develops an efficient numerical scheme for solving three-dimensional Poisson's equations for the purpose of obtaining body-fitted curvilinear coordinates. The successive line overrelaxation method is employed as a relaxation scheme to accelerate the solution convergence rate. The validity of the proposed approach is demonstrated by generating the mesh system around a three-dimensional wing. In all two- and three-dimensional cases, the proposed multigrid strategy is shown to be considerably more efficient than the corresponding single-grid method. About 40 percent of the work spent on the single-grid method is needed for the multigrid method, and, using the multigrid method, there is no need to find the optimal relaxation factor. P.D.

A91-42248

A STUDY OF AEROACOUSTIC PERFORMANCE OF A CONTRA-ROTATING AXIAL FLOW COMPRESSOR STAGE

P. B. SHARMA, D. S. PUNDHIR, and K. K. CHAUDHRY (Indian Institute of Technology, New Delhi, India) Defence Science Journal (ISSN 0011-748X), vol. 41, April 1991, p. 165-180. Aero Research and Development Board of India-supported research. refs

Copyright

This paper reports the results of an experimental investigation into the aeroacoustic performance of a contrarotating axial flow compressor stage having a hub-tip ratio of 0.66. Aerodynamic superiority of a contrastage is examined from the point of view of higher pressure rise, increased through flow and rotating stall suppression. Measurements of sound pressure level and real-time analysis of the noise signals is reported for different speed combinations for clean and distorted inlet flow for two axial gaps between the contrarotors. The effect of pitch chord ratio and axial gap between the rotors on the aeroacoustic performance is discussed. The study reveals that the axial gap between the rotors significantly affects the aeroacoustic performance of a contrastage. Author

A91-42256*# Old Dominion Univ., Norfolk, VA.
EFFECT OF NOSE BLUNTNESS ON FLOWFIELD OVER SLENDER BODIES IN HYPERSONIC FLOWS
D. J. SINGH, S. N. TIWARI (Old Dominion University, Norfolk, VA), and A. KUMAR (NASA, Langley Research Center, Hampton, VA) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 5, Apr.-June 1991, p. 166-171. Previously cited in issue 09, p. 1276, Accession no. A89-25228. refs
Copyright

A91-42277#
NEW MIXING-LENGTH MODEL FOR TURBULENT HIGH-SPEED FLOWS
M. SITU and J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 29, June 1991, p. 872, 873. Abridged. Previously cited in issue 18, p. 2754, Accession no. A89-42051.
Copyright

A91-42279#
VORTICAL FLOW SOLUTIONS USING A TIME-LAGGED, THIN-LAYER, NAVIER-STOKES ALGORITHM
JON S. MOUNTS (United Technologies Research Center, East Hartford, CT), DAVE M. BELK (USAF, Armament Laboratory, Eglin AFB, FL), and JAMES E. MILTON (Florida, University, Eglin AFB) AIAA Journal (ISSN 0001-1452), vol. 29, June 1991, p. 876, 877. Abridged. Previously cited in issue 21, p. 3253, Accession no. A89-47686. refs

A91-42280#
KERNEL FUNCTION OCCURRING IN SUBSONIC UNSTEADY POTENTIAL FLOW
MAHER N. BISMARCK-NASR (Instituto Tecnologico de Aeronautica, Sao Jose dos Campos, Brazil) AIAA Journal (ISSN 0001-1452), vol. 29, June 1991, p. 878, 879. Abridged. refs
Copyright

This paper deals with the Kernel function of the integral equation relating the pressure to the normal-wash distribution in unsteady potential subsonic flow. Exact solutions of the involved integrals of the Kernel function are given in terms of new functions. Efficient and accurate numerical evaluation of these functions are described. Author

A91-42284*# Old Dominion Univ., Norfolk, VA.
MULTIGRID AND UPWIND VISCOUS FLOW SOLVER ON THREE-DIMENSIONAL OVERLAPPED AND EMBEDDED GRIDS
OKTAY BAYSAL, KAMRAN FOULADI, and VICTOR R. LESSARD (Old Dominion University, Norfolk, VA) AIAA Journal (ISSN 0001-1452), vol. 29, June 1991, p. 903-910. Previously cited in issue 09, p. 1281, Accession no. A89-25379. refs
(Contract NAG1-664)
Copyright

A91-42298#
NAVIER-STOKES SOLUTION OF COMPLETE TURBULENT FLOW PAST FINITE AXISYMMETRIC BODIES
SEOK KI CHOI and CHING JEN CHEN (Iowa, University, Iowa City) AIAA Journal (ISSN 0001-1452), vol. 29, June 1991, p. 998-1001. refs
(Contract N00167-86-K-0019)
Copyright

In most previous studies of Navier-Stokes equations, solutions at the trailing portions of a finite axisymmetric body are dependent on the flow conditions specified at the middle of the body. With a view to avoiding this deficiency in half-body calculations, and obtain the solution of the entire flowfield, the present calculation for the Reynolds-averaged Navier-Stokes equations (as well as of the k-epsilon model in a nonorthogonal body-fitted coordinate system) begins far upstream of the body, with flow conditions furnished by uniform flow equations. Overall agreement with measurements is obtained. O.C.

A91-42307*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMMENT ON 'CRITIQUE OF TURBULENCE MODELS FOR SHOCK-INDUCED FLOW SEPARATION'
CHING-MAO HUNG (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 29, June 1991, p. 1021-1023; Author's Reply, p. 1023, 1024. refs
Copyright

A91-42330
PARETO-OPTIMAL SHAPES OF AXISYMMETRIC BODIES MOVING AT HIGH SUPERSONIC VELOCITIES [PARETO-OPTIMAL'NYE FORMY OSESIMMETRICHNYKH TEL PRI DVIZHENII S BOL'SHIMI SVERKHZVUKOVYMI SKOROSTIAMI]
O. A. GIL'MAN and N. N. PILIUGIN Prikladnaia Matematika i Mekhanika (ISSN 0032-8235), vol. 55, Mar.-Apr. 1991, p. 290-297. In Russian. refs
Copyright

The paper deals with the problem of optimizing the shape of an axisymmetric body based on three criteria: wave resistance and radiant and convective heating during motion in the atmosphere at high supersonic velocities. The optimal solution of the multicriterial problem is determined on the basis of Pareto's optimality. A system of integrodifferential equations for determining the optimal solution is obtained, and a numerical solution algorithm is proposed. V.L.

A91-42534#
LOW-DIMENSIONAL DESCRIPTION OF THE DYNAMICS IN SEPARATED FLOW PAST THICK AIRFOILS
ANIL E. DEANE and CATHERINE MAVRIPLIS (Princeton University, NJ) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 9 p. refs
(Contract N00014-90-J-1315; AF-AFOSR-90-0261; NSF DMS-89-06292; NSF CTS-89-57213)
(AIAA PAPER 91-1622) Copyright

Results are presented for the numerical simulation of unsteady viscous incompressible flow past thick airfoils. Specifically, flow past a NACA 4424 at an angle of attack of 2.5 deg and Reynolds numbers in the range of 1700 to 4000 has been simulated using the spectral element method. At these conditions the flow is separated and an unsteady wake is formed. Application of the method of empirical eigenfunctions reveals the structure of the most energetic components of the flow. These are found to occur in pairs that, through phase exchange, are responsible for the vortex shedding. A set of ordinary differential equations is obtained for the amplitudes of these eigenfunctions by a Galerkin projection of the Navier-Stokes equations. The solutions of the model system are compared with the full simulation. The work is of relevance to the transition process and observed routes to chaos in airfoil wakes. Author

A91-42535#
NAVIER-STOKES SOLUTION FOR HIGH-LIFT MULTIELEMENT AIRFOIL SYSTEM WITH FLAP SEPARATION
REUBEN R. CHOW and KING-WAI CHU (Grumman Corporate Research Center, Bethpage, NY) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 14 p. refs
(AIAA PAPER 91-1623) Copyright

The Navier-Stokes solution is presented for the flow about a two-dimensional high-lift multielement airfoil system in which flap separation is the dominating feature. An elliptic mesh solver is used to generate the stacked structured C-mesh system for computing the flow field. The solution is calculated using the PARC2D code modified specifically in the present work to treat the multielement surface boundary conditions. A semi-adaptive procedure using the trailing-edge streamlines and the separation streamline is proposed in order to correctly predict the flap separation pressure level. The computed surface pressure results are compared with experimental data and also with the results from using the unstructured triangular mesh scheme. The deficiency of the present approach on predicting the maximum lift as well as future improvement of the analysis is also discussed. Author

A91-42536*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

COMPARISON OF CRYOGENIC WIND TUNNEL, FLIGHT, AND COMPUTATIONAL RESULTS FOR A THIN, LOW-ASPECT-RATIO WING

PIERCE L. LAWING, JULIO CHU (NASA, Langley Research Center, Hampton, VA), WILLIAM E. MILHOLEN, II, and NDAONA CHOKANI (North Carolina State University, Raleigh) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs

(AIAA PAPER 91-1626) Copyright

A research program was conducted at NASA Langley Research Center to build and test a thin, pressure instrumented wing. The wing chosen was the canard of the X-29, which has a maximum thickness of 5 percent of chord. The wing has 90 pressure taps and was built utilizing an advanced laminated metal technique. It was tested in the 0.3-Meter Transonic Cryogenic Tunnel at transonic Mach numbers and over a wide range of Reynolds number. The data are compared with flight data and Navier-Stokes computational results. Author

A91-42537#

STATIC AND DYNAMIC WATER TUNNEL FLOW VISUALIZATION STUDIES OF A CANARD-CONFIGURED X-31A-LIKE FIGHTER AIRCRAFT MODEL

SHESHAGIRI K. HEBBAR, MAX F. PLATZER (U.S. Naval Postgraduate School, Monterey, CA), and HUI M. KWON (Korean Air Force, Seoul, Republic of Korea) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. U.S. Navy-supported research. refs

(AIAA PAPER 91-1629)

A low-speed flow-visualization investigation was performed to study the vortex development and bursting phenomena on a 2.3 percent scale model of an X-31A-like fighter aircraft using dye injection in a water tunnel. It is found that the presence of a canard delays the wing vortex breakdown. It is also found that a close-coupled high-canard configuration results in more favorable aerodynamic interference between the vortex systems of the canard and the wing upper surface. K.K.

A91-42538*# Rockwell International Corp., Los Angeles, CA.

NUMERICAL STUDY OF THE X-31 HIGH ANGLE-OF-ATTACK FLOW CHARACTERISTICS

DAVID T. YEH, MICHAEL W. GEORGE, WILLARD C. CLEVER, CLEMENT K. TAM, and CHUNG-JIN WOAN (Rockwell International Corp., Los Angeles, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. Research supported by Rockwell International Corp. and NASA. refs

(AIAA PAPER 91-1630) Copyright

The application of CFD methods to high-angle-of-attack flight regimes is studied. The X-31 configuration was chosen as the model due to its inherent designed high-angle-of-attack characteristics and capabilities, the existence of a wind tunnel database, and the ongoing flight test program. The flow characteristics of the X-31 at high angle-of-attack are presented and the CFD capability for studying the effects of canard deflection on aerodynamic control during poststall is revealed. K.K.

A91-42539#

COMPRESSIBLE BOUNDARY LAYER STABILITY ANALYZED WITH THE PSE EQUATIONS

F. P. BERTOLOTTI (Princeton University, NJ) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 14 p. DARPA-supported research. refs

(Contract N00014-86-K-0759; AF-AFOSR-90-0124)

(AIAA PAPER 91-1637) Copyright

The parabolized stability equations (PSE) for compressible flows are derived and solved to analyze the stability of a supersonic flat plate boundary layer to small amplitude disturbances at Mach numbers ranging from 0.5 to 4.5. The PSE are free from the commonly invoked parallel-flow approximation, and consequently, yield growth rates that are in better agreement with experimental data. Owing to their parabolic character, the PSE are efficiently solved using an implicit marching procedure. This, and other advantages are discussed. A method for generating the initial conditions is also presented. Author

A91-42542*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

GOERTLER INSTABILITY AND HYPERSONIC QUIET NOZZLE DESIGN

FANG-JENQ CHEN, STEPHEN P. WILKINSON (NASA, Langley Research Center, Hampton, VA), and IVAN E. BECKWITH (NASA, Langley Research Center; George Washington University, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. refs

(AIAA PAPER 91-1648) Copyright

A concept for nozzle design which incorporates slow expansion rates and a radial flow region is developed for use on a hypersonic (Mach 6) nozzle. It is shown that the boundary-layer suction slot upstream of the nozzle throat is necessary to remove upstream turbulent boundary layers and to initialize a new laminar boundary layer on the downstream nozzle wall. In effect, the laminar boundary-layer flow can be extended more effectively farther downstream by a slow expansion contour based on the present design concept than by a rapid expansion contour used in previous pilot quiet nozzles. K.K.

A91-42544#

SECOND-ORDER GODUNOV METHODS AND SELF-SIMILAR STEADY SUPERSONIC THREE-DIMENSIONAL FLOWFIELDS

JACOB KRISPIN (Enig Associates, Inc., Silver Spring, MD) and HARLAND M. GLAZ (Maryland, University, College Park) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 15 p. refs

(Contract NSF ISI-89-60133; NSF DMS-87-03971)

(AIAA PAPER 91-1653)

Second-order Godunov schemes for the calculation of steady supersonic three-dimensional flowfields, using operator splitting relative to a fixed marching direction, have been implemented for Cartesian geometries. A limited parametric study of self-similar, oblique shock wave reflections off a wedge was conducted using this approach. The main result is that all of the well-known types of self-similar reflection, i.e., regular reflection and the three types of Mach reflection, simple, complex (CMR), and double (DMR), can be easily found in the relevant parameter space using standard equations-of-state, and that the reflection patterns are structurally stable with respect to small parameter variations. There is no unequivocal theoretical or experimental verification of the existence of either CMR or DMR for steady supersonic flow, self-similar or otherwise. Several versions of the second-order Godunov methodology and the results of comparison studies are discussed as well. Author

A91-42547#

CFD EVALUATION OF TRANSONIC-SUPERSONIC WAVE FRONT PROPAGATION EFFECTS

WEIHNURNG TIARN and ROBERT CAVALLERI (Applied Technology Associates, Inc., Orlando, FL) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 9 p. refs

(AIAA PAPER 91-1657) Copyright

It is shown that the analysis of the wave front distortion of optical radiation propagated through the atmosphere can be accomplished via computational fluid dynamics. A wedge and a sphere cylinder are considered under different transonic free stream conditions. Numerical data are provided which confirm the degree of distortion for the different bodies under different conditions. K.K.

A91-42550*# San Diego State Univ., CA.
UNSTEADY FLUID DYNAMIC MODEL FOR PROPELLER INDUCED FLOW FIELDS
JOSEPH KATZ (San Diego State University, CA), DALE L. ASHBY (NASA, Ames Research Center, Moffett Field, CA), and STEVEN YON AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 8 p. refs
(Contract NCC2-458)
(AIAA PAPER 91-1664) Copyright

A potential flow based three-dimensional panel method was modified to treat time dependent flow conditions in which the body's geometry may vary with time. The main objective of this effort was the study of a flow field due to a propeller rotating relative to a nonrotating body which is otherwise moving at a constant forward speed. Calculated surface pressure, thrust and torque coefficient data for a four-bladed marine propeller/body compared favorably with previously published experimental results. Author

A91-42553#
LASER VELOCIMETRY MEASUREMENTS OF SUPERSONIC VORTEX FLOWS ON A SIMPLE RAZOR-EDGED DELTA WING
LINDA G. SMITH, MARK S. MAURICE, GEORGE L. SEIBERT, and CHARLES TYLER (USAF, Wright Laboratory, Wright-Patterson AFB, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-1684)

As part of an ongoing and developing project for computational fluid dynamic code verification and validation, off-body flow visualizations and fluid velocity measurements are conducted in a supersonic vortex flow. Three-dimensional laser velocimetry measurements are made in the leeward flowfield over a simple razor-edged delta wing with 75-deg sweep angle. Tests are conducted at Mach 1.9 and Reynolds number of 2.4 x 10 to the 6th based on model root chord. The measurements made define the location of the vortex core and provide the flowfield velocities surrounding the vortex. The difficulties inherent with seeding high velocity vortex flows are discussed. Based on test results, improved flow seeding techniques for vortex core definition are being developed. Author

A91-42554#
LDV MEASUREMENTS IN THE ROLL-UP REGION OF THE TIP VORTEX FROM A RECTANGULAR WING
B. R. RAMAPRIAN (Washington State University, Pullman) and YOUXIN ZHENG AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 9 p. refs
(Contract DAAL03-87-G-0011; DAAL03-91-G-0026; AF-AFOSR-90-0131)
(AIAA PAPER 91-1685) Copyright

The evolving three-dimensional flow field of the tip vortex in the near wake of a rectangular wing was studied in detail using three-component laser Doppler velocimetry. The flow quantities measured were the three components of the instantaneous velocity. These data were used to obtain the distributions of velocity, vorticity, circulation and turbulent intensity across the vortex at several axial locations in the flow. The results obtained form the most extensive data base available so far and can be used in the development of numerical models for the tip vortex in the near wake of the wing. The data are also useful in understanding the process of roll-up of the shear layer into the vortex in the near wake. Author

A91-42558*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPER/HYPERSONIC AERODYNAMIC CHARACTERISTICS FOR A TRANSATMOSPHERIC VEHICLE CONCEPT HAVING A MINIMUM DRAG FOREBODY
W. P. PHILLIPS and CHRISTOPHER I. CRUZ (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 14 p. refs
(AIAA PAPER 91-1694) Copyright

Experimental longitudinal and lateral-directional aerodynamic characteristics were obtained for a generic transatmospheric vehicle concept having a replaceable minimum drag forebody shape. The alternate forebody tested was a 1/4-power series body. Tests were made over a range of Mach numbers from 2 to 10 at a nominal Reynolds number, based on a length of 2.3 x 10 to the 8th and angles of attack from -4 to 20 deg. The minimum drag forebody provided significant improvements in minimum drag and L/D for the configuration as well as a longitudinally stabilizing increment. Although the baseline configuration is longitudinally unstable, the L/D improvements at low to moderate angles of attack would enhance cruise performance. Varying wing incidence angles was demonstrated as an effective horizontal trim device without significant trim drag penalties. Author

A91-42559#
NAVIER-STOKES COMPUTATIONS OF HYPERSONIC FLOW PAST A BLUNT EDGE DELTA WING AT SEVERAL ANGLES OF ATTACK
SHIVAKUMAR SRINIVASAN, PETER ELIASSON, and ARTHUR RIZZI (Aeronautical Research Institute of Sweden, Bromma) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 13 p. refs
(AIAA PAPER 91-1698) Copyright

Numerical simulations for the laminar hypersonic flow past a blunt edged delta wing have been performed by solving the Navier-Stokes equations. The Navier-Stokes equations have been solved using the explicit finite volume four-stage Runge-Kutta scheme. It has been observed that in the case of blunt edged delta wings at high angles of attack, the hypersonic flow is dominated by a shear layer that separates just past the blunt leading edge forming a more distributed vortical region over the wing, rather than a concentrated vortex structure, as observed at lower speeds. The solutions are analyzed and compared with available experimental data. Author

A91-42561*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL AND EXPERIMENTAL AFTBODY FLOW FIELDS FOR HYPERSONIC, AIRBREATHING CONFIGURATIONS WITH SCRAMJET EXHAUST FLOW SIMULATION
LAWRENCE D. HUEBNER (NASA, Langley Research Center, Hampton, VA) and KENNETH E. TATUM (Lockheed Engineering and Sciences Co., Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 16 p. refs
(AIAA PAPER 91-1709) Copyright

Computational results are presented for three issues pertinent to hypersonic, airbreathing vehicles employing scramjet exhaust flow simulation. The first issue consists of a comparison of schlieren photographs obtained on the aftbody of a cruise missile configuration under powered conditions with two-dimensional computational solutions. The second issue presents the powered aftbody effects of modeling the inlet with a fairing to divert the external flow as compared to an operating flow-through inlet on a generic hypersonic vehicle. Finally, a comparison of solutions examining the potential of testing powered configurations in a wind-off, instead of a wind-on, environment, indicate that, depending on the extent of the three-dimensional plume, it may be possible to test aftbody powered hypersonic, airbreathing configurations in a wind-off environment. Author

A91-42562#
EFFECT OF MODEL COOLING ON PERIODIC TRANSONIC FLOW
S. RAGHUNATHAN, F. ZARIFI-RAD (Belfast, Queen's University, Northern Ireland), and D. G. MABEY (Royal Aerospace Establishment, Bedford, England) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26,

1991. 10 p. refs
(AIAA PAPER 91-1714) Copyright

The effect of variation in the temperature ratio T(w)/T(ad), where T(w) is the wall temperature and T(ad) is adiabatic recovery temperature in K) on transonic periodic flows on biconvex airfoils was investigated in experiments conducted in an intermittent transonic wind tunnel with a running time of 15 sec at atmospheric pressure. The models were 14- and 18-percent-thick biconvex airfoils of various chord lengths, made of two aluminum halves with fourteen static orifices (made of stainless steel tubes) on the upper surface, five orifices at 5.00 mm intervals, and nine at 2.5 mm interfals. Results show that periodic flows at transonic speeds can be modified strongly by cooling. The effects observed as the model is cooled are considered to illustrate the phenomena occurring in adiabatic flows at greatly increased Reynolds numbers. I.S.

A91-42564#
DRAG AND LIFT IN NONADIABATIC TRANSONIC FLOW
GUENTER H. SCHNERR and ULRICH DOHRMANN (Karlsruhe, Universitaet, Federal Republic of Germany) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. Research supported by Klein, Schanzlin & Becker Stiftung. refs
(Contract DFG-ZI-18/31)
(AIAA PAPER 91-1716) Copyright

Lifting and nonlifting transonic flows around single airfoils have been calculated including heat addition from partial phase change of the fluid itself. For demonstration of the limits of possible effects in nonadiabatic aerodynamics, two different processes are investigated: nonequilibrium heat addition after homogeneous nucleation and equilibrium condensation. The numerical calculation is based on the Euler equation, linked with either the classical nucleation theory and microscopic or macroscopic droplet growth laws, or an equilibrium condensation process. An improved explicit, time dependent, diabatic finite volume method is developed to calculate steady flows. For internal flows with homogeneous nucleation the pressure drag may increase or decrease about 60 and 25 percent, respectively. Simultaneously the lift decreases up to 35 percent. Assuming the same process for atmospheric flight simulations, the lift decreases more than 10 percent. Equilibrium condensation increases the lift about 30 percent and raises the pressure drag substantially, more than 200 percent. Author

A91-42567#
SUPERSONIC INLET FLOW COMPUTATIONS USING FORTIFIED NAVIER-STOKES APPROACH
SHINICHI KURODA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) and KOZO FUJII (Institute of Space and Astronautical Science, Sagamihara, Japan) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-1730) Copyright

Two-dimensional flow fields about the basic experimental inlet model of mixed-compression type designed at Mach number 3.0 is numerically simulated using the Fortified Navier-Stokes(FNS) approach. Complete inlet system including the flow-plug which controls the back pressure in the experiment is considered. Computations with adequate back pressure and with excessive one are performed. Comparison with the experimental data is presented in terms of the schlieren photograph and the static pressure. A preliminary computation for the flow field about the inlet model with bleed chamber is also included. Author

A91-42568#
STEADY AND UNSTEADY SOLUTIONS OF THE NAVIER-STOKES EQUATIONS FOR FLOWS ABOUT AIRFOILS AT LOW SPEEDS
PHILIP S. BERAN (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-1733)

Steady and unsteady solutions are obtained of Navier-Stokes equations corresponding to viscous flows about the NACA-0012 airfoil at large angles of attack and at very low (not above 5000) Reynolds numbers. Equilibrium solutions are computed using an efficient numerical technique based on Newton's method and Gaussian elimination, and dynamic solutions are obtained using a semiimplicit first-order-accurate time-integration algorithm. Using these two algorithms, a path of Hopf points in a parameter space defined by Reynolds number and number of attack was approximately calculated. It was found that a loss of stability to unsteady motions occurs across this path in the direction of increasing Reynolds number or increasing angle of attack. I.S.

A91-42571#
ON THREE-DIMENSIONAL FLOW SEPARATION CRITERIA
T. C. TAI and M. WALKER (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 9 p. U.S. Navy-supported research. refs
(AIAA PAPER 91-1740) Copyright

The criteria for three-dimensional, vortex-type flow separation are reviewed and conditions for creation of a vortex flow are discussed. An attempt to define the corresponding separation criteria is made. The convergence of surface limiting streamlines is treated as the necessary condition for seperation, while the strength of the underlying viscous-inviscid interaction provides the sufficient condition. Lighthill's idea of volume flow thickness is extended by including the variation of the crossflow metric coefficient in a viscous layer. A new boundary-layer shape factor is then postulated based on the revised volume flow thickness to measure the strength of the viscous-inviscid interaction. The concept is supported by thin-layer Navier-Stokes data over an F-14A aircraft wing and an elliptically-nosed cylinder. Based on the cases considered, it seems a range of the shape factor values may be found to indicate the likelihood of the vortex-type separation in three-dimensions. Author

A91-42572#
APPLICATION OF INDICIAL THEORY TO THE PREDICTION OF UNSTEADY SEPARATION
P. REISENTHEL and D. NIXON (Nielsen Engineering and Research, Inc., Mountain View, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 16 p. refs
(Contract DAAL03-87-C-0008)
(AIAA PAPER 91-1742) Copyright

It is shown, for viscous flow about a two-dimensional cylinder, that several key aspects characterizing the time-dependent behavior of boundary layer separation can be predicted within a moderate degree of accuracy over a large span of frequencies. The semianalytic prediction involved only a convolution integral based on the knowledge of the step response of the flow field to small perturbations. The test functions employed to evaluate the range of applicability of indicial theory to the separation process are the vorticity flux across the separating boundary layer, the separation angle, and the drag coefficient. Though the results are limited to low-Reynolds-number laminar flow, they establish that the unsteady characteristics of two-dimensional flow separation may be predicted utilizing indicial theory. R.E.P.

A91-42573#
LEADING EDGE EFFECT ON RAREFIED HYPERSONIC FLOW OVER A FLAT PLATE
K. S. HEFFNER, L. GOTTESDIENER, A. CHPOUN, and J. C. LENGRAND (CNRS, Laboratoire d'Aerothermique, Meudon, France) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-1749) Copyright

The effect of various leading edge bevel angles in the range of 0 to 80 deg on rarefied hypersonic flow over a flatplate is studied using a direct simulation Monte Carlo method. Experimental wall heat transfer measurements were carried out on different models and compared with numerical results. It is found that leading edge bevel angles larger than 15 deg significantly change flow-field parameters and wall quantities with respect to the zero-thickness case for the given flow conditions. K.K.

A91-42574#
NAVIER-STOKES CORRELATION OF A SWEPT HELICOPTER ROTOR TIP AT HIGH ALPHA
MATTHEW T. SCOTT and JIM C. NARRAMORE (Bell Helicopter Textron, Inc., Fort Worth, TX) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 15 p. refs
(AIAA PAPER 91-1752) Copyright

The aerodynamics of a helicopter rotor tip are analyzed theoretically and experimentally to correlate the flow in a nonrotating flow at high alpha and yawed conditions. Flow visualizations, hot wire anemometry, and force data taken experimentally for the hyperbolic blade tip are correlated with a thin-layer Navier-Stokes solver. Observed flow patterns on the blade are very similar to the simulated surface traces, and the numerical results are demonstrated to be an effective tool for analyzing experimental data. Numerical modeling predicts higher integrated forces and separation lines that are mislocated, and the location of the tip vortex is found to be 2 in. outboard of that derived experimentally. The effects that cause the differences between modeling and experimental observations are discussed, with particular attention given to the turbulence model, the transition criterion, and diffusion. C.C.S.

A91-42575#
EXPERIMENTAL INVESTIGATION OF THE NEAR WAKE STRUCTURE OF A HELICOPTER ROTOR IN FORWARD FLIGHT
G. BRIASSULIS and J. ANDREOPOULOS (City College, New York) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-1753) Copyright

Experimental and theoretical studies of the behavior of rotating blades are overviewed, and focus is placed on the wake of an idealized two-bladed helicopter rotor in forward flight. Time-dependent measurements of three-dimensional velocity vectors are obtained in wind-tunnel tests for two pitch angles. The existence of an Omega(z) component of the vorticity vector is discovered in profiles of the streamwise component of the velocity vector and at both edges of the wake. Large levels of turbulent kinetic energy are found almost everywhere in the wake, while peaks of power spectral densities are located in velocity components at frequencies two to four times higher than the blade passage frequency, suggesting a break-up of the vortex-sheets or tip-vortices due to large-scale instabilities. V.T.

A91-42576#
INVESTIGATION OF THE TIP SHAPE INFLUENCE ON THE FLOWFIELD AROUND HOVERING ROTOR BLADES
D. FAVIER, C. MARESCA (Aix-Marseille II, Universite, Marseille, France), E. BERTON, and P. P. DE HUGUES AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. Aerospatiale-supported research. refs
(Contract DRET-88-197)
(AIAA PAPER 91-1754) Copyright

The paper presents a comparative study on the flowfield around hovering rotor blades with either rectangular or swept tip shapes. For both blade tip geometries the experiments include measurements of the instantaneous velocity field around the blade and in its wake, the bound circulation distribution along the span, the tip vortex path, and visualizations of the vortical structures generated by the blade tip. When compared to the rectangular tip, the swept tip is shown to modify the wake geometry and to generate a dual vortex structure which produces a stronger instability of the tip vortex path. This vortex instability significantly affects the tangential velocity field around the blade itself, and thus introduces a significant bound circulation perturbation. The correlation between the bound circulation behavior, the tangential velocity field and the tip vortex development close to the blade is also discussed from the present tests data set. Author

A91-42577#
CORRELATIVE BEHAVIOURS OF SHOCK/BOUNDARY LAYER INTERACTION INDUCED BY SHARP FIN AND SEMICONE
XUE-YING DENG (Beijing University of Aeronautics and Astronautics, People's Republic of China) and JIN-HUA LIAO AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 7 p. NNSFC-supported research. refs
(AIAA PAPER 91-1756) Copyright

The interactions between shock waves and turbulent boundary layers caused by unswept sharp fins and semicones are investigated experimentally. The complex flow structures of three-dimensional interactions are divided into simplified flow regimes, and the correlation method is used to distinguish parameters that control flow behavior in each regime. The interaction regime upstream of the inviscid shock is considered to correlate flow behavior with two shock generators. The freestream Mach numbers are 1.79, 2.04, and 2.50, and the Reynolds number is 2.4 x 10 to the 7th/m. Correlations of the upstream influence line and the primary separation line can be developed based uniquely on the inviscid shock strength. Other parameters, such as the curvature of the inviscid shock and the Mach number of the free-stream turbulent boundary layer, are found to have no effect on the flow behavior studied. C.C.S.

A91-42580#
MACH 6 TURBULENT BOUNDARY LAYER CHARACTERISTICS ON SMOOTH AND ROUGH SURFACES
P. J. DISIMILE (Cincinnati, University, OH) and N. SCAGGS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. USAF-supported research. refs
(AIAA PAPER 91-1762) Copyright

An experimental investigation into the effects of surface roughness on turbulent boundary layer characteristics at hypersonic speeds is presented. The tests were performed on a flat plate/wedge combination at a nominal Mach number of 6 for unit Reynolds numbers between approximately 33 and 98 million/meter. To assure and verify two-dimensionality, side fences were added to the model surfaces adjacent to the intersection region. Comparing the surface pressure distributions with and without the fences showed them to be excellent. The separation distance for the rough surface case was found to be 10 to 12 times greater than that found on the smooth surface model. R.E.P.

A91-42581*# Pennsylvania State Univ., University Park.
HYPERSONIC SHOCK/BOUNDARY-LAYER INTERACTION DATABASE
G. S. SETTLES and L. J. DODSON (Pennsylvania State University, University Park) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. Previously announced in STAR as N91-15986. refs
(Contract NAG2-565)
(AIAA PAPER 91-1763) Copyright

Turbulence modeling is generally recognized as the major problem obstructing further advances in computational fluid dynamics (CFD). A closed solution of the governing Navier-Stokes equations for turbulent flows of practical consequence is still far beyond grasp. At the same time, the simplified models of turbulence which are used to achieve closure of the Navier-Stokes equations are known to be rigorously incorrect. While these models serve a definite purpose, they are inadequate for the general prediction of hypersonic viscous/inviscid interactions, mixing problems, chemical nonequilibria, and a range of other phenomena which must be predicted in order to design a hypersonic vehicle computationally. Due to the complexity of turbulence, useful new turbulence models are synthesized only when great expertise is brought to bear and considerable intellectual energy is expended. Although this process is fundamentally theoretical, crucial guidance may be gained from carefully-executed basic experiments. Following the birth of a new model, its testing and validation once again demand comparisons with data of unimpeachable quality. This report concerns these issues which arise from the experimental aspects of hypersonic modeling and represents the results of the first phase of an effort to develop compressible turbulence models. Author

A91-42582#

A PHYSICAL MODEL OF THE SWEPT SHOCK WAVE/BOUNDARY-LAYER INTERACTION FLOWFIELD

F. S. ALVI and G. S. SETTLES (Pennsylvania State University, University Park) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 15 p. refs
(Contract AF-AFOSR-89-0315)
(AIAA PAPER 91-1768) Copyright

New data are presented on the structure of fin-induced, swept shock/boundary layer interactions. The new data are produced by a nonintrusive PLS (Planar Laser Scattering) imaging technique. A range of interaction strengths, from barely separated to very strongly separated, is covered for freestream Mach numbers of 3 and 4. These new data, when combined with previous results on the flowfield and interaction 'footprint', are sufficient to allow the construction of a physical model for the swept interaction flowfield structure and behavior. This physical model is presented and discussed in terms of 6 detailed flowfield maps which take advantage of the inherent quasiconical behavior of the class of interactions considered. Author

A91-42594#

NAVIER-STOKES CALCULATIONS FOR ATTACHED AND SEPARATED FLOWS USING DIFFERENT TURBULENCE MODELS

N. J. YU, STEVEN R. ALLMARAS, and KEVIN G. MOSCHETTI (Boeing Commercial Airplanes, Seattle, WA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-1791) Copyright

Turbulence models currently used in thin-layer Navier-Stokes codes are evaluated and applied to analyze three wing-body configurations. The areas of evaluation are focused on the applicability of the models for attached and separated flow simulations, and the sensitivity of the models to the variations in grid distributions. Computational results are compared with wind tunnel surface pressure data and wind tunnel boundary layer velocity profiles. Preliminary results indicate that the nonequilibrium model of Johnson and King consistently gives good test/theory correlation on wing pressures for both attached and separated flows. Chordwise grid resolution near the wing trailing edge is found to have a large impact on the predicted surface pressure distributions for a highly aft-loaded supercritical wing design. In addition, modifications of eddy viscosity computations are discussed that improve numerical stability for grids with dense normal grid spacing at the wing surface. Author

A91-42595#

DYNAMIC STALL EXPERIMENTS ON A SWEPT THREE-DIMENSIONAL WING IN COMPRESSIBLE FLOW

PETER F. LORBER, ALFRED F. COVINO, JR., and FRANKLIN O. CARTA (United Technologies Research Center, East Hartford, CT) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 17 p. refs
(Contract DAAL03-89-C-0013)
(AIAA PAPER 91-1795) Copyright

An experiment has been performed to investigate the transient aerodynamic response of a three-dimensional wing undergoing pitching motions to angle of attack above static stall. The experimental parameters included sweep angles of 0, 15, and 30 deg, Mach numbers from Mc = 0.2 to 0.6, and pitch rates from 0.001 to 0.025. Data were obtained from 112 surface pressure transducers for steady flow, sinusoidal oscillations, and constant rate ramps. This paper describes the experiment and discusses the dependence of the aerodynamic loads on the test parameters. Of particular interest is the effect of locally supersonic flow on stall inception, and the interactions between the tip vortex and the stall vortex. Author

A91-42596#

THE VORTEX KINEMATICS ASSOCIATED WITH AN OSCILLATING DELTA WING

STEPHEN A. HUYER and MARVIN W. LUTTGES (Colorado, University, Boulder) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 16 p. refs
(Contract AF-AFOSR-88-0272)
(AIAA PAPER 91-1797) Copyright

The present experiments focused on the vortex kinematics associated with an oscillating delta wing. A leading edge smokewire stained the potential flow field showing the three-dimensional nature of the conical leading edge vortex structure. Both still and high speed video photography documented the flow history for an extended range of reduced frequencies and mean angles of attack. Four stages of flow development were characteristic: (1) initiation of discrete vortices each similar to a cylindrical three-dimensional dynamic stall vortex; (2) transition into a conical delta wing vortex; (3) subsequent vortex instability resulting in global separation or shedding of discrete structures; (4) flow reattachemnt for cases of global separation. The temporal characteristics of these flow processes were measured as well as the kinematics of vortex cross-scetional area. These data provided evidence for differing vorticity production, accumulation, diffusion and convection mechanisms as well as hysteresis and pressure gradient effects. To demonstrate the global effects of these unsteady flow fields, they were correlated with previously acquired force balance data. Author

A91-42597#

NUMERICAL INVESTIGATION OF THE EFFECT OF LEADING EDGE GEOMETRY ON DYNAMIC STALL OF AIRFOILS

STEVEN P. GROHSMEYER, JOHN A. EKATERINARIS, and MAX F. PLATZER (U.S. Navy, Naval Postgraduate School, Monterey, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. U.S. Navy-supported research. refs
(AIAA PAPER 91-1798) Copyright

The dynamic stall of pitching airfoils is investigated by the numerical solution of the full compressible unsteady two-dimensional Navier-Stokes equations using an alternating-direction-implicit scheme. The flow is assumed to be fully turbulent, and the turbulent stresses are modeled by the Baldwin-Lomax eddy viscosity model. The objective of this study is to investigate the influence of the leading edge geometry on unsteady flow separation. For this purpose three airfoils are analyzed, namely, the NACA 0012 baseline airfoil, the NACA 0012-63 having the same leading edge radius but different contouring forward of maximum thickness, and the NACA 0012-33 having a smaller leading edge radius. It is found that a larger leading edge radius, thicker contouring of the forward part of the airfoil, or increasing pitch rate results in delaying flow separation and formation of the dynamic stall vortex to a higher angle of attack, yielding a higher peak lift coefficient. Within the scope of this study, incipient flow reversal was found to occur in response to essentially the same critical pressure gradient distribution for different pitch rates and Mach numbers. Author

A91-42603#

HOPF BIFURCATION IN VISCOUS FLOWS ABOUT AIRFOILS AT LOW SPEEDS

PHILIP S. BERAN and MARK J. LUTTON (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-1807)

Hopf bifurcation points in viscous, incompressible flows about a NACA 0012 airfoil are computed for very low Reynolds numbers (less than 500). The efficient numerical technique developed by Griewank and Reddien for the direct calculation of Hopf points has been adapted for the analysis of airfoil flows. The Griewank and Reddien (GR) algorithm involves the construction of an expanded system of nonlinear, algebraic equations that are solved to yield the location of the Hopf point and the solution of the steady-state equations at the Hopf point. Solutions of the steady-state equations for the airfoil problem have been reported elsewhere. These equations are expanded in a manner consistent with the GR algorithm and then solved using Newton's method and Gaussian elimination. During the solution process, Reynolds number is allowed to vary while angle of attack is held fixed. The computed locations of Hopf points, a path in a parameter space defined by Reynolds number and angle of attack, has been verified through time-integration of equilibrium solution points and through direct calculation of eigenvalue spectra using EISPACK. Author

A91-42604#

SOURCES OF HIGH ALPHA VORTEX ASYMMETRY AT ZERO SIDESLIP

L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 9 p. Research supported by Lockheed Missiles and Space Co., Inc. refs

(AIAA PAPER 91-1810) Copyright

A review of existing experimental results for slender bodies and delta wings, tested at high angles of attack, reveals that no physical evidence exists that vortex asymmetry on slender pointed bodies or delta wings has ever occurred through the so called hydrodynamic instability process. It will be shown that in the numerous tests performed, asymmetric flow separation and/or asymmetric flow reattachment were the flow mechanisms triggering the vortex asymmetry. Slender wing rock is found to result from a basic lack of roll damping, existing for attached leading edge vortices, and the vortex-asymmetry is generated at nonzero roll angle, i.e., for asymmetric flow conditions. Author

A91-42605#

CHINE FOREBODY VORTEX MANIPULATION BY MECHANICAL AND PNEUMATIC TECHNIQUES ON A DELTA WING CONFIGURATION

DHANVADA M. RAO and CHITH K. PURAM (Vigyan, Inc., Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 8 p. USAF-supported research. refs

(AIAA PAPER 91-1812) Copyright

An exploratory low-speed wind tunnel study was conducted on alternate means of manipulating forebody chine vortices, in order to control their interaction with a closely coupled delta wing at high angles of attack. Flow visualizations and upper-surface pressure measurements were performed to observe the effects of chine dihedral/anhedral deflections and of spanwise blowing through chine edge slots. Of special interest was the feasibility of generating large and controlled asymmetries of the wing flow fields by nonsymmetrical chine manipulation in the post-stall range. Both the mechanical and pneumatic techniques investigated showed significant potential for lateral control at angles of attack to 50 degrees. Author

A91-42609#

SOME CHARACTERISTICS OF AND DYNAMIC SCALING BEHAVIOR IN STRONG VORTEX FLOWS

J. F. SLOMSKI and D. W. LACEY (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 15 p. refs

(AIAA PAPER 91-1821)

A Navier-Stokes solver is applied to some simple canonical forebody and forebody/delta wing shapes at different angles of attack and free stream conditions. Resulting solutions are examined to determine the extent of any dynamic scaling based on some initial formulations of new scaling parameters. Evidence of hysteresis has been found during relaxation of a strong vortex flow field from a perturbed condition. This hysteresis may have important implications for the same or scaled initial conditions when random perturbations occur in the flow field. The effect of body surface imperfections on the strong vortex flow field, and its scaling behavior are also reported. R.E.P.

A91-42611#

VORTEX TOPOLOGY FOR RECTANGULAR WINGS IN PICTURES, SKETCHES AND CONJECTURES

PETER FREYMUTH (Colorado, University, Boulder) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. refs

(Contract AF-AFOSR-88-0241)

(AIAA PAPER 91-1824) Copyright

The vortex structures around planar rectangular wings in steady flow are visualized and distilled into topologically consistent vortex line models. Two distinct flow modes were found. In the low to medium angle of attack mode, vorticity production near the leading edge of the wing is partly balanced by back diffusion of vorticity into the wing in regions of adverse pressure gradients. In the high angle of attack mode, the vorticity produced is mainly convected into the wake in the form of a vortex sheet surrounding the circumference of the wing and continually shedding from it. Author

A91-42612#

NUMERICAL EVALUATION OF VORTEX FLOW CONTROL DEVICES

CHAO-HO SUNG, MICHAEL J. GRIFFIN, and RODERICK M. COLEMAN (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 9 p. U.S. Navy-supported research. refs

(AIAA PAPER 91-1825) Copyright

An improved numerical method for the solution of the three-dimensional incompressible, Reynolds-averaged Navier-Stokes equations based on a central-difference finite-volume, explicit Runge-Kutta time-stepping scheme is applied to evaluate vortex flow control devices. Three configurations including a baseline, a leading edge fairing, and a fillet at angles of attack of 0 and 6 deg are presented. The computed pressure on the entire flat-plate and the streamwise velocity components in the wake 3 chord lengths downstream from the leading edge are first validated with the experimental data. The effectiveness of the leading edge fairing and the fillet is then discussed in terms of the ability of each to reduce the strength of the horseshoe vortex. Other important design parameters including the nose shape, Reynolds number, incoming boundary layer thickness and the endwall profiling are also discussed. It is demonstrated that the numerical approach is a valuable tool for the design of vortex flow control devices. Author

A91-42630*# Lockheed Engineering and Sciences Co., Hampton, VA.

STRUCTURED AND UNSTRUCTURED REMESHING METHOD FOR HIGH-SPEED FLOWS

GURURAJA R. VEMAGANTI (Lockheed Engineering and Sciences Co., Hampton, VA), EARL A. THORNTON (Virginia, University, Charlottesville), and ALLAN R. WIETING (NASA, Langley Research Center, Hampton, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Mar.-Apr. 1991, p. 158-164. Previously cited in issue 06, p. 758, Accession no. A90-19832. refs

(Contract NSG-1321)

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A91-42710

TRANSONIC FLUTTER ANALYSIS OF AERODYNAMIC SURFACES IN THE PRESENCE OF STRUCTURAL NONLINEARITIES

I. W. TJATRA, R. K. KAPANIA, and B. GROSSMAN (Virginia Polytechnic Institute and State University, Blacksburg) (Computational technology for flight vehicles; Proceedings of the

Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 211-218. refs
Copyright
The influence of structural nonlinearities on the transonic aeroelastic behavior of a two-degree-of-freedom system consisting of an airfoil which is plunging and pitching is considered. The preload and freeplay nonlinearity in the spring model are treated using the asymptotic expansion method which takes into account the influence of the higher harmonics. The aerodynamic load vector is obtained by solving the unsteady transonic small-disturbance equation using an ADI finite-difference algorithm. The frequency domain solution of the aeroelastic equation is obtained using the U-g method, and the aeroelastic response is carried out by applying Newmark-beta and Wilson-theta methods. A comparison is made between the results obtained from these two solutions. The effects of preload and freeplay magnitudes on the stability of the system and the corresponding reduced frequency and mass density ratio at neutrally stable response are studied. Author

A91-42711* Korea Advanced Inst. of Science and Technology, Seoul (Republic of Korea).
STATIC AEROELASTIC ANALYSIS OF A THREE-DIMENSIONAL OBLIQUE WING
I. LEE (Korea Advanced Institute of Science and Technology, Seoul, Republic of Korea), H. MIURA, and M. K. CHARGIN (NASA, Ames Research Center, Moffett Field, CA) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 219-227. refs
Copyright
A capability to perform static aeroelastic analyses of an oblique wing at arbitrary skew positions was developed based on the framework of the MSC/NASTRAN static aeroelastic analysis. By means of DMAP alterations, a portion of the subsonic static aeroelastic analysis scheme was modified to insert an aerodynamic influence coefficient matrix created externally by the NASA-Ames aerodynamic panel codes. The modified scheme can cover the subsonic as well as the supersonic range for both symmetric and asymmetric configurations. Static aeroelastic responses of the oblique wing are studied at two skew angles and, in particular, the capability to calculate 3D camber effects on the aerodynamic properties of the wing is investigated. Various aerodynamic coefficients of the rigid oblique wing are computed for two Mach numbers, 0.7 and 1.4, and the angle of attack is varied from -5 through 15 deg. Also, the wing flexibility effects on the aerodynamic coefficients and the displacement are examined at a Mach number of 0.7 for a 45-deg swept wing. Author

A91-42719
MULTIBLOCK MESH GENERATION FOR MULTIPLE ELEMENT AIRFOILS WITH EULER SOLUTIONS
M. E. M. STEWART (Princeton University, NJ) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 325-331. refs
Copyright
A novel search algorithm for the decomposition of arbitrary, two-dimensional domains into nonoverlapping, topologically rectangular blocks is described. The algorithm automates several stages in the domain decomposition and grid generation process in two dimensions. To demonstrate the technique, solutions to the Euler equations for several multielement airfoil configurations are presented. Author

A91-42721* Massachusetts Inst. of Tech., Cambridge.
COMPUTATION AND VISUALIZATION OF LEADING EDGE VORTEX FLOWS
E. M. MURMAN, T. M. BECKER, and D. DARMOFAL (MIT, Cambridge, MA) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 341-348. refs
(Contract NAG1-507; NAG1-855; AF-AFOSR-89-0395; N00014-89-J-1448)
Copyright
The modeling of vortical flows is a continuing requirement for the design and analysis of flight vehicles. In this paper, the computation of leading edge vortices is considered. The solution of the laminar, thin-layer Navier-Stokes equations for a transonic delta wing is presented as a representative example. Issues relating to the visualization of the results are discussed, and illustrations using the newly developed software VISUAL3 on a Stardent graphics supercomputer are included. Author

A91-42726
NUMERICAL SIMULATION OF A THREE-DIMENSIONAL SHOCK WAVE-TURBULENT BOUNDARY LAYER INTERACTION GENERATED BY A SHARP FIN AT MACH 4
D. D. KNIGHT (Rutgers University, New Brunswick, NJ) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 391-399. refs
(Contract AF-AFOSR-86-0266)
Copyright
The 3D inviscid-viscous interaction generated by the intersection of an oblique shock with a turbulent boundary layer is examined theoretically. An incoming Mach 4 equilibrium turbulent boundary layer at Re of 200,000 interacts with an oblique shock formed by a 16-deg sharp fin mounted normal to the flat plate. The theoretical model is the 3D compressible Reynolds-averaged Navier-Stokes equations with turbulence incorporated through the Baldwin-Lomax algebraic eddy viscosity model. Computed results for the surface skin friction, surface pressure, and surface streamline angles, are compared with experimental measurements and previous numerical results. The present results display good agreement with experiment, except in specific isolated regions. Author

A91-42728
COMPUTATIONAL AERODYNAMICS METHODOLOGY FOR THE AEROSPACE PLANE
S. R. CHAKRAVARTHY (Rockwell International Science Center, Thousand Oaks, CA) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 415-435. refs
Copyright
The aerodynamic design of the Aerospace Plane encompasses a wide range of computational fluid dynamics regimes: low speed to hypersonic velocities; perfect and real gas; internal and external flows; complex geometry; shock waves, boundary layers, and their interactions; and turbulence and transition. An outline of two approaches that provide a unified treatment of all these regimes of interest is presented. The first approach uses the Unified-Solution-Algorthms series of codes. Here, a TVD upwing formulation is used in a finite-volume multizone structure-grid framework along with a host of useful implicit solution methodologies such as approximate factorization and relaxation. The second approach is based on accuracies of second order and higher, geometry flexibility including structured and unstructured grids, and fully automatic mesh generation. Author

A91-42730
ASYMMETRIC SEPARATED FLOWS OVER SLENDER BODIES AT SUPERSONIC SPEEDS
M. J. SICLARI (Grumman Corporate Research Center, Bethpage, NY) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles,

Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 447-460. refs
Copyright

An efficient multigrid central-difference, finite-volume Navier-Stokes solver is used to study the natural occurrence of steady anomalous asymmetric separated flow solutions at high incidence and at supersonic speeds. The regime in which asymmetic conical flows are likely to occur is documented as a function of Mach number and cone angle. It is also shown that the existence of asymmetric flows is not unique to circular cones but is exhibited for a variety of cross-sectional shapes. A parabolized Navier-Stokes solution is presented for a 3D body exhibiting asymmetric flow behavior. Author

A91-42736* Analytical Services and Materials, Inc., Hampton, VA.
A GENERALIZED PATCHED-GRID ALGORITHM WITH APPLICATION TO THE F-18 FOREBODY WITH ACTUATED CONTROL STRAKE
R. T. BIEDRON (Analytical Services and Materials, Inc., Hampton, VA) and J. L. THOMAS (NASA, Langley Research Center, Hampton, VA) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 563-576. refs
Copyright

Analysis of complex configurations using structured grids virtually demands multiple blocks of grids. To facilitate calculations involving multiple blocks, a geneal grid-block patching algorithm based on generalized coordinate inerpolation has been developed. The computational grid may contain as many arbirarily shaped blocks as required to make the grid generation problem tractable and to accurately model the fow features. Results are presented for several test cases as well as for the F-18 forebody control strake. The methodology developed has application to overlapped or embedded grids. Author

A91-42813#
TURBULENT FLOW PREDICTIONS FOR AFTERBODY/NOZZLE GEOMETRIES INCLUDING BASE EFFECTS
A. J. PEACE (Aircraft Research Association, Ltd., Bedford, England) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 396-403. Research supported by Ministry of Defence Procurement Executive of England. Previously cited in issue 18, p. 2758, Accession no. A89-42092. refs
Copyright

A91-42814*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INFLUENCE OF THICKNESS AND CAMBER ON THE AEROELASTIC STABILITY OF SUPERSONIC THROUGHFLOW FANS
JOHN K. RAMSEY (NASA, Lewis Research Center, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 404-411. Previously announced in STAR as N89-25957. refs
Copyright

An engineering approach was used to include the nonlinear effects of thickness and camber in an analytical aeroelastic analysis of casecades in supersonic acial flow (supersonic leading-edge locus). A hybrid code using Lighthill's nonlinear piston theory and Lane's linear potential theory was developed to include these nonlinear effects. Lighthill's theory was used to calculate the unsteady pressures on the noninterference surface regions of the airfoils in cascade. Lane's theory was used to calculate the unsteady pressures on the remaining interference surface regions. Two airfoil profiles were investigated (a supersonic throughflow fan design and a NACA 66-206 airfoil with a sharp leading edge). Results show that compared with predictions of Lane's potential theory for flat plates, the inclusion of thickness (with or without camber) may increase or decrease the aeroelastic stability, depending on the airfoil geometry and operating conditions. When thickness effects are included in the aeroelastic analysis, inclusion of camber will influence the predicted stability in proportion to the magnitude of the added camber. The critical interblade phase angle, depending on the airfoil profile and operating conditions, may also be influenced by thickness and camber. Compared with predictions of Lane's linear potential theory, the inclusion of thickness and camber decreased the aerodynamic stiffness and increased the aerodynamic damping at Mach 2 and 2.95 for a cascade of supersonic throughflow fan airfoils oscillating 180 degrees out of phase at a reduced frequency of 0.1. Author

A91-42816#
COMBINED TANGENTIAL-NORMAL INJECTION INTO A SUPERSONIC FLOW
P. S. KING, R. H. THOMAS, J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg), and F. S. BILLIG (Johns Hopkins University, Laurel, MD) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 420-430. Previously cited in issue 09, p. 1284, Accession no. A89-25492. refs
Copyright

A91-42820*# Sverdrup Technology, Inc., Brook Park, OH.
LARGE-SCALE ADVANCED PROPELLER BLADE PRESSURE DISTRIBUTIONS - PREDICTION AND DATA
N. NALLASAMY, O. YAMAMOTO, S. WARSI (Sverdrup Technology, Inc., Brook Park, OH), and L. J. BOBER (NASA, Lewis Research Center, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 452-461. Previously cited in issue 20, p. 3084, Accession no. A89-47026. refs
Copyright

A91-42902
A GENERAL METHOD FOR PRACTICAL CONFORMAL MAPPING OF AERODYNAMIC SHAPES
J. L. NIETO, J. HUREAU, and M. MUDRY (Orleans, Universite, France) European Journal of Mechanics, B/Fluids (ISSN 0997-7546), vol. 10, no. 2, 1991, p. 147-160. refs
Copyright

A general calculation code is presented for the conformal mapping of a domain limited by a unit circle onto a second domain which permits application to a wide variety of domains. The case of a smooth boundary is developed with particular attention given to the differences in the scheme as opposed to that of Timman. The first term from the Laurent series is unnecessary, and the Schwarz integral formula is employed to obtain transformal mapping in the entire domain. Perturbation related to the presence of corners can be accounted for by a technique which isolates boundary singularities. Numerical examples are given for some aerodynamic profiles, and convergence is achieved after 40-60 iterations with 'weight factors' of 0.8 or 0.9. The numerical method allows the conformal mapping of a large number of domains limited by any kind of curve including interior cases and general forms other than traditional wing profiles. C.C.S.

A91-42957#
A METHOD FOR CORRECTING WALL PRESSURE MEASUREMENTS IN SUBSONIC COMPRESSIBLE FLOW
C. DUCRUET (Lille I, Universite, France) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202), vol. 113, June 1991, p. 256-260. Research supported by ONERA and DRET. refs
Copyright

A theoretical and experimental investigation has been made of the static pressure hole problem in subsonic flow. Thanks to a linearization, the effects of the boundary layer, of the velocity gradient and of the wall curvature could be separated so that a formula of correction containing three influence functions has been obtained. These functions were determined in the case of practical requirements by means of experiments made on appropriate models for two values of the depth-to-diameter ratio and for at least three values of the Mach number. Then, the method of correction has been applied to the flow around an airfoil at zero angle of attack. Author

A91-43078#
AUTOMATIC DESIGN OF TRANSONIC AIRFOILS TO REDUCE THE SHOCK INDUCED PRESSURE DRAG
ANTONY JAMESON (Princeton University, NJ) IN: Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Collection of Papers. Haifa, Israel, Technion - Israel Institute of Technology, 1990, p. 5-17. refs

The use of control theory for the optimum design of aerodynamic configurations is discussed. The application of this method to the reduction of shock induced pressure drag on airfoils in two-dimensional transonic flow is demonstrated. Computational results which demonstrate how the method can be used to reshape the profile to reduce the pressure drag in transonic flow by a factor of ten are presented. It is suggested that the present approach can be used for the optimization of the complete wing. K.K.

A91-43100#
EULER SOLVER FOR ARBITRARY CONFIGURATIONS - FURTHER APPLICATIONS
B. EPSTEIN, A. L. LUNTZ, and A. NACHSHON (Israel Aircraft Industries, Ltd., Lod) IN: Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Collection of Papers. Haifa, Israel, Technion - Israel Institute of Technology, 1990, p. 205-216. refs

Applications of a three-dimensional Euler code capable of treating arbitrary aerodynamic configurations in a wide range of flight conditions are described. The present applications verify the code in flight regimes not covered by potential codes by comparison with wind tunnel experiments and analytical solutions. Results are presented for different types of forebodies and on one of the delta wings used in the International Vortex Flow Experiment. K.K.

A91-43103*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RECENT ADVANCES IN HYPERSONIC TECHNOLOGY
DOUGLAS L. DWOYER (NASA, Langley Research Center, Hampton, VA) IN: Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Supplement. Haifa, Israel, Technion - Israel Institute of Technology, 1990, p. 16-20.

This paper will focus on recent advances in hypersonic aerodynamic prediction techniques. Current capabilities of existing numerical methods for predicting high Mach number flows will be discussed and shortcomings will be identified. Physical models available for inclusion into modern codes for predicting the effects of transition and turbulence will also be outlined and their limitations identified. Chemical reaction models appropriate to high-speed flows will be addressed, and the impact of their inclusion in computational fluid dynamics codes will be discussed. Finally, the problem of validating predictive techniques for high Mach number flows will be addressed. Author

A91-43142
SYNTHESIS OF EXPERIMENTAL RIBLET STUDIES IN TRANSONIC CONDITIONS
E. COUSTOLS (ONERA, Toulouse, France) and V. SCHMITT (ONERA, Chatillon, France) IN: Turbulence control by passive means; Proceedings of the 4th European Drag Reduction Meeting, Lausanne, Switzerland, July 24, 1989. Dordrecht, Netherlands, Kluwer Academic Publishers, 1990, p. 123-140. Research supported by Airbus Industrie and Service Technique des Programmes Aeronautiques. refs
Copyright

The present paper summarizes the status of the experimental research carried out both on ONERA/CERT and ONERA/Modane, as regards internal manipulators, commonly named, by a lot of researchers, riblets. That turbulent boundary layer manipulation program was begun at CERT in mid-1986. Emphasized will be drag reduction performances of such passive devices, tested at transonic conditions, on a cylindrical body, a CAST 7 aerofoil for two-dimensional turbulent boundary layers, and, at last, a complete 1/11th scale Airbus A320 model. Author

A91-43307*# Douglas Aircraft Co., Inc., Long Beach, CA.
NEW AIRFOIL DESIGN CONCEPT
PRESTON A. HENNE and ROBERT D. GREGG, III (Douglas Aircraft Co., Long Beach, CA) Journal of Aircraft (ISSN 0021-8669), vol. 28, May 1991, p. 300-311. Research supported by McDonnell Douglas Corp. Previously cited in issue 21, p. 3263, Accession no. A89-47660. refs
(Contract NAS1-15327)
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A91-43308#
EFFECT OF THICKNESS ON THE UNSTEADY AERODYNAMICS OF CLOSELY COUPLED OSCILLATING AIRFOILS
K. ROKHSAZ, B. P. SELBERG, and W. EVERSMAN (Missouri-Rolla, University, Rolla) Journal of Aircraft (ISSN 0021-8669), vol. 28, May 1991, p. 312-319. Previously cited in issue 12, p. 1775, Accession no. A89-30766. refs
Copyright

A91-43309#
VISUALIZATION MEASUREMENTS OF VORTEX FLOWS
MARTIN V. LOWSON (Bristol, University, England) Journal of Aircraft (ISSN 0021-8669), vol. 28, May 1991, p. 320-327. Previously cited in issue 09, p. 1274, Accession no. A89-25166. refs
Copyright

A91-43385*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HYPERSONIC RAREFIED FLOW ABOUT A COMPRESSION CORNER - DSMC SIMULATION AND EXPERIMENT
JAMES N. MOSS, JOSEPH M. PRICE (NASA, Langley Research Center, Hampton, VA), and CH.-H. CHUN (DLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 22 p. refs
(AIAA PAPER 91-1313) Copyright

The phenomena of shock/boundary-layer interactions and flow separation are investigated using both computational and experimental methods for low-density hypersonic flow about two-dimensional compression corners. The numerical calculations are made with the direct simulation Monte Carlo (DSMC) method. Experimental measurements provide information concerning the flowfield structure and surface flow patterns by means of gas glow discharge and oil flow pictures, respectively. Comparison of the two data sets provides a qualitative basis for assessing the ability of the DSMC method to describe such flows. Author

A91-43387*# Vigyan Research Associates, Inc., Hampton, VA.
HYPERSONIC RAREFIED FLOW ABOUT A DELTA WING - DIRECT SIMULATION AND COMPARISON WITH EXPERIMENT
M. C. CELENLIGIL (Vigyan Research Associates, Inc., Hampton, VA) and JAMES N. MOSS (NASA, Langley Research Center, Hampton, VA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 14 p. refs
(AIAA PAPER 91-1315) Copyright

Three-dimensional simulations of hypersonic rarefied flow about a delta wing are made using the direct simulation Monte Carlo (DSMC) method of Bird, and the results of the computations are compared with recent experimental data obtained in a vacuum wind tunnel at the DLR in Gottingen, Germany. The present study considers Mach 8.89 nitrogen flow for a range of conditions that include Knudsen numbers of 0.016 to 3.505 for an incidence angle of 30 deg, and angles of incidence of 15 to 60 deg for a constant Knudsen number of 0.389. The calculations provide details concerning the flowfield structure and surface quantities. Comparisons between the calculations and the available experimental measurements are made for aerodynamic and overall

heat-transfer coefficients and recovery temperature. The agreement between the measured and calculated data are very good, well within the estimated measurement uncertainty. Comparisons are also made with modified Newtonian and free-molecule theories.
Author

A91-43388*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AN EFFICIENT DSMC ALGORITHM APPLIED TO A DELTA WING

D. F. G. RAULT, R. G. WILMOTH (NASA, Langley Research Center, Hampton, VA), and G. A. BIRD (Sydney, University, Australia) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 12 p. refs

(AIAA PAPER 91-1316) Copyright

A new algorithm for 3D direct simulation Monte Carlo (DSMC) is tested and numerical results are compared with wind tunnel data and results obtained earlier with a more traditional DSMC code. The test case is the flowfield around a delta wing at incidence at Knudsen number of 0.016 and Mach number of 20.2. The results are shown to compare favorably with both experimental and earlier numerical results. The new algorithm is described with special emphasis placed on its distinctive features: Cartesian/unstructured combination grid, special body surface definition, discretization in physical space.
Author

A91-43389#

DIRECT SIMULATION OF WAVERIDERS IN HYPERSONIC RAREFIED FLOW

FREDERICK A. KAUTZ, II (MIT, Lexington, MA) and JUDSON R. BARON (MIT, Cambridge, MA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 39 p. SDIO-sponsored research. refs

(AIAA PAPER 91-1317) Copyright

The study focuses on a numerical evaluation based on the direct simulation Monte Carlo (DSMC) method, exploring the character of the transition regime flow for a caret waverider. The numerical simulations are based on a three-dimensional 'pixel'-based DSMC scheme, and flow simulations are carried out at three Knudsen numbers (0.22, 0.39, and 0.75) for a speed ratio of 16. Field distributions are presented for both a diatomic nondissociating species model with rotational degrees of freedom and an air model using five species. The scale of compression regions, disturbance extent from the body, and surface quantities including heat transfer are considered, and it is pointed out that comparisons with on-design performance characteristics and free-molecule flow theory indicate that a physically consistent behavior is obtained for a flow about the waverider. Computational issues are examined with regard to the trade-off of cell-size, cell number, cell subdivision, simulated particle count, and domain extent/boundary conditions as a function of basic nondimensional parameters of the flow.
V.T.

A91-43417*# North Carolina State Univ., Raleigh.

AN APPROXIMATE VISCOUS SHOCK LAYER APPROACH TO CALCULATING HYPERSONIC FLOWS ABOUT BLUNT-NOSED BODIES

F. MCN. CHEATWOOD and F. R. DEJARNETTE (North Carolina State University, Raleigh) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 12 p. refs

(Contract NCC1-100)

(AIAA PAPER 91-1348) Copyright

An approximate axisymmetric method has been developed which can reliably calculate fully viscous hypersonic flows over blunt-nosed bodies. By substituting Maslen's second order pressure expression for the normal momentum equation, a simplified form of the viscous shock layer (VSL) equations is obtained. This approach can solve both the subsonic and supersonic regions of the shock layer without a starting solution for the shock shape. Since the method is fully viscous, the problems associated with coupling a boundary-layer solution with an inviscid-layer solution are avoided. This procedure is significantly faster than the parabolized Navier-Stokes (PNS) or VSL solvers and would be useful in a preliminary design environment. Problems associated with a previously developed approximate VSL technique are addressed. Surface heat transfer and pressure predictions are comparable to both VSL results and experimental data. The present technique generates its own shock shape as part of its solution, and therefore could be used to provide more accurate initial shock shapes for higher-order procedures which require starting solutions.
Author

A91-43452*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

VISCOUS EQUILIBRIUM COMPUTATIONS USING PROGRAM LAURA

FRANCIS A. GREENE (NASA, Langley Research Center, Hampton, VA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 12 p. refs

(AIAA PAPER 91-1389) Copyright

The Langley Aerothermodynamic Upwind Relaxation Algorithm (LAURA) has been modified to compute viscous equilibrium flow. Periodic calls to the thermodynamic and transport property curve-fits enable solutions to be computed for small percentage increase in computer time when compared with perfect gas times. The code is used to compute the hypersonic flow over slender and blunt cones, and solutions are compared with other computational techniques and flight data.
Author

A91-43453#

NUMERICAL SIMULATION OF HYPERSONIC VISCOUS FLOW FOR THE DESIGN OF H-II ORBITING PLANE (HOPE). II

YUKIMITSU YAMAMOTO (National Aerospace Laboratory, Chofu, Japan) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 27 p. refs

(AIAA PAPER 91-1390) Copyright

Three-dimensional upwind flux-split Navier-Stokes codes are applied to hypersonic flow around new models of HOPE. Numerical results were compared with experimental data of HWT and shock tunnel at NAL. In order to enlarge the applicability of CFD for more practical designing purposes, the gas jet injection and the effects of rudder and elevon deflections is investigated numerically. In order to study the aerodynamic environments of high Mach number area of HOPE flight trajectory, Mach number and real gas effects are analyzed by using the chemical nonequilibrium code, which is developed by combining finite-rate chemical reactions to the current perfect gas flux-split code. A fully implicit ADI scheme is used to avoid the stiffness problem of time integration process. In the present paper, this nonequilibrium code is further applied to the analysis of Orbitor Re-entry Experiments (OREX), which is to be conducted to gather aerothermodynamic data, before the scheduled HOPE first flight. These works have been done as the joint research of NAL and NASDA.
Author

A91-43494*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ENHANCEMENTS TO THE HIGH SPEED CONVECTIVE HEATING AND VISCOUS DRAG PREDICTION TECHNIQUES OF THE AERODYNAMIC PRELIMINARY ANALYSIS SYSTEM (APAS)

CHRISTOPHER I. CRUZ and WALTER C. ENGELUND (NASA, Langley Research Center, Hampton, VA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 10 p. refs

(AIAA PAPER 91-1435)

APAS is an interactive computer program that allows a user to quickly estimate the aerodynamic characteristics of aerospace and aeronautical vehicles throughout the speed range using a single geometry definition. This report documents the major differences between the high speed analysis portion of the APAS and the Mark III version of the hypersonic arbitrary-body program from which it has evolved and compares convective heating and viscous drag results from the APAS with CFD results, experimental data, and flight data.
Author

A91-43501#
AN APPROACH TO AERODYNAMIC CHARACTERISTICS OF LOW RADAR CROSS-SECTION FUSELAGES
JIAZHENG PAN, YIFEI WANG, and CAIWEN ZHANG (Institute of Pilotless Aircraft, People's Republic of China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956), vol. 23, June 1991, p. 7-13. In Chinese, with abstract in English. refs

The low-speed aerodynamic characteristics were investigated for three 'panel' polygonal-cross-section fuselage models and compared with those of a circular-cross-section fuselage model. Results of tunnel tests and engineering evaluations at angles of attack up to 50 deg show that polygonal-cross-section fuselages are better than the circular-section fuselages both with respect to stealth characteristics (lower radar cross section) and to aerodynamic characteristics including the lift force and the maximum lift-drag ratio. Moreover, it is shown that the polygonal-cross-section fuselages can produce larger steady sideforces than those produced by the circular-section fuselage at high angles of attack and zero sideslip and that the produced angle of attack is lower than that of circular-section fuselage. I.S.

A91-43502#
A PRIMARY STUDY OF REYNOLDS NUMBER EFFECT IN TRANSONIC FLOW
KEMING CHENG (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956), vol. 23, June 1991, p. 14-19. In Chinese, with abstract in English. refs

The macroscopic manifestations of Re number effect (ReNE) are summarized, and the analysis of the ReNE is made from physical insight and boundary layer equations. Examination shows that ReNE is essentially realized by interfering with the evolution of boundary layer, which is collectively reflected in the influence of Re number on separation and, rather in general, on the location and the scale of shock wave-boundary layer interaction region. This is a natural aspect of the ReNE. The influence of Re number on the gas dynamics parameters, for instance, the center location of pitching moment, is carried out by this approach. The action of the ReNE is not isolated, and, to some extent, is restricted by other flow conditions, such as flight Mach number and body shape, from which an idea concerning the control of the ReNE is proposed. Author

A91-43510#
AN APPROXIMATE COMPUTATION METHOD TO COMPUTE LOW-SPEED AERODYNAMIC CHARACTERISTICS OF WING WITH SEPARATION
JUNZHENG ZHU Nanjing Aeronautical Institute, Journal (ISSN 1000-1956), vol. 23, June 1991, p. 116-120. In Chinese, with abstract in English.

An approximate method is presented to compute low-speed aerodynamic characteristics of high-middle aspect ratio and low sweep angle wing with separation. For given plane forms and geometrical angles of attack wing, the linear lifting surface theory is used to compute the first value of spanwise lift and the moment distribution of wing, and the linear lifting surface theory is applied to the computation of the downwash flow field. So, the effective angle of attack is obtained at each wing section. According to known effective angles of attack and Reynolds number, the corresponding second value of spanwise lift and the moment distribution of wing is obtained from experimental data of airfoil aerodynamic characteristics. Iteration is done again and again until convergence is reached. Author

A91-43547*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STUDY OF CLUSTER FORMATION AND ITS EFFECTS ON RAYLEIGH AND RAMAN SCATTERING MEASUREMENTS IN A MACH 6 WIND TUNNEL
B. SHIRINZADEH, M. E. HILLARD, A. B. BLAIR, and R. J. EXTON (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 17 p. refs
(AIAA PAPER 91-1496) Copyright

Using a frequency-doubled Nd-YAG pulsed laser and a single-intensified CCD camera, Rayleigh scattering measurements have been performed to study the cluster formation in a Mach 6 wind tunnel at NASA Langley Research Center. These studies were conducted both in the free stream and in a model flow field for various flow conditions to gain an understanding of the dependence of the Rayleigh scattering (by clusters) on the local pressures and temperatures in the facility. Using the same laser system, simultaneous measurements of the local temperature have also been performed using the rotational Raman scattering of molecular nitrogen and determined the densities of molecular oxygen and nitrogen by using the vibrational Raman scattering from these species. Quantitative results are presented in detail with emphasis on the applicability of the Rayleigh scattering for obtaining quantitative measurements of molecular densities both in the free stream and in the model flow field. Author

A91-43554*# California Univ., Berkeley.
A STUDY OF FLOW SEPARATION ON AN ASPECT RATIO THREE FLAP AT MACH NUMBER 2.4
MICHAEL D. COON and GARY T. CHAPMAN (California, University, Berkeley) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 20 p. refs
(Contract NCA2-446)
(AIAA PAPER 91-1620) Copyright

Static pressure distributions and dark central ground interferometry are used to document the flow on a flap over a range of Reynolds numbers and deflection angles. The pressure profiles and interferograms are analyzed to distinguish laminar, transitional and turbulent flows in attached, incipient and separated cases. Sideplates are used to compare two and three dimensional effects. Data is also presented for extended flaps used to isolate the effect of the trailing edge expansion. The issues of unsteadiness and hysteresis are also addressed. Author

A91-43555# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A PARAMETRIC STUDY OF THE LEADING EDGE ATTACHMENT LINE FOR THE F-16XL
JOLEN FLORES, EUGENE TU (NASA, Ames Research Center, Moffett Field, CA), BIANCA ANDERSON, and STEPHEN LANDERS (NASA, Flight Research Center, Edwards, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 14 p. refs
(AIAA PAPER 91-1621) Copyright

A three-dimensional Navier-Stokes code is used to computationally simulate the flow about a modified F-16XL. Transition mechanisms (e.g. attachment line location and crossflow instability) near the swept wing leading edge are analyzed in detail. Flow visualization is used to study the influence of angle-of-attack on the aforementioned transition mechanisms. Validation of the code is accomplished by comparison of numerically generated surface pressures with that obtained by in-flight experiments. Author

A91-43556*# Naval Postgraduate School, Monterey, CA.
NAVIER-STOKES SOLUTIONS FOR AN OSCILLATING DOUBLE-DELTA WING
JOHN A. EKATERINARIS (U.S. Navy-NASA Joint Institute of Aeronautics, Moffett Field, CA) and LEWIS B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 11 p. Research sponsored by U.S. Navy-NASA Joint Institute of Aeronautics. refs
(AIAA PAPER 91-1624) Copyright

An upwind-biased implicit scheme is used to investigate steady-state and unsteady Navier-Stokes solutions of the vortical flow over a double-delta wing configuration. The governing equations are solved numerically with a fully upwind, implicit, iterative, and factorized numerical scheme. Steady-state solutions for fixed angles of attack and unsteady solutions for a sinusoidal oscillatory motion are obtained. The steady-state solutions on the baseline grid are in agreement with the experiment, and grid refinements show some improvements of the predictions. The higher-order accuracy of the present scheme yields equivalent solutions on smaller grid densities compared to solutions obtained with a second-order accurate method on larger grids. As the angle of attack increases, the grid resolution requirements for adequate resolution of the leeward-side vortical flowfield become very severe. The unsteady solutions are in general agreement with the measurements and show a qualitative correlation with the experiment. P.D.

A91-43557#
AIRFOILS ADMITTING NON-UNIQUE SOLUTIONS OF THE EULER EQUATIONS
ANTONY JAMESON (Princeton University, NJ) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 14 p. Research sponsored by DARPA and IBM Corp. refs
(AIAA PAPER 91-1625) Copyright

Some airfoils that admit nonunique solutions of the Euler equations are presented. The calculations, which were performed on very fine meshes, strongly indicate that even when the production of entropy by shock waves is properly included in the mathematical model, nonuniqueness may still occur and may exhibit hysteresis in certain narrow bands of Mach number and angle of attack. They also provide a warning that optimization does not necessarily lead to a good design. The benefits that might be obtained by using an optimization method depend greatly on the use of good judgment in the choice of the cost function. P.D.

A91-43558#
COMPUTATIONAL FLUID DYNAMICS IN THE DESIGN OF THE YF-23 ATF PROTOTYPE
RICHARD J. BUSCH, JR. (Northrop Corp., Aircraft Div., Hawthorne, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 24 p. refs
(AIAA PAPER 91-1627)

An overview of the use of Computational Fluid Dynamics Methods during the design and development of the Northrop/McDonnell Douglas YF-23 is presented. A description of the methods is provided, as well as a rationale for their selection as appropriate for project design applications. Selected applications of the CFD methods to the YF-23 design are presented. Computed results are validated with test data. Author

A91-43559*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLIGHT TEST AND NUMERICAL SIMULATION OF TRANSONIC FLOW AROUND YAV-8B HARRIER II WING
LIE-MINE GEA, WEI J. CHYU, MICHAEL W. STORTZ, ANDREW C. ROBERTS (NASA, Ames Research Center, Moffett Field, CA), and CHUEN-YEN CHOW (Colorado, University, Boulder) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 16 p. refs
(Contract NCC2-630)
(AIAA PAPER 91-1628)

A computational fluid dynamics (CFD) method is used to study the aerodynamics of the YAV-8B Harrier II wing in the transonic region. A numerical procedure is developed to compute the flow field around the complicated wing-pylon-fairing geometry. The surface definition of the wing and pylons were obtained from direct measurement using theodolite triangulation. A thin-layer Navier-Stokes code with the Chimera technique is used to compute flow solutions. The computed pressure distributions at several span stations are compared with flight test data and show good agreement. Computed results are correlated with flight test data that show the flow is severely separated in the vicinity of the wing-pylon junction. Analysis shows that shock waves are induced by pylon swaybrace fairings, that the flow separation is much stronger at the outboard pylon and that the separation is caused mainly by the crossflow passing the geometry of wing-pylon junction. Author

A91-43561*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TRIM ANGLE MEASUREMENTS IN FREE-FLIGHT FACILITIES
LESLIE A. YATES and ETHIRAJ VENKATAPATHY (NASA, Ames Research Center, Moffett Field; Eloret Institute, Palo Alto, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 14 p. refs
(Contract NCC2-583; NCC2-420)
(AIAA PAPER 91-1632)

The aerodynamic cofficients and trim angle for an aerobrake at Mach 9.2 and 11.8 were found using a combination of experiment and computation. Free-flight tests were performed at NASA Ames Research Center's Hypervelocity Free-Flight Aerodynamic Facility, and the forebody pressure distribution was calculated using a three-dimensional Navier-Stokes code with an effective specific heat ratio. Using the computed drag, lift, and moments to prescribe the number of terms in the aerodynamic coefficient expansions and to specify the values of the higher order terms, the experimental aerodynamic coefficients and trim angle were found using a six-degree-of-freedom, weighted, least-squares analysis. The experimental and computed aerodynamic coefficients and trim angles are in good agreement. The trim angle obtained from the free-flight tests, 14.7 deg, differs from the design trim angle, 17 deg, and from the Langley wind tunnel results, 12 deg in air and 17 deg in CF4. These differences are attributable to real-gas effects. Author

A91-43562*# Naval Air Development Center, Warminster, PA.
POTENTIAL FLOW APPLICATIONS TO COMPLEX CONFIGURATIONS
A. CENKO, W. TSENG (U.S. Navy, Naval Air Development Center, Warminster, PA), and M. MADSON (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-1634)

Recent advances in CFD methods have enabled the analytic calculation of the carriage loads for stores mounted on complex aircraft. The latest results have demonstrated excellent agreement with test data for the F-15 at M = 0.98. However, in a preliminary design environment, the necessity of generating and validating a Euler grid to fit the aircraft and store arrangement may not be feasible, particularly when effects of configuration changes are considered. For that reason alternative approaches which require less time to arrive at an answer deserve consideration. The paper presents the results of a study to determine if potential flow solutions can give acceptable estimates of store carriage loads at transonic speeds in a timely manner. Author

A91-43563*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLIGHT EXPERIMENTS MEASURING BOUNDARY-LAYER DISTURBANCES IN LAMINAR FLOW AND CORRELATION WITH STABILITY ANALYSIS
CYNTHIA C. LEE, CLIFFORD J. OBARA (NASA, Langley Research Center, Hampton, VA), PAUL M. VIJGEN (High Technology Corp., Hampton, VA), and MICHAEL S. WUSK (Analytical Services and Materials, Inc., Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 22 p. refs
(AIAA PAPER 91-1635) Copyright

Flight test results are reported from an experiment designed to study the detailed growth of disturbances in the laminar boundary layer. A gloved wing section incorporating closely-spaced flush-mounted streamwise-located instrumentation for measuring instability frequencies and amplitude growths as well as pressure distributions was used. The growth of Tollmien-Schlichting (T-S) and crossflow instabilities is predicted by the linear e exp n method and compared to the measured boundary-layer disturbance frequencies. The predictions showed good agreement with the measured data. The results exhibited fair agreement with previous n(T-S) and n(CF) flight correlations for several of the conditions analyzed. It is inferred from the high n(T-S) values for these data that moderately swept wings at compressible speeds can withstand higher combinations of n(T-S) and n(CF) values and still remain laminar than previously thought. P.D.

A91-43564*# High Technology Corp., Hampton, VA.
COMPRESSIBLE STABILITY OF GROWING BOUNDARY LAYERS USING PARABOLIZED STABILITY EQUATIONS
CHAU-LYAN CHANG, MUJEEB R. MALIK (High Technology Corp., Hampton, VA), GORDON ERLEBACHER, and M. Y. HUSSAINI (NASA, Langley Research Center; ICASE, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 22 p. refs
(Contract NAS1-18240; NAS1-18605)
(AIAA PAPER 91-1636) Copyright

The parabolized stability equation (PSE) approach is employed to study linear and nonlinear compressible stability with an eye to providing a capability for boundary-layer transition prediction in both 'quiet' and 'disturbed' environments. The governing compressible stability equations are solved by a rational parabolizing approximation in the streamwise direction. Nonparallel flow effects are studied for both the first- and second-mode disturbances. For oblique waves of the first-mode type, the departure from the parallel results is more pronounced as compared to that for the two-dimensional waves. Results for the Mach 4.5 case show that flow nonparallelism has more influence on the first mode than on the second. The disturbance growth rate is shown to be a strong function of the wall-normal distance due to either flow nonparallelism or nonlinear interactions. The subharmonic and fundamental types of breakdown are found to be similar to the ones in incompressible boundary layers. P.D.

A91-43565*# Vigyan Research Associates, Inc., Hampton, VA.
ASSESSMENT OF MEANFLOW SOLUTIONS FOR INSTABILITY ANALYSIS OF TRANSITIONING FLOWS
VENKIT IYER (Vigyan, Inc., Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 16 p. refs
(Contract NAS1-18585)
(AIAA PAPER 91-1638) Copyright

Meanflow solutions of 3D supersonic flow past a cone at incidence and a swept leading edge wing have been obtained by thre methods, viz., boundary-layer, parabolized Navier-Stokes, and thin shear-layer Navier-Stokes solvers. The smoothness and accuracy of the solution profiles are compared with a view to applying the meanflow solution to boundary-layer stability analysis. Author

A91-43567#
TRANSITION PREDICTIONS USING REYNOLDS-AVERAGED NAVIER-STOKES AND LINEAR STABILITY ANALYSIS METHODS
R. RADESPIEL, K. GRAAGE, and O. BRODERSEN (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-1641) Copyright

The coupling of a 2D Navier-Stokes solver with a linear stability analysis method for laminar boundary layers is investigated in order to allow predictions of airfoil flows including transition due to Tollmien-Schlichting waves. The first part of the investigations covers the numerical accuracy of the laminar boundary layers computed by the Navier-Stokes solver and its effect on the stability predictions. Then, results for coupled computations of time-averaged flow fields and transition are compared to wind tunnel data. It is found that airfoil drag values are correctly predicted for varying angle of attack and Reynolds number. Author

A91-43571*# High Technology Corp., Hampton, VA.
WAVES PRODUCED FROM A HARMONIC POINT SOURCE IN A SUPERSONIC BOUNDARY LAYER
P. BALAKUMAR and M. R. MALIK (High Technology Corp., Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 25 p. refs
(Contract NAS1-18240)
(AIAA PAPER 91-1646) Copyright

The disturbance wave pattern produced by a harmonic point source in a compressible flat-plate boundary layer is computed using linear stability theory and direct numerical integration approach. Receptivity coefficients are computed for the spectrum of spanwise modes generated at the source. The effect of boundary layer growth on the development of linear waves is determined by using the method of multiple scales. Results are presented for Mach numbers of 0, 2, 4.5, and 7. It is found that disturbances spread in wedge-shaped regions behind the source and the wedge angle decreases with Mach number. The lateral spreading angle for the instability waves turns out to be quite close to the angle found experimentally for turbulence lateral contamination. Author

A91-43572*# Analytical Services and Materials, Inc., Hampton, VA.
SECONDARY INSTABILITY OF HIGH-SPEED FLOWS AND THE INFLUENCE OF WALL COOLING AND SUCTION
NABIL M. EL-HADY (Analytical Services and Materials, Inc., Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 21 p. refs
(Contract NAS1-19320)
(AIAA PAPER 91-1647) Copyright

The periodic streamwise modulation of the supersonic and hypersonic boundary layers by a two-dimensional first-mode or second-mode wave makes the resulting base flow susceptible to a broad-band spanwise-periodic three-dimensional type of instability. The principal parametric resonance of this instability (subharmonic) has been analyzed using Floquet theory. The effect of Mach number and the effectiveness of wall cooling or wall suction in controlling the onset, the growth rate, and the vortical structure of the subharmonic secondary instability are assessed for both a first-mode and a second-mode primary wave. Author

A91-43574#
CFD COMPUTATIONS FOR AERO-OPTICAL ANALYSIS OF SUPERSONIC SHEAR LAYERS
STEPHEN C. CHAN and ROBERT P. ROGER (Teledyne Brown Engineering, Huntsville, AL) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 13 p. refs
(AIAA PAPER 91-1659) Copyright

This paper presents the approach and some results of the CFD component of a laboratory test program designed to investigate aero-optical effects of coolant shear layers above hypersonic interceptor seeker windows. CFD is used to design a dual nozzle test chamber as well as for pre-test measurements planning and post-test data analysis. Test measurements provide mean and fluctuating flowfield quantities and optical data. Post-test CFD results also serve as input to a wave-optics aero-optical code which provides analytical results to compare to the optics test data. A multispecies, nonreacting flow formulation, employing a flux-difference splitting algorithm, is used to model the supersonic dual nozzle test chamber. Computed results for chamber shock structures and shear layer characteristics compare well with initial test data. In addition, CFD predictions of the near wall shear for interceptor flight environments and for the laboratory test chamber conditions show that the tests in fact simulate flight conditions very well. Author

A91-43575*# Rockwell International Science Center, Thousand Oaks, CA.
NUMERICAL STUDY OF JUNCTURE FLOWS
CHUNG-LUNG CHEN (Rockwell International Science Center, Thousand Oaks, CA) and CHING-MAO HUNG (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26,

1991. 12 p. Rockwell International Corp.-sponsored research. refs
(AIAA PAPER 91-1660) Copyright

The present paper describes a computational study of laminar/turbulent and subsonic/supersonic horseshoe vortex systems generated by a cylindrical protuberance mounted on a flat plate. Various vortex structures are predicted and discussed. Low-speed laminar juncture flows are computed to determine the Reynolds number effect with the same incoming boundary-layer thickness. For a low subsonic laminar flow, the number of vortex arrays increases with the Reynolds number, in agreement with both experimental and numerical observations. Qualitative comparisons are made along with the computations, experimental observations, and analytical work. For incompressible flow, the relationships among pressure extrema, vorticity, and singular points in flow structure are discussed. A parametric study of the effect of the free-stream Mach number on the flow structure for laminar flow is conducted. The juncture flow when the incoming flow is turbulent and supersonic is computed. P.D.

A91-43577#
ON THE USE AND THE ACCURACY OF COMPRESSIBLE FLOW CODES AT LOW MACH NUMBERS
G. VOLPE (Grumman Corporate Research Center, Bethpage, NY) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. DARPA-sponsored research. refs
(AIAA PAPER 91-1662) Copyright

The accuracy and performance of three two-dimensional compressible flow codes at free-stream Mach numbers as low as 0.001 are examined. Two of the codes employ a finite-volume discretization scheme along with a multistage time-stepping algorithm to solve the Euler equations. The two codes differ in their respective use of cell-centered and node-centered differencing schemes. The third code uses an implicit finite-difference procedure to solve the unsteady Navier-Stokes equations. Computational test cases are the inviscid steady flow over a circular cylinder and the impulsively-started viscous flow over a cylinder. Errors in the numerical results are presented as functions of mesh size and computational Mach number. It is shown that for certain classes of problems, the compressible codes can be sufficiently accurate to predict flow features at essentially incompressible speeds and that they can be adequately efficient since there is no need to lower excessively the computational Mach number in order to extract these results. Author

A91-43580#
THREE-DIMENSIONAL UPWINDING NAVIER-STOKES CODE WITH K-EPSILON MODEL FOR SUPERSONIC FLOWS
KHALED S. ABDOL-HAMID (Analytical Services and Materials, Inc., Hampton, VA), KENJI UENISHI, and WILLIAM TURNER (GE Aircraft Engines, Cincinnati, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-1669) Copyright

The application of a new-generation PAB3D code for solving the 3D Navier-Stokes and k-epsilon turbulence model equations is discussed. In the present work, the Jones-Launder high/low Reynolds number form of the k-epsilon equations are extended to 3D form. The present PAB3D (with k-epsilon) code with its multiblock/multizone capability appears to be well suited for the study of complex 3D configurations. High-order-accuracy upwind schemes are used to predict both the mean flow and turbulence independent variables. Different supersonic and subsonic flow problems are simulated and compared with experimental data to show the capabilities of the present code. Author

A91-43584#
COMBUSTING FLOW SIMULATIONS OF DETONATION AND SHOCK-INDUCED COMBUSTION WAVES FOR RAM ACCELERATOR CONFIGURATIONS WITH VISCOUS EFFECT
C. CHUCK, S. EBERHARDT, and D. T. PRATT (Washington, University, Seattle) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-1674) Copyright

The possibility of using shock-induced combustion or an oblique detonation wave in hypersonic air-breathing engines has been investigated during the last few years. Numerical solutions of detonation/laminar boundary-layer and shock-deflagration/laminar boundary-layer interactions in ram accelerator configurations are presented. In this work, the Navier-Stokes' equations with a 7 species combustion model are cast into a conservation law form so that imbedded discontinuities are captured without oscillations. The algorithm developed employs either a new implicit method or the point-implicit TVD MacCormack method. Exothermic calculations performed using the new implicit method are identical to results obtained using the point implicit method with more than 20 percent reduction in CPU time. A small region of flow separation is observed in one case where the detonation wave interacts with the boundary-layer at the projectile surface. Under all the given conditions, there is no evidence that unsteady flow results from the interaction of the shock-deflagration or detonation wave system and the boundary-layer. Author

A91-43587#
COMPARISONS OF NUMERICAL AND EXACT SOLUTIONS FOR OBLIQUE DETONATIONS WITH STRUCTURE
JOSEPH M. POWERS and MATTHEW J. GRISMER (Notre Dame, University, IN) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 15 p. University of Notre Dame-supported research. refs
(AIAA PAPER 91-1677) Copyright

Numerical predictions of the two-dimensional, inviscid, supersonic, reactive flow of a calorically perfect ideal gas over a straight wedge are compared with the predictions of a linear asymptotic model valid in the hypersonic limit. Solution features predicted by the asymptotic model include a curved shock attached to the wedge tip, a reaction layer parallel to the shock, and a vorticity layer parallel to the wedge surface. For sufficiently high Mach number and heat release, the numerical model predicts similar behavior, and the differences in the predictions of the two methods are of the same order of magnitude as the inherent error of the asymptotic method. As heat release is lowered and Mach number held constant, apparent numerical artifacts obscure features predicted by the asymptotic method. The results suggest that the asymptotic solution has utility as a benchmark to verify the predictions of many high-speed, multidimensional, reacting flow codes. Author

A91-43588#
BLOCK-STRUCTURED COMPUTATION OF THREE-DIMENSIONAL TRANSONIC EULER EQUATIONS
AKIN ECER and ALI D. CAN (Purdue University, Indianapolis, IN) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. Research supported by GE Aircraft Engines and IBM Corp. refs
(AIAA PAPER 91-1679) Copyright

A block-structured solution developed for three-dimensional transonic flows around complex geometries, utilizing a block-relaxation scheme is reported. The scheme corresponds to the utilization of an implicit solution scheme for each block together with explicit iterations on the boundary conditions between the neighboring blocks; the scheme can be adopted for parallel processing to process each block simultaneously. It is observed that the characteristics of individual flow regions have to be considered in order to solve a large problem efficiently, and the relaxation parameter guarantees the stability of the inner block solutions while interlocking balancing parameters maintain the stability of interblock solutions. Parallel computers can be used where a different level of computational effort is required for different flow regions. V.T.

A91-43589*# Old Dominion Univ., Norfolk, VA.
AN EFFICIENT METHOD FOR ESTIMATING NEIGHBORING STEADY-STATE NUMERICAL SOLUTIONS TO THE EULER EQUATIONS
ARTHUR C. TAYLOR, III, GENE W. HOU, and VAMSHI M. KORIVI (Old Dominion University, Norfolk, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 22 p. refs
(Contract NSF DMC-86-57917; NAG1-1265)
(AIAA PAPER 91-1680) Copyright

The paper concentrates on a linear approximation method for predicting the changes occurring in steady-state numerical solutions of the Euler equations as a consequence of small changes in the independent variables which control the problem. The importance of proper boundary-condition treatment and other issues concerning the problem are covered along with the importance of proper algorithm selection for a fully supersonic inviscid flow. The method is applied to a subsonic nozzle involving variation of the pressure on the outflow boundary and to a supersonic inlet involving variation of the inflow Mach number. In the subsonic test case, the comparisons between the predicted and conventional numerical solutions are shown to be good, while in the supersonic test case, the agreement between the approximation method and conventional numerical solution starts out well but rapidly degenerates at some point in the flowfield as the perturbation of the boundary conditions is increased. V.T.

A91-43590*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A QUANTITATIVE STUDY OF UNSTEADY COMPRESSIBLE FLOW ON AN OSCILLATING AIRFOIL
L. W. CARR (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), M. S. CHANDRASEKHARA (U.S. Naval Postgraduate School, Monterey, CA), and N. J. BROCK (Aerometrics, Sunnyvale, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 17 p. Research supported by U.S. Navy and U.S. Army. refs
(Contract AF-AFOSR-ISSA-89-0067; AF-AFOSR-MIPR-90-0012)
(AIAA PAPER 91-1683) Copyright

Detailed interferometric measurements of the flow near the leading edge of an oscillating airfoil offer the first detailed experimental quantification of the locally compressible flow field that surrounds an oscillating airfoil at moderate subsonic Mach numbers. Interferograms obtained by a specially adapted real-time point-diffraction interferometry technique have revealed significant characteristics of this complex, and very rapidly varying, locally supersonic flow. Instantaneous pressure distributions determined from these interferograms document the effect of unsteadiness on the leading-edge flow environment. Author

A91-43595*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL PERFORMANCE ESTIMATES FOR A GENERIC HYPERSONIC FOREBODY
SCOTT L. LAWRENCE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 16 p. refs
(AIAA PAPER 91-1695) Copyright

The computation of a hypersonic flow past the forebody of a hypersonic vehicle is analyzed for two sets of flow conditions: the first represents flow conditions of an experimental test of the model in the Calspan 96-inch shock tunnel, and the second set is chosen to represent actual flight conditions. Solutions are derived for sharp- and blunt-nose versions of the geometry in order to understand the effects of the entropy layer on the forebody pressure and heat transfer rates. Some sensitivity of predicted heating rates to grid refinement is observed, but it is found to be small compared to the effects of bluntness. Real-gas effects are studied for the blunt-nose version at flight-like conditions, and these effects are found to have a significant effect on inlet-face performance measures such as mass capture and kinetic energy efficiency. V.T.

A91-43598#
A MULTIDOMAIN EULER CODE APPLIED TO HYPERSONIC FLOWS
J. L. DA COSTA, PH. GUILLEN (ONERA, Chatillon, France), and J. V. HACHEMIN AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 13 p. refs
(AIAA PAPER 91-1699) Copyright

A multidomain approach coupled to a time-dependent or a space marching strategy is applied to the computation of several hypersonic flow fields. A code based on an explicit/implicit finite-volume method using structured grids is presented. This multidomain Euler code is applied to the analysis of the hypersonic behavior of spacecraft like Hermes or launchers like Ariane 5. A delta-wing case is also considered in order to show the ability of the code to simulate vortex zones accurately. It is demonstrated that a large number of discretization nodes are needed in order to get a reasonable grid resolution in vortex regions, and that space marching multidomain strategy seems adequate for computing more complex configurations and can take into account the viscous effects in only one domain just near the body. V.T.

A91-43602#
MULTIGRID SOLUTION OF HYPERSONIC FLOWS USING RATIONAL RUNGE-KUTTA SCHEME
KOJI MORINISHI (Kyoto Institute of Technology, Japan) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-1703) Copyright

Explicit finite-difference solutions of hypersonic flows for reentry problems are presented. The spatial derivatives fo the Navier-Stokes equations are discretized by the central finite-difference approximations. The artificial dissipation models based on the second and fourth differences are added. The upwind TVD dissipation model of Yee (1987) is also considered for comparison. The two-stage rational Runge-Kutta method is used for the time stepping scheme. The facilities of the scheme are examined for hypersonic flows over a double ellipse and a double ellipsoid at an angle of attack of 30 deg. The central difference scheme with the artificial dissipation models gives the converged solutions even at a high Mach number of 25. The upwind TVD model predicts a shock wave sharply, while the convergence rate of the model is slower than those of the artificial dissipation models. The rational Runge-Kutta scheme for the compressible Navier-Stokes equations is confirmed to be reliable even for the analyses of hypersonic flows. Author

A91-43604*# Maryland Univ., College Park.
A NUMERICAL STUDY OF THE FLOW ESTABLISHMENT TIME IN HYPERSONIC SHOCK TUNNELS
JANG-YEON LEE and MARK J. LEWIS (Maryland, University, College Park) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 15 p. NASA-supported research. refs
(AIAA PAPER 91-1706) Copyright

This paper presents a numerical study of unsteady hypersonic viscous flows in 2D hypersonic shock tunnels. The numerical experiments on the combined nozzle/model flows, utilizing the configurations mounted in the test section of a 14.7-long shock tunnel, which has a design Mach number of Me = 6 and a stagnation temperature of T(0) = 3063 R, have been performed by solving the 2D Navier-Stokes equations with an ADI-type TVD scheme. The flow establishment times around aerodynamic models, such as a flat plate, a biconvex airfoil, thin and thick double wedges, and a circular cylinder, are calculated and compared. The analysis shows that, for the most severely separated case of a circular cylinder, the flow becomes stabilized within about 8 msec including the starting process, and its nondimensional flow establishment time is 46. The flow establishment time increases with increasing length of the separated region and decreases with increasing freestream velocity. Author

A91-43612#
MIXING ENHANCEMENT IN COMPRESSIBLE MIXING LAYERS - AN EXPERIMENTAL STUDY
E. M. FERNANDO and S. MENON (Quest Integrated, Inc., Kent, WA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 14 p. refs
(Contract F33615-88-C-2904; F33615-89-C-2931)
(AIAA PAPER 91-1721) Copyright

This paper presents results from an experimental study of mixing enhancement in compressible mixing layers. In this study, helium was injected at Mach 1.0 from a tangential slot injector at a backward-facing step into a Mach 2.5 airstream. The tests consisted of studying the influence of various geometries of the splitter plate between the two streams on the growth rate of the resulting mixing layer. The results indicate that the splitter plate geometry can significantly enhance the observed mixing layer growth rates. The geometry that gave the greatest mixing enhancement resulted in a twofold increase in the mixing layer thickness over the reference flat splitter plate case. Author

A91-43614#
ON THE CONVECTION VELOCITY OF TURBULENT STRUCTURES IN SUPERSONIC SHEAR LAYERS
PAUL E. DIMOTAKIS (California Institute of Technology, Pasadena) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 22 p. refs
(Contract AF-AFOSR-88-0155; AF-AFOSR-90-0304)
(AIAA PAPER 91-1724) Copyright

The study deals with the estimation of the convection velocity of turbulent vortical structures in low-Mach-number supersonic shear layers. It is assumed that, for low supersonic convective Mach numbers, shocks will form in one of the two shear-layer free streams. The strength of the shocks are estimated, and the convection velocity and associated convective Mach numbers are calculated by matching the estimated total pressure at the stagnation points in the convective frame. It is concluded that good quantitative estimates for the observed values of the convective Mach number can be obtained, if it does not contradict the empirical stream selection rule suggesting that shocks will be borne by the low-speed stream, if it is subsonic. It is suggested that the existence of an elliptic region may be responsible for constraints which can override the principle of stationarity as viewed in a vortex-fixed frame in which the dynamics can be described in terms of temporal growth. V.T.

A91-43615*# North Carolina State Univ., Raleigh.
EVALUATION OF A THREE-DIMENSIONAL NAVIER-STOKES SOLVER FOR TRANSONIC FLOW OVER A LOW-ASPECT-RATIO WING MOUNTED IN A WIND TUNNEL
WILLIAM E. MILHOLEN, II, NDAONA CHOKANI (North Carolina State University, Raleigh), PIERCE L. LAWING, and JULIO CHU (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 22 p. refs
(Contract NCC1-98)
(AIAA PAPER 91-1725) Copyright

A three dimensional Navier-Stokes solver is evaluated for transonic flow over a thin, swept, low-aspect ratio wing. The computational study was undertaken in support of a wind tunnel experimental program. The computational results are compared to experimental surface pressure data obtained in a cryogenic wind tunnel with an adaptive wall test section. The results show favorable agreement over a wide range of conditions, further the numerical results provide additional data of the complex three-dimensional flow field. Differences in the predictions and experiment suggest a need to conduct further experiments to evaluate the adaptive wall testing technique, and to model the tunnel sidewall boundary layer in the computations. Author

A91-43617#
A NUMERICAL STUDY OF COMPRESSIBLE VISCOUS FLOW IN A NOVEL EXHAUST SYSTEM
MADHAVAN NARAYANAN, SUSAN X. YING (Florida State University, Tallahassee), CHOUDARY R. BOBBA, and JAMES L. YOUNGHANS (GE Aircraft Engines, Cincinnati, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 8 p. refs
(AIAA PAPER 91-1728) Copyright

A numerical method is applied to investigate the flow physics inside an unconventional converging-diverging nozzle. The simulation is performed for both a slotted ejector nozzle and a baseline nozzle. Results show good agreement with experimental data. The detailed flow visualization on numerical solutions reveals complex patterns of shockwave/viscous flow interactions due to the primary flow and jets. Additionally, the numerical solutions show significant differences in the flow physics in these nozzles. Author

A91-43619*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A POWERED LIFT EXPERIMENT FOR CFD VALIDATION
KARLIN R. ROTH (NASA, Ames Research Center, Moffett Field, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-1731) Copyright

The transitional flight characteristics of a geometrically simplified STOVL aircraft configuration were measured in the NASA Ames 7- by 10-Foot Wind Tunnel. The experiment is the first in a sequence of tests designed to provide detailed data for evaluating the capability of computational fluid dynamics methods to predict the important flow parameters for powered lift. The model consists of a 60-deg delta wing planform with two circular high-pressure air jets located in a blended fuselage. The measured flows have a maximum freestream Mach number of 0.2. The flow is sonic and at ambient temperature in both jets. The data presented include forces and moments measured using an internal balance, pressures measured at the 281 surface pressure ports, and jet pressures and temperatures. Measurements of the flow are also made in the tunnel test section upstream and downstream of the model and at the jet exists to provide boundary conditions for the planned computations. Author

A91-43629#
DETAILED MEASUREMENTS ON UNSTEADY PROPERTIES IN THREE-DIMENSIONAL SHOW WAVE/TURBULENT BOUNDARY LAYER INTERACTION INDUCED BY BLUNT FIN AT MACH NUMBER 4
SHIGERU ASO (Kyushu University, Fukuoka, Japan), SEISHI KURANAGA (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan), and MASANORI HAYASHI (Nishinippon Institute of Technology, Fukuoka, Japan) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-1755) Copyright

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

A91-43631*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
3-D NAVIER-STOKES ANALYSIS OF CROSSING, GLANCING SHOCKS/TURBULENT BOUNDARY LAYER INTERACTIONS
D. R. REDDY (NASA, Lewis Research Center, Cleveland, OH)

AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 13 p. Previously announced in STAR as N91-24130. refs
(Contract NAS3-25366)
(AIAA PAPER 91-1758) Copyright

Three dimensional viscous flow analysis is performed for a configuration where two crossing and glancing shocks interact with a turbulent boundary layer. A time marching 3-D full Navier-Stokes code, called PARC3D, is used to compute the flow field, and the solution is compared to the experimental data obtained at the NASA Lewis Research Center's 1 x 1 ft supersonic wind tunnel facility. The study is carried out as part of the continuing code assessment program in support of the generic hypersonic research at NASA Lewis. Detailed comparisons of static pressure fields and oil flow patterns are made with the corresponding solution on the wall containing the shock/boundary layer interaction in an effort to validate the code for hypersonic inlet applications. Author

A91-43632*# Rutgers Univ., New Brunswick, NJ.
ON THE QUASI-CONICAL FLOWFIELD STRUCTURE OF THE SWEPT SHOCK WAVE-TURBULENT BOUNDARY LAYER INTERACTION
DOYLE D. KNIGHT and DIAS BADEKAS (Rutgers University, New Brunswick, NJ) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 20 p. NASA-sponsored research. refs
(Contract AF-AFOSR-86-0266)
(AIAA PAPER 91-1759) Copyright

The swept oblique shock-wave/turbulent-boundary-layer interaction generated by a 20-deg sharp fin at Mach 4 and Reynolds number 21,000 is investigated via a series of computations using both conical and three-dimensional Reynolds-averaged Navier-Stokes equations with turbulence incorporated through the algebraic turbulent eddy viscosity model of Baldwin-Lomax. Results are compared with known experimental data, and it is concluded that the computed three-dimensional flowfield is quasi-conical (in agreement with the experimental data), the computed three-dimensional and conical surface pressure and surface flow direction are in good agreement with the experiment, and the three-dimensional and conical flows significantly underpredict the peak experimental skin friction. It is pointed out that most of the features of the conical flowfield model in the experiment are observed in the conical computation which also describes the complete conical streamline pattern not included in the model of the experiment. V.T.

A91-43633# Texas Univ., Austin.
AN EXPERIMENTAL/COMPUTATIONAL STUDY OF HEAT TRANSFER IN SHARP FIN INDUCED TURBULENT INTERACTIONS AT MACH 5
P. E. RODI, D. S. DOLLING (Texas, University, Austin), and DOYLE D. KNIGHT (Rutgers University, New Brunswick, NJ) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 17 p. Research supported by USAF and U.S. Navy. refs
(Contract NGT-50172)
(AIAA PAPER 91-1764) Copyright

Sharp fin induced shock wave/turbulent boundary layer interactions at Mach 5 were investigated. The experimental measurements included mean surface heat transfer and mean pressure distributions and surface flow visualization for fin angles of attack of 8- and 16-deg. Time averaged conical Navier-Stokes calculations have been performed for these cases using the Baldwin-Lomax turbulence model. Author

A91-43634*# Calspan Corp., Buffalo, NY.
STUDIES OF SHOCK/SHOCK INTERACTION ON SMOOTH AND TRANSPIRATION-COOLED HEMISPHERICAL NOSETIPS IN HYPERSONIC FLOW
M. S. HOLDEN, K. M. RODRIGUEZ (Calspan Corp., Buffalo, NY), and R. J. NOWAK (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 81 p. refs
(Contract NAS1-18570; NAG1-1138)
(AIAA PAPER 91-1765)

Experimental studies are conducted to examine the utilization of transpiration cooling to reduce the peak-heating loads in areas of shock/shock interaction. Smooth and transpiration-cooled nosetip models, 12 inches in diameter, were employed in these studies, which focused on defining the pressure distributions and heat transfer in type III and IV interaction areas. Transpiration cooling was determined to significantly increase the size of the shock layer and to move the peak-heating point around the body. A transpiration-cooling rate of more than 30 percent of the freestream maximum flux did not lower the peak-heating level more than 10 percent, but the integrated heating loads were reduced. R.E.P.

A91-43635#
NUMERICAL INVESTIGATION ON SHOCK WAVE/BOUNDARY-LAYER INTERACTIONS IN A CONSTANT AREA DIFFUSER AT MACH 3
PEI LIN, G. V. R. RAO, and GEORGE M. O'CONNOR (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 13 p. refs
(Contract F33657-87-C-2214)
(AIAA PAPER 91-1766) Copyright

On the basis of the numerical results obtained by the present simulation of Mach 3 supersonic flow subject to back-pressure in a constant-area planar duct, an interpretation of the formation of an oblique shock train and shock wave/boundary-layer interaction is presented. The effect of confinement is examined by varying the entrance flow with boundary layer-profile thickness. While the shock train length remains nearly unchanged at lower back pressure, it increases with momentum thickness at higher back pressure. For a given back-pressure value, higher Mach numbers result in greater shock-diamond span, in association with shorter overall shock length. A potential instability is identified around the wall pressure plateaus, where the shock length changes with small variations in back pressure. O.C.

A91-43638*# Analytical Services and Materials, Inc., Hampton, VA.
OPPORTUNITIES FOR APPLICATIONS OF NATURAL LAMINAR FLOW TECHNOLOGY AT HIGH-SUBSONIC SPEEDS
JEFF VIKEN, W. PFENNINGER (Analytical Services and Materials, Inc., Hampton, VA), R. D. WAGNER, and F. S. COLLIER, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 44 p. refs
(AIAA PAPER 91-1773)

The possible profiles of high subsonic speed airfoils with extensive regions of natural laminar flow (NLF) are explored, on the bases of calculations which suggest that high subsonic Mach number NLFs are obtainable for both swept and unswept wing applications at certain Reynolds numbers. Attention is given to the transonic pressure distributions of airfoils for unswept wings at freestream Mach numbers of 0.65-0.80 and chord Reynolds numbers of up to 50 million. The case of 10-30 deg swept-wing NLF airfoils is also investigated for chord Reynolds numbers of 15-50 million. O.C.

A91-43642*# DCW Industries, La Canada, CA.
PROGRESS IN HYPERSONIC TURBULENCE MODELING
DAVID C. WILCOX (DCW Industries, Inc., La Canada, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 15 p. NASA-supported research. refs
(Contract DAAL03-89-C-0032)
(AIAA PAPER 91-1785) Copyright

A compressibility modification is developed for k-omega (Wilcox, 1988) and k-epsilon (Jones and Launder, 1972) models, that is similar to those of Sarkar et al. (1989) and Zeman (1990). Results of the perturbation solution for the compressible wall layer demonstrate why the Sarkar and Zeman terms yield inaccurate skin friction for the flat-plate boundary layer. A new compressibility term is developed which permits accurate predictions of the compressible mixing layer, flat-plate boundary layer, and shock separated flows. I.S.

A91-43643*# Old Dominion Univ., Norfolk, VA.
APPLICATION OF A REYNOLDS STRESS TURBULENCE MODEL TO A SUPERSONIC HYDROGEN-AIR DIFFUSION FLAME
R. CHANDRASEKHAR and S. N. TIWARI (Old Dominion University, Norfolk, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs
(Contract NAG1-423)
(AIAA PAPER 91-1786) Copyright
A second-order differential Reynolds Stress turbulence model has been applied to the Favre-averaged Navier-Stokes equations for the study of supersonic flows undergoing hydrogen-air chemical reactions. An assumed Beta Probability Density Function is applied to account for the chemical source terms in the conservation equations. An algebraic Reynolds Flux model is used for the fluctuating density-velocity as well as the species mass fraction-velocity correlations. The variances of temperature and species fluctuations are also modelled using an algebraic flux technique. A seven-species, seven-reaction finite rate chemistry mechanism is used to simulate the combustion processes. The resulting formulation is validated by comparison with experimental data on reacting supersonic axisymmetric jets. Results obtained for specific conditions indicate that the effect of chemical reaction on the turbulence is significant. Author

A91-43646#
FLOW FIELD STRUCTURE AND DEVELOPMENT NEAR THE ROOT OF A STRAIGHT WING PITCHING AT CONSTANT RATE
SCOTT J. SCHRECK (U.S. Air Force Academy, Colorado Springs, CO), GREGORY A. ADDINGTON, and MARVIN W. LUTTGES (Colorado, University, Boulder) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 14 p. USAF-sponsored research. refs
(AIAA PAPER 91-1793)
A straight wing having rectangular planform and a NACA 0015 cross section was attached to a circular splitter plate. This configuration was dynamically pitched at constant rate about the wing quarter chord to angles exceeding the static stall angle. Flow near the right angle corner formed by the juncture of the wing and splitter plate was characterized in detail using surface pressure measurements and flow visualization. Both types of data showed that the leading edge vortex extended into the juncture region where it underwent profound three-dimensional alterations to convection rate and cross-section. These modifications to leading edge vortex behavior were accompanied by prominent spanwise variations in stall angle and normal force coefficient. When appropriately correlated, visualization results and pressure data suggest physical mechanisms that might account for these modified kinematics. Author

A91-43647*# Old Dominion Univ., Norfolk, VA.
EFFECTS OF LEADING-EDGE FLAP OSCILLATION ON UNSTEADY DELTA WING FLOW AND ROCK CONTROL
OSAMA A. KANDIL and AHMED A. SALMAN (Old Dominion University, Norfolk, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 15 p. refs
(Contract NAG1-648)
(AIAA PAPER 91-1796) Copyright
The isolated and interdisciplinary problems of unsteady fluid dynamics and rigid-body dynamics and control of delta wings with and without leading-edge flap oscillation are considered. For the fluid dynamics problem, the unsteady, compressible, thin-layer Navier-Stokes (NS) equations, which are written relative to a moving frame of reference, are solved along with the unsteady, linearized, Navier-displacement (ND) equations. The NS equations are solved for the flowfield using an implicit finite-volume scheme. The ND equations are solved for the grid deformation, if the leading-edge flaps oscillate, using an ADI scheme. For the dynamics and control problem, the Euler equation of rigid-body rolling motion for a wing and its flaps are solved interactively with the fluid dynamics equations for the wing-rock motion and subsequently for its control. A four-stage Runge-Kutta scheme is used to explicitly integrate the dynamics equation. Author

A91-43648*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
LASER VELOCIMETRY MEASUREMENTS OF OSCILLATING AIRFOIL DYNAMIC STALL FLOW FIELD
M. S. CHANDRASEKHARA (NASA, Ames Research Center, Moffett Field; U.S. Navy-NASA Joint Institute of Aeronautics, Monterey, CA) and S. AHMED (MCAT Institute, San Jose, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 13 p. Research supported by U.S. Army, USAF, and U.S. Navy. refs
(AIAA PAPER 91-1799) Copyright
Ensemble-averaged two-component velocity measurements over an airfoil experiencing oscillatory dynamic stall under compressibility conditions were obtained. The measurements show the formation of a separation bubble over the airfoil that persists till angles of attack close to when the dynamic stall vortex forms and convects. The fluid attains mean velocities as large as 1.6 times the free stream velocity with instantaneous values of 1.8 times the free stream velocity. The airfoil motion induces these large velocities in regions that are far removed from the surface. Author

A91-43649#
SUPERSONIC VISCOUS FLOW CALCULATIONS FOR AXISYMMETRIC, TWO AND THREE-DIMENSIONAL CONFIGURATIONS
P. K. KHOSLA, T. E. LIANG, S. G. RUBIN, and M. HAGENMAIER (Cincinnati, University, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. refs
(Contract AF-AFOSR-90-0096)
(AIAA PAPER 91-1802) Copyright
An efficient pressure based flux split numerical scheme for the reduced form of the Navier-Stokes equations has been considered for the computation of supersonic flows. Both shock fitting and shock capturing procedures have been considered. A Mach number range of 1.4 to 15 has been investigated for flow over axisymmetric surface cavities, for base flow with and without a propulsive jet and for two-dimensional compression ramps. The results are in agreement with other calculations and available experimental data. A form of 'laminar flow breakdown' has been observed for a surface trough geometry. Author

A91-43650*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MACH 3.5 BOUNDARY-LAYER TRANSITION ON A CONE AT ANGLE OF ATTACK
RUDOLPH A. KING (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 14 p. refs
(AIAA PAPER 91-1804)
Boundary-layer transition on a sharp 5-deg half-angle cone at incidence was investigated at Mach 3.5 in NASA's Supersonic Low-Disturbance Pilot Tunnel. The tests were conducted with low and high levels of freestream acoustic disturbance, and four angles of attack (alpha/theta-c = 0, 0.12, 0.4, and 0.8). Transition data, obtained with and without significantly reduced freestream acoustic disturbance levels, are compared with conventional ('noisy') wind-tunnel data. It was found that, under quiet flow conditions, there was no significant unit Reynolds number effect, whereas with noisy flow conditions, a significant unit Reynolds number effect was measured on and near the windward ray for alpha/theta-c values 0.4 and 0.8. I.S.

A91-43651#

VORTICAL FLOWS ABOUT A LONG CYLINDER AT M = 3.5 AND ALPHA = 18 DEG

T. HSIEH, A. B. WARDLAW, JR. (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD), and T. J. BIRCH (Royal Aerospace Establishment, Bedford, England) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 15 p. Research supported by Ministry of Defence Procurement Executive. refs
(AIAA PAPER 91-1808)

Numerical and experimental investigations are described of a 15-caliber ogive cylinder with a nose fineness of 3 at Mach 3.5, angle of attack of 18 deg and Reynolds number of 4 million per foot. Laminar and turbulent solutions are obtained and computed surface pressure are compared to measurement along the entire model. Also, calculated crossflow plane pitot pressures are compared to experimental surveys at stations 5.5 and 11.5 calibers from the nose. These surveys indicate that the leeside flowfield structure contains the usual vortex, shear layer emanating from the separation point, and weak crossflow shock windward of the vortex. In addition, a pressure gradient atop the leeside vortex at the 5.5 caliber station is visible which develops into a shock at the 11.5 caliber station. These features are predicted by the numerical solutions. For reason not fully understood, the laminar solution is in better agreement with the experiment than the turbulent one and captures some details of the complicated crossflow pitot pressure profiles. Author

A91-43652#

NUMERICAL INVESTIGATION OF THE EFFECTS OF BLOWING ON HIGH ANGLE OF ATTACK FLOW OVER DELTA WINGS

D. FINDLAY, S. KERN (U.S. Navy, Naval Air Development Center, Warminster, PA), and O. KWON (Georgia Institute of Technology, Atlanta) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 18 p. refs
(AIAA PAPER 91-1809)

A numerical investigation of leading edge blowing as a method to influence the main vortex generated over a slender swept wing at a high angle of attack is performed for a simple delta wing and a complete wing-body-nacelle configuration. Predictions from Navier-Stokes and Euler solutions are compared against a baseline of no blowing for each arrangement. During certain conditions a significant influence on vortex strength and location has been demonstrated. It is shown that an ability to influence the vortex flow field of a swept wing by imposing blowing through a slot along a portion of the wing leading edge is possible. R.E.P.

A91-43653#

NUMERICAL SIMULATION OF THE UNSTEADY VORTEX STRUCTURE OVER A DELTA WING

RAYMOND E. GORDNIER and MIGUEL R. VISBAL (USAF, Wright Laboratory, Wright-Patterson AFB, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 14 p. refs
(AIAA PAPER 91-1811) Copyright

The structure of the shear layer which emanates from the leading edge of a 76 deg sweep delta wing and forms the primary vortex is investigated numerically. The flow conditions are M(infinity) = 0.2, Re = 50,000 and angle of attack of 20.5 deg. Computational results are obtained using a Beam-Warming type algorithm. The existence of a Kelvin-Helmholtz type instability of the shear layer which emanates from the leading edge of the delta wing is demonstrated. A description is provided of the three-dimensional, unsteady behavior of the small-scale vortices associated with this instability. The numerical results are compared qualitatively with experimental flow visualization exhibiting a similar behavior. Author

A91-43654#

HIGH ANGLE OF ATTACK AERODYNAMICS OF A GLIDE VEHICLE

J. P. NARAIN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 16 p. Research sponsored by Lockheed Missiles and Space Co., Inc. refs
(AIAA PAPER 91-1813) Copyright

The NASA-Ames F3D Navier-Stokes solver has been modified to include a multi-block scheme, wake dominated flow field effects, and equilibrium air real gas effects for high altitude maneuvering vehicles. The algebraic Renormalization Group theoy turbulence model is also incorporated in the program. The numerical predictions are compared against the test data for a hypersonic glide vehicle. The correlations are excellent for all angles of attack. Author

A91-43655#

NUMERICAL SIMULATION OF VORTEX BREAKDOWN OVER A DELTA WING

W. P. WEBSTER and JOSEPH S. SHANG (USAF, Wright Laboratory, Wright-Patterson AFB, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-1814)

Vortex breakdown over a 70-deg delta wing at alpha = 33 deg and Re = 400,000 has been simulated numerically using the Navier-Stokes equations. Unsteady vortex breakdown began at 30 percent root chord. The instantaneous position of the vortex core formed a spiral, the 'sense' of which was counter to the rotational direction of the primary vortex. When observed over time, the spiral traced an elliptically shaped region which extended into the wake to 1.30 root chords. Time-averaged flowfield quantities were compared to experimenal data and were seen to be fairly good. The time-averaged flowfield resembled a 'bubble' type of vortex breakdown while the instantaneous flowfield appeared to be the 'spiral' type. Author

A91-43656*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

VORTEX BREAKDOWN IN A SUPERSONIC JET

ANDREW D. CUTLER and BRIAN S. LEVEY (NASA, Langley Research Center; George Washington University, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 14 p. refs
(Contract NCC1-24; NAS1-18458)
(AIAA PAPER 91-1815) Copyright

This paper reports a study of a vortex breakdown in a supersonic jet. A supersonic vortical jets were created by tangential injection and acceleration through a convergent-divergent nozzle. Vortex circulation was varied, and the nature of the flow in vortical jets was investigated using several types of flow visualization, including focusing schlieren and imaging of Rayleigh scattering from a laser light sheet. Results show that the vortical jet mixed much more rapidly with the ambient air than a comparable straight jet. When overexpanded, the vortical jet exhibited considerable unsteadiness and showed signs of vortex breakdown. I.S.

A91-43657*# Purdue Univ., West Lafayette, IN.

THE VORTEX INTERACTION IN A PROPELLER/STATOR FLOW FIELD

R. T. JOHNSTON and J. P. SULLIVAN (Purdue University, West Lafayette, IN) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 9 p. NASA-supported research. refs
(AIAA PAPER 91-1818) Copyright

The vortex interaction encounered in the flow field of a propeller and a stator has been investigated using smoke flow visualization. A stator at angle of attack was used to generate a line vortex which interacted with the helical vortex filaments generated by a propeller. Changes in the relative vortex strengths and vortex rotational directions yielded several distinct vortex structures. Axial flow in the vortex cores is determined to influence the development of the vortex interaction. Author

A91-43658#
INTERACTION BETWEEN A VORTEX DOMINATED WAKE AND A SEPARATED FLOWFIELD
N. M. KOMERATH, J.-M. KIM, and S.-G. LIOU (Georgia Institute of Technology, Atlanta) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs
(Contract DAAL03-88-C-0003)
(AIAA PAPER 91-1819) Copyright

The interaction between a rotor wake and the separated flow downstream of an axisymmetric back-step is considered, as a basic representation of higher-order aerodynamic interactions around rotorcraft. The velocity and surface pressure fields are related to previous flow visualization results. The major visualized features are confirmed by azimuth-resolved velocity data and vorticity contours which are phase-linked to the rotor. Vortex interaction features are also seen clearly in the azimuth-resolved surface pressure. A secondary, counter-rotating vortical structure appears downstream of the tip vortex. While the blade frequency is the primary temporal descriptor of the problem, multiple time scales do occur, with pressure spectra showing peaks at the shear layer natural frequencies, the rotor frequency, and their harmonics. Instability of the tip vortex trajectories causes a large spectral peak at the rotor frequency. Vortex interaction with the boundary layer generates local unsteadiness, as seen from histograms of velocity taken during 0.5-deg azimuth intervals. Author

A91-43659#
THE LAMINAR HORSESHOE VORTEX SYSTEM FORMED AT A CYLINDER/PLATE JUNCTURE
MIGUEL R. VISBAL (USAF, Wright Laboratory, Wright-Patterson AFB, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 17 p. refs
(AIAA PAPER 91-1826)

A computational study of steady and periodic laminar horseshoe vortex flows generated upstream of a cylinder/flat plate juncture is presented. The flow fields are simulated utilizing the full three-dimensional unsteady Navier-Stokes equations and a time-accurate implicit algorithm. For the case of a single primary vortex, a new type of laminar horseshoe vortex topology is identified and found to be independent of the computational grid. In the new topology, the foremost line of coalescense is an attachment rather than a separation line. This unusual feature shows that convergence of skin-friction lines is a necessary but not sufficient condition for separation. R.E.P.

A91-43675#
TIME DEPENDENT CALCULATIONS USING MULTIGRID, WITH APPLICATIONS TO UNSTEADY FLOWS PAST AIRFOILS AND WINGS
ANTONY JAMESON (Princeton University, NJ) AIAA, Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-26, 1991. 14 p. refs
(AIAA PAPER 91-1596) Copyright

The study focuses on the use of a multigrid scheme as a driver for a fully implicit time stepping scheme in such cases where there are large variations in mesh sizes, and the use of an explicit scheme would result in a severe restriction on the time step. Both two- and three-dimensional unsteady flows past moving bodies are considered, and the Euler equations are formulated in a general moving coordinate system allowing for deformation as well as displacement of the mesh. It is demonstrated that the multigrid implicit scheme can be used for calculating unsteady flows in the flutter regime with 24 to 36 time steps in each oscillation period, corresponding to Courant numbers larger than 4000 in the smallest mesh cell. V.T.

A91-44048#
A NUMERICAL STUDY OF SURGE AND ROTATING STALL IN AXIAL COMPRESSORS
H. ISHII and Y. KASHIWABARA (Hitachi, Ltd., Mechanical Engineering Research Laboratory, Tsuchiura, Japan) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-1896) Copyright

This paper briefly summarizes the features of surge and rotating stall in multistage axial compressors based on test results in a 17-stage compressor. Additionally, it proposes a numerical model for both surge and rotating stall, which expands on the previous fundamental model and aims at a more accurate representation of surge and rotating stall for practical applications. The model deals with the full set of fluid equations for two-dimensional unsteady compressible flow in the axial and circumferential directions throughout the compressor. A set of differential equations is solved by the Galerkin procedure for the angular variable and the finite difference method for axial and time variables. The basic function and validity of the proposed model are examined by numerical simulation of both surge and rotating stall in a model compressor and by comparison with test results in single-stage compressors. Author

A91-44091#
AERODYNAMIC CHARACTERISTICS OF MACH-3 AIR-INTAKE TESTED IN SUPERSONIC WIND TUNNEL
R. YANAGI, S. SHINDO, A. MURAKAMI, K. SAKATA (National Aerospace Laboratory, Tokyo, Japan), S. HONAMI (Tokyo, Science University, Japan) et al. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 8 p.
(AIAA PAPER 91-2011) Copyright

The present experimental investigations of ramp-type supersonic air intakes address the requirements of prospective SST, HST, and transatmospheric vehicles employing airbreathing propulsion systems. In addition to studying pressure recovery, these efforts have given attention to flow path flow patterns, using visualization techniques. The test results obtained illustrate the internal compression effect obtainable by means of cowl and throat terminal shock waves, and its importance to aerodynamic performance and stability. Also critical is an air-bleed system for avoidance of boundary-layer separation. O.C.

A91-44093#
DESIGN AND DEVELOPMENT OF A COMPACT BIFURCATED TURBOPROP INLET
A. B. BARTA, W. A. BENNETT, B. R. VITTAL, and M. R. KRISHNAN (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-2017) Copyright

A compact bifurcated turboprop inlet was successfully designed and developed for low total pressure loss and distortion, and for removing foreign objects from the engine flow path analytical tools were used to create and analyze the basic 3D branched flow path. The inlet was further developed experimentally with a 40 percent scale model using quantitative measurements and flow visualization. The judicious use of computational fluid dynamics tools in conjunction with experimental testing and development can result in a successful design. Author

A91-44097#
EFFECTS OF STREAMWISE PRESSURE GRADIENT ON THE SUCTION SURFACE BOUNDARY LAYER OF A TURBINE AIRFOIL
S. L. ELLIS, D. C. BOGARD, and M. E. CRAWFORD (Texas, University, Austin) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. Research supported by Allied Signal Aerospace Co. and USAF. refs
(AIAA PAPER 91-2030) Copyright

A wind tunnel test section was designed to simulate the effects of streamwise pressure gradient on the boundary layer developing on the suction surface of a gas turbine airfoil. This study was part of an ongoing research program investigating various aspects of turbine film cooling and is the groundwork for future studies involving film cooling effectiveness in the presence of mainstream pressure gradients. The pressure distribution under consideration was typical of those encountered on airfoils in high-pressure, high-work turbines that are currently being developed for high-performance aircraft applications. Numerical simulations were performed using the 2D boundary layer code TEXSTAN to predict the accelerating flow field in the turbine based on sponsor-supplied airfoil data. By matching the nondimensional acceleration and Reynolds numbers from the numerical simulation, a contoured roof was developed for the test section of an existing wind tunnel that would induce a flow at low speed and low temperature that is dynamically similar to the flow across the turbine blade. Experimental verification of the facility was accomplished with wall static pressure measurements and LDV velocity measurements. Author

A91-44127#

PERFORMANCE COMPARISONS OF NAVIER-STOKES CODES FOR SIMULATING THREE-DIMENSIONAL HYPERSONIC CROSSFLOW/JET INTERACTION

D. C. WEATHERLY and J. M. MCDONOUGH (Kentucky, University, Lexington) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. Research supported by McDonnell Douglas Space Systems Co. refs

(AIAA PAPER 91-2096) Copyright

The paper reports efforts to compare performance of the CFD codes RPLUS and a fully viscous modification of ARC3D in simulations of a hypersonic crossflow/jet interaction problem. The modified ARC3D code yielded a poorly developed solution after 2000 pseudotime steps. The convergence history is compared with past simulations; an improved grid and no use of the turbulence model has not removed a tendency for the solution to diverge temporarily early in the simulation. The RPLUS solution diverged rapidly in every attempted run. Contamination spreads from the jet to destroy the solution in less than ten steps. The problem may lie in the implementation of supersonic inflow boundary conditions. Author

A91-44137#

APPLICATION OF A MULTIBLOCK/MULTIZONE CODE (PAB3D) FOR THE THREE-DIMENSIONAL NAVIER-STOKES EQUATIONS

KHALED S. ABDOL-HAMID (Analytical Services and Materials, Inc., Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs

(AIAA PAPER 91-2155) Copyright

The multiblock/multizone version of the code (PAB3D) is applied to external and internal flow problems to examine its capacity for describing complex geometries. Four turbulence models and three numerical schemes for the multiblock/multizone approach are employed and an adaptive grid methodology is considered to solve the three-dimensional Navier-Stokes equations. The governing equations are solved by flux-vector-splitting and flux-difference-splitting, and the latter solves the equations globally for the steady state mode. The amount of grid generation is found to be reduced by the PAB3D, the turbulence models considered are not found to be adequately complex, and the adaptive grid methodology is employed to predict axis switching in a jet plume. A nozzle performance package is presented which can predict discharge coefficients thrust ratios for a particular axisymmetric nozzle. Flowfields for complex aerodynamic configurations can be simulated with the PAB3D and the options presented. C.C.S.

A91-44138#

INTAKES AND BOUNDARY LAYER CROSSFLOWS FOR HYPERSONIC VEHICLES

L. H. TOWNEND, T. R. F. NONWEILER, E. G. BROADBENT, J. PIKE, and G. PAGAN (Advanced Propulsion and Energy Control Systems, Ltd., Liss, England) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. Research supported by Ministry of Technology of England, USAF, and McDonnell Douglas Corp. refs

(AIAA PAPER 91-2160) Copyright

The hypersonic intake problem is essentially subject to viscous complication, since boundary layers form under adverse streamwise pressure gradients. At least at some design conditions, particular forms of allswept intakes permit the achievement of known crossflows in the boundary layer, and these controlled crossflows offer the prospect of reducing the demand for internal bleeds, subject to the acceptance of geometric constraints for example on intake sweep and the extent of compression. Analysis and CFD are applied in this paper to the design of such compression surfaces for the viscous flow of perfect and real gas - examples of application to intake-forebody and engine/airframe integration are presented. Author

A91-44164#

COMPUTATIONS OF THREE-DIMENSIONAL VISCOUS FLOWS IN TURBOMACHINERY CASCADES

YUICHI MATSUO (National Aerospace Laboratory, Chofu, Japan) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs

(AIAA PAPER 91-2237) Copyright

Three-dimensional viscous flows in turbomachinery cascades are investigated by solving time-averaged compressible Navier-stokes equations. An implicit finite difference code based on a high accuracy upwind scheme has been developed and applied to the studies of the complex flows inside both turbine and compressor blade rows. A sufficiently fine grid is employed for accuracy enhancement. Numerical results are compared with experimental data to validate the code performance, to understand the flow details and to identify the loss mechanism. Author

A91-44165#

IMPROVED TURBULENCE MODELING FOR GAS TURBINE APPLICATION

D. CHOI and C. J. KNIGHT (Textron Defense Systems, Everett, MA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. Research supported by Textron Lycoming. refs

(AIAA PAPER 91-2239) Copyright

Coakley's (1983) q-omega turbulence model equations have been studied to improve their accuracy in aerodynamic and heat-transfer analyses for flows through turbomachinery cascades in the context of high freestream turbulence, strong pressure gradient, and streamline curvature effects. Both fully turbulent and transitional two-dimensional boundary layers, with varying freestream turbulence intensity, are extensively studied based on a boundary layer code. The resulting formulation is then incorporated into a two-dimensional Navier-Stokes code for application to the midspan region of the Langston cascade. Author

A91-44173#

ON THE USE OF CFD IN HSCT INLET AND NOZZLE DESIGN

JEFFREY J. BROWN, CYNTHIA C. CLARK, DAVID M. SOMMERFIELD, and WILLIAM H. WAKELEY (Boeing Commercial Airplane Group, Seattle, WA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs

(AIAA PAPER 91-2255) Copyright

The PARC Navier-Stokes code has been found to be extremely useful in the design of high speed civil transport engine inlets and nozzles. Results of analyses are presented that show calculations of design-oriented quantities such as drag coefficient, airflow capacity, and surface loads. The analyses include an axisymmetric, mixed-compression inlet at takeoff and transonic operation, a two-dimensional, external-compression inlet at cruise, and a clamshell thrust reverser at critical operating points across the flight envelope. Author

A91-44176#

A FINITE VOLUME LAMBDA FORMULATION

F. CASALINI and A. DADONE (Bari, Universita, Italy) AIAA,

SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. Research supported by Ministero dell'Universita e della Ricerca Scientifica e Tecnologica. refs
(AIAA PAPER 91-2258) Copyright

A Finite Volume Lambda Formulation for solving Euler equations and apt to handle compressible as well as transonic flow computations is presented. The easy extension of the methodology to the solution of Navier-Stokes equations is indicated. The integration scheme is in nonconservative form in smooth flow regions, in order to take advantage of its superior accuracy and fastness, while it automatically switches to conservative form in shock regions, in order to capture them correctly. Computations of two- and three-dimensional shockless source flows prove the superior accuracy and fastness of the proposed technique in comaprison with a classical conservative upwind methodology. Moreover, computed results referring to some two- and three-dimensional test cases are compared with numerical or experimental published ones, thus showing the capabilities of the proposed formulation to deal with inviscid subsonic as well as transonic flow cases. Author

A91-44215#
C.F.D. OF THE BASE FLOW ON A PLANE BODY BETWEEN A SUBSONIC FLOW ON ONE SIDE AND A SUPERSONIC FLOW ON THE OTHER
M. J. IZADI and G. W. ZUMWALT (Wichita State University, KS) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-2372) Copyright

A computation program is developed for computing flows for a plane body that is between a subsonic flow on one side and a supersonic flow on the other side, a situation represented by the 'base' (i.e., any rearward facing surface) of a flight vehicle. It is shown this flow computation can handle flows that are either subsonic or supersonic, attached or separated. It is shown that the computed results of the wake shape, the velocities of the major streamlines, and the base pressure ratio are as expected. The method has modest computer requirements. I.S.

A91-44254# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATION OF AN UNSTEADY NAVIER-STOKES SOLVER TO TRANSONIC TURBINE DESIGN
AKIL A. RANGWALLA, NATERI K. MADAVAN (NASA, Ames Research Center; Sterling Federal Systems, Inc., Moffett Field, CA), and PAUL D. JOHNSON (Pratt and Whitney Group, West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 18 p. NASA-supported research. refs
(AIAA PAPER 91-2468) Copyright

This study presents a numerical evaluation of the performance of the first stage of a new-generation turbine design. The numerical method solves the two-dimensional Navier-Stokes equations using a system of patched grids. Three-dimensional effects of stream-tube contraction are also modeled. The study focuses on the effects of axial gap variation on the unsteady rotor-stator interactions and on stage performance. Results are presented for three different axial gaps. The results indicate that the unsteady interactions can be very large in this design. These interactions affect not only the stage efficiency but also substantially alter the time-averaged features of the flow. In particular, for the case of the smallest axial gap, it was found that there was an unsteady shock on the stator suction surface which spanned the gap region and impinged upon the moving rotor airfoils. Author

A91-44257#
NAVIER-STOKES RESULTS FOR HYPERSONIC INLET FLOWS
A. BRENNEIS and K. M. WANIE (MBB GmbH, Munich, Federal Republic of Germany) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 14 p. BMVg-supported research. refs
(AIAA PAPER 91-2472) Copyright

This paper reports on the two-dimensional numerical investigations made on the hypersonic NASA P8 inlet by using the multiblock version of the Navier-Stokes code NSFLEX. The first order in time-discretized implicit governing equations, written in conservative form, are driven to steady state by applying a point Gauss-Seidel relaxation scheme. The inviscid flux calculation, based on a linear locally one-dimensional Riemann solver (flux-difference splitting) and a modified Steger-Warming flux-vector splitting scheme to overcome flow regions with high gradients, is described. A van Albada-type sensor is employed. Diffusive fluxes are approximated with central differences. Fully vectorized curve fits for the ratio of specific heats; the temperature and the transport coefficients are incorporated to include equilibrium real gas effects. The NSFLEX analyses show the influence of the grid refinement and the numerical viscosity on the result. The adiabatic wall boundary condition changes completely the behavior of the flow field compared to the flow with prescribed wall temperature. Although the free stream total temperature is very low (811 K) real gas effects already affect the flow variables, especially the pitot pressure. Author

A91-44259*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A DESIGN STRATEGY FOR THE USE OF VORTEX GENERATORS TO MANAGE INLET-ENGINE DISTORTION USING COMPUTATIONAL FLUID DYNAMICS
BERNHARD H. ANDERSON (NASA, Lewis Research Center, Cleveland, OH) and RALPH LEVY (Scientific Research Associates, Inc., Glastonbury, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 35 p. Previously announced in STAR as N91-24131. refs
(AIAA PAPER 91-2474) Copyright

A reduced Navier-Stokes solution technique was successfully used to design vortex generator installations for the purpose of minimizing engine face distortion by restructuring the development of secondary flow that is induced in typical 3-D curved inlet ducts. The results indicate that there exists an optimum axial location for this installation of corotating vortex generators, and within this configuration, there exists a maximum spacing between generator blades above which the engine face distortion increases rapidly. Installed vortex generator performance, as measured by engine face circumferential distortion descriptors, is sensitive to Reynolds number and thereby the generator scale, i.e., the ratio of generator blade height to local boundary layer thickness. Installations of corotating vortex generators work well in terms of minimizing engine face distortion within a limited range of generator scales. Hence, the design of vortex generator installations is a point design, and all other conditions are off design. In general, the loss levels associated with a properly designed vortex generator installation are very small; thus, they represent a very good method to manage engine face distortion. This study also showed that the vortex strength, generator scale, and secondary flow field structure have a complicated and interrelated influence over engine face distortion, over and above the influence of the initial arrangement of generators. Author

A91-44260#
A NUMERICAL INVESTIGATION FOR SUPERSONIC INLET WITH THROAT CAVITY
JUNJI SHIGEMATSU (Ishikawajima-Kogyo Co., Ltd., Tokyo, Japan), KAZUOMI YAMAMOTO (National Aerospace Laboratory, Tokyo, Japan), KAZUO SHIRAISHI, and ATSUSHIGE TANAKA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-2477) Copyright

An implicit finite-difference Navier-Stoks code is developed and applied to a mixed-compression configuration with a throat cavity. The interaction between the aperture shock wave and the terminal shock wave is predicted to be the distorted shock wave observed experimentally. It is noted that the purpose of the throat cavity is to enhance inlet characteristcs such as total pressure recovery. K.K.

A91-44263#
INLET/FAN COWL DESIGN FOR INCREASED ANGLE-OF-ATTACK REQUIREMENTS OF TRANSPORT AIRCRAFT - METHODOLOGY AND TEST RESULTS
T. L. ANDREW, T. R. LEHNIG, and S. G. RAHM (GE Aircraft Engines, Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 13 p. refs
(AIAA PAPER 91-2481) Copyright

The paper describes an improved inlet/fan cowl design for subsonic transport-type aircraft, which meets more stringent low-speed and high-angle-of-attack requirements of transport aircraft than the previously tested designs, concurrent with negligible impact on cruise drag and hardware. In the development of the new design, CFD techniques were applied, including a recently reported 3D Euler solver; pertinent geometric parameters were determined using a data base of previously tested inlet designs. Results of wind tunnel testing demonstrated the improved aerodynamic performance of the redesigned inlet/fan cowl. I.S.

A91-44287#
APPLICATION OF SWEEP TO IMPROVE EFFICIENCY OF A TRANSONIC FAN. II - PERFORMANCE AND LASER TEST RESULTS
D. C. RABE, D. A. HOYING (USAF, Aero Propulsion and Power Laboratory, Wright-Patterson AFB, OH), and S. G. KOFF (Pratt and Whitney Group, West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. U.S. Navy-sponsored research. refs
(AIAA PAPER 91-2544)

In order to improve efficiency through reduced shock losses, advanced transonic fans are evolving with blade leading edge sweep. A high tip speed shroudless fan with a high degree of leading edge sweep was designed to reduce shock related losses. The steady-state performance and laser test results obtained from this advanced fan are presented. The measured spanwise performance shows an increase in efficiency in the portions of the span where the leading edge sweep is greatest. Detailed laser measurement of the intrarotor flow field identified two weak shock waves within the swept rotor. A passage shock wave is formed at the blade leading edge and follows the blade leading edge sweeep. A second shock wave forms in the throat region and is swept to a lesser degree. Because the sweep of a shock surface reduces its effective shock strength, increases in fan efficiency are possible. The high degree of sweep of these two shock waves appears to confirm that the increase in efficiency in the swept region is a result of lower shock related losses. Author

A91-44304*# McDonnell-Douglas Corp., Saint Louis, MO.
THE IMPACT OF LO-CONFIGURED FOREBODIES ON INLET APPROACH FLOWFIELDS
RAYMOND C. HADDAD, DONALD C. BINGAMAN (McDonnell Douglas Corp., Saint Louis, MO), LEWIS E. SURBER (USAF, Wright Laboratory, Wright-Patterson AFB, OH), and E. A. BARE (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 23 p. refs
(AIAA PAPER 91-2599) Copyright

The stress on low observability (LO) characteristics has directed fighter aircraft forebody configurations toward contours which generate strong vortices in the vicinity of the fuselage half-breadth, in both maneuvering and cruising flight conditions; these vortices can reduce integrated inlet performance and degrade inlet/engine compatibility. The present investigation has employed high-speed experimental flowfield surveys to characterize advanced LO-contoured fighters' inlet-approach flowfields. Attention is given to forebody angle-of-attack-induced shielding of the inlets at various Mach numbers. O.C.

A91-44318*# Duke Univ., Durham, NC.
PREDICTION OF UNSTEADY AERODYNAMIC LOADS IN CASCADES USING THE LINEARIZED EULER EQUATIONS ON DEFORMING GRIDS
KENNETH C. HALL and WILLIAM S. CLARK (Duke University, Durham, NC) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 15 p. refs
(Contract NAG3-1192)
(AIAA PAPER 91-3378) Copyright

A linearized Euler solver for calculating unsteady flows in turbomachinery blade rows due to both incident gusts and blade motion is presented. Using the linearized Euler technique, one decomposes the flow into a mean (or steady) flow plus an unsteady, harmonically varying, small disturbance flow. Linear variable coefficient equations describe the small disturbance behavior of the flow, and are solved using a pseudo-time marching Lax-Wendroff scheme. For the blade motion problem, a harmonically deforming computational rid that conforms to the motion of vibrating blades eliminates large error producing mean flow gradient terms that would otherwise appear in the unsteady flow tangency boundary condition. The paper also presents a new, numerically exact, nonreflecting far-field boundary condition based on an eigenanalysis of the discretized equations. Computed flow solutions demonstrate the computational accuracy and efficiency of the present method. The solution of the linearized Euler equations requires one to two orders of magnitude less computer time than solution of the nonlinear Euler equations using traditional time-accurate time-marching techniques. In addition, the deformable grid significantly improves the accuracy of the solution. Author

A91-44320#
AN EFFICIENT METHOD IN PREDICTING ROTOR/STATOR INTERACTION
S. H. CHEN, A. H. EASTLAND, and E. D. JACKSON (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-3380) Copyright

The turbomachine blade failures attributable to high vibratory stresses generated by stationary/rotating blade-row interactions are presently addressed by means of a frequency-domain potential paneling method for predicting the forced responses in which the rotor and stator are decoupled, and their forced responses are solved separately. The unsteady loading on the upstream blade row due to the downstream blade row is assumed to be purely potential; a pseudounsteady approach is used to avoid wake-cutting. The CPU time of this approach is only 0.01 of that for a Navier-Stokes solution and 0.1 that for an Euler finite-difference solution. O.C.

N91-25103*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LOW-SPEED, POWERED GROUND EFFECTS OF A GENERIC, HYPERSONIC CONFIGURATION
GREGORY M. GATLIN 1990 62 p
(NASA-TP-3092; L-16861; NAS 1.60:3092) Avail: NTIS HC/MF A04 CSCL 01A

A study was undertaken in the NASA Langley 14- by 22-foot subsonic tunnel to determine the low-speed aerodynamic characteristics of a powered, generic, hypersonic configuration in ground effect. The model was a simplified configuration consisting of a triangular wedge forebody, a rectangular mid-section which housed the flow through, an ejector type propulsion simulation system, and a rectangular wedge afterbody. Additional model components included a delta wing, a rectangular wedge forebody, inlet fences, exhaust flow deflectors, and afterbody fences. Aerodynamic force and moment data were obtaind over an angle of attack range from -4 to 18 degrees while model height above the tunnel floor was varied from 1/4 inch to 6 feet. Variations in freestream dynamic pressure, from 10 psf to 80 psf, and engine ejector pressure yielded a range of thrust coefficients from 0 to 0.8. Author

N91-25106*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EVALUATION OF PANEL CODE PREDICTIONS WITH EXPERIMENTAL RESULTS OF INLET PERFORMANCE FOR A 17-INCH DUCTED PROP/FAB SIMULATOR OPERATING AT MACH 0.2
D. R. BOLDMAN, C. IEK, D. P. HWANG, R. J. JERACKI, M. LARKIN, and G. SORIN (Pratt and Whitney Aircraft, East Hartford, CT.) 1991 18 p Presented at the 27th Joint Propulsion Conference, Sacramento, CA, 24-27 Jun. 1991; sponsored by AIAA, SAE, ASME, and the American Society for Electrical Engineers
(NASA-TM-104428; E-6261; NAS 1.15:104428; AIAA-91-3354) Avail: NTIS HC/MF A03 CSCL 01A

An axisymmetric panel code was used to evaluate a series of ducted propeller inlets. The inlets were tested in the Lewis 9 by 15 Foot Low Speed Wind Tunnel. Three basic inlets having ratios of shroud length to propeller diameter of 0.2, 0.4, and 0.5 were tested with the Pratt and Whitney ducted prop/fan simulator. A fourth hybrid inlet consisting of the shroud from the shortest basic inlet coupled with the spinner from the largest basic inlet was also tested. This later configuration represented the shortest overall inlet. The simulator duct diameter at the propeller face was 17.25 inches. The short and long spinners provided hub-to-tip ratios of 0.44 at the propeller face. The four inlets were tested at a nominal free stream Mach number of 0.2 and at angles of attack from 0 degrees to 35 degrees. The panel code method incorporated a simple two-part separation model which yielded conservative estimates of inlet separation. Author

N91-25107*# Purdue Univ., West Lafayette, IN. School of Aeronautics and Astronautics.
A QUIET FLOW LUDWIEG TUBE FOR STUDY OF TRANSITION IN COMPRESSIBLE BOUNDARY LAYERS: DESIGN AND FEASIBILITY Final Report, 1 May 1990 - 1 May 1991
STEVEN P. SCHNEIDER 27 Jun. 1991 34 p
(Contract NAG1-1133)
(NASA-CR-188499; NAS 1.26:188499) Avail: NTIS HC/MF A03 CSCL 01A

Laminar-turbulent transition in high speed boundary layers is a complicated problem which is still poorly understood, partly because of experimental ambiguities caused by operating in noisy wind tunnels. The NASA Langley experience with quiet tunnel design has been used to design a quiet flow tunnel which can be constructed less expensively. Fabrication techniques have been investigated, and inviscid, boundary layer, and stability computer codes have been adapted for use in the nozzle design. Construction of such a facility seems feasible, at a reasonable cost. Two facilities have been proposed: a large one, with a quiet flow region large enough to study the end of transition, and a smaller and less expensive one, capable of studying low Reynolds number issues such as receptivity. Funding for either facility remains to be obtained, although key facility elements have been obtained and are being integrated into the existing Purdue supersonic facilities. Author

N91-25108 Mississippi State Univ., Starkville.
A DRAG ANALYSIS OF THE EARLY STAGES OF LARGE-SCALE HIGH-ALTITUDE FREE BALLOON ASCENTS Ph.D. Thesis
JAMES RAYMOND CRUMP 1990 87 p
Avail: Univ. Microfilms Order No. DA9108938

A drag analysis is performed for the early stages of large scale high altitude balloon ascents. The investigation is developed through an energy method based on motion and added mass. Relations are derived for general buoyant objects and then specifically applied to actual balloon ascents. Among the results of these relations are: an added mass coefficient based on motion history; a time constant for general buoyant objects; and the effects of lifting gas uncertainty on the drag coefficient. The analysis reveals that the drag effects due to steady motion are the most significant for a majority of the early portion of ascent. Drag coefficients are obtained and the sensitivity of their value is discussed with respect to buoyancy. Actual experimental data demonstrate the abnormally high drag of these vehicles when compared to objects of similar Reynolds number. Dissert. Abstr.

N91-25110 Washington Univ., Seattle.
SELF-PROPELLED SLENDER AXISYMMETRIC BODY FLOWS: ERRORS IN THE POISSON EQUATION FIELD CALCULATION Ph.D. Thesis
PENG YIP HO 1990 173 p
Avail: Univ. Microfilms Order No. DA9109803

The present study was motivated by an interest in the interactive flow of self-propelled low drag bodies. Two approaches for finding flow solutions to the axisymmetric Poisson equation were investigated: first, by superposition of a number of simpler solutions; second, the partial differential equation were approximated by a finite difference equation. In the first approach, point sources located on the body centerline are used to model the body. Numerical experiments using this approach to model a sphere demonstrated the method's susceptibility to round-off errors which prove this technique to be unacceptable for modeling flows about high aspect ratio bodies. The accuracy of the method is sensitive to how floating point numbers and operations are treated by the machine and software. A set of guidelines for using the axial source method is proposed to avoid gross errors in the computations. In the second approach, the governing partial differential equations are expressed in terms of the stream function. The nonlinearity of the flow field is reflected in a highly nonlinear stream function field. This means that the higher order spatial derivatives of the stream function cannot be neglected with respect to the first and second order spatial derivatives in the governing equation. The truncation of these higher order terms in the finite difference approximation results in significant errors. The nonlinearity of the flow is greatest in regions that are dominated by vorticity because of the large velocity gradients. These regions include the propeller slipstream, and the viscous boundary layer. Use of higher order finite difference approximations may not reduce the truncation error because of the difficulty of maintaining consistent higher order approximation of the derivatives adjacent to the body surface. The finite difference approximation to the stream function is, therefore, an inaccurate means of modeling the high Reynolds number propeller-hull interaction phenomenon. The method is accurate for low Reynolds number flows, as the truncation error vanishes for these flows. Dissert. Abstr.

N91-25111 Maryland Univ., College Park.
DYNAMIC ANALYSIS OF ADVANCED TIP ROTORS INCLUDING THREE-DIMENSIONAL AERODYNAMICS Ph.D. Thesis
KI CHUNG KIM 1990 277 p
Avail: Univ. Microfilms Order No. DA9110317

A systematic investigation of the effects of tip sweep, anhedral, and planform taper on helicopter rotor blade response and loads is conducted using comprehensive structural and aerodynamic models. A finite element method is used for the structural analysis, and a three-dimensional (3D) finite difference aerodynamic analysis, based on unsteady transonic small disturbance theory (TSD), is used to calculate the aerodynamic loads. The blade and its tip are treated as elastic beams undergoing flap bending, lag bending, elastic twist and axial deflections. Nonlinear transformation relations based on moderate rotations are used to assemble the blade and tip elements. The blade response is calculated from nonlinear periodic normal mode equations using a finite element in time scheme. To represent the inflow distributions through the rotor disk, a free wake model is used. Dynamic stall and reverse flow effects are also included. Vehicle trim and rotor elastic response are calculated as one coupled solution using Newton's method. The blade steady response, rotor controls and blade loads are recalculated using the three dimensional lift and moment obtained from the TSD analysis. An iterative coupling scheme is developed for efficient coupling between the aeroelastic and 3D finite difference codes. Calculated results are correlated satisfactorily with flight test data obtained from the Gazelle helicopter (with a straight-tip blade) for several level flight conditions. Results are then calculated for this rotor with advanced tip shapes and the effects of 3D aerodynamics are assessed. For a high forward speed condition, there is a considerable influence of 3D aerodynamics on blade response and loads and the correlation of aerodynamic loads is improved with the inclusion of 3D aerodynamics, particularly near the outboard section of the blade. Inclusion of 3D effects in pitching moment appears quite large and helps to improve the correlation for torsional moment in the high speed case. Tip sweep introduces a kinematic axial-lag coupling induced by the centrifugal force. Dissert. Abstr.

N91-25114# National Aerospace Lab., Tokyo (Japan).
A COMPUTATIONAL AND EXPERIMENTAL ANALYSIS OF JOINED-WING AERODYNAMICS
NAOKI HIROSE, TAKESHI OHNUKI, MASAKATA HASHIMOTO, and MASAYUKI ISHIKAWA (Mitsui Engineering and Shipbuilding Co. Ltd., Tokyo, Japan) Nov. 1990 24 p In JAPANESE; ENGLISH summary
(NAL-TR-1088T; ISSN-0389-4010) Avail: NTIS HC/MF A03

Aerodynamic characteristics of a joined wing were investigated by computational methods and by a low speed wind tunnel experiment for the purpose of understanding the aerodynamic characteristics and advantages of such a wing over conventional configurations, and to examine the feasibility of using it in a practical application. Extended lifting line theory, the three dimensional potential flow panel method, and the finite difference method were used. Author

N91-25115# National Aerospace Lab., Tokyo (Japan).
VELOCITY MEASUREMENTS INSIDE THE LEADING EDGE VORTEX FORMED ON A DELTA WING
KENICHI RINOIE, AKIHITO IWASAKI, TOSHIMI FUJITA, and HIROTOSHI FUJIEDA Nov. 1990 22 p In JAPANESE; ENGLISH summary
(NAL-TR-1087; ISSN-0389-4010) Avail: NTIS HC/MF A03

Measurements were made to investigate the three dimensional structure of the leading edge vortex formed on a delta wing with a 60 degree sweep. The behavior of the vortex was studied by means of a lift measurement, surface pressure measurements and flow visualization tests. Mean velocities and velocity fluctuations were measured using a laser two focus velocimeter (L2F). The flow pattern inside the secondary separation vortex is shown from the results of the above measurements. The relationship between the mean velocities and the velocity fluctuations are also shown. Since this was the first time the L2F had been used in the NAL gust wind tunnel, the problem of the present experimental method using the L2F is discussed. Author

N91-25116# National Aerospace Lab., Tokyo (Japan).
AN INVESTIGATION OF A TWO-DIMENSIONAL HYBRID LAMINAR FLOW CONTROL AIRFOIL AT HIGH SUBSONIC FLOW. PART 1: AERODYNAMIC CHARACTERISTIC OF A BASIC AIRFOIL NLAM78
OSAMU NONAKA, YOJI ISHIDA, MAMORU SATO, and HIROSHI KANDA Aug. 1990 27 p In JAPANESE; ENGLISH summary
(NAL-TR-1076; ISSN-0389-4010) Avail: NTIS HC/MF A03

The experimentally determined aerodynamic characteristics of the NLAM 78 airfoil section, a natural-laminar airfoil, over the Mach number range 0.6 to 0.85 and angles of incidence from -1 to 4 as well as the Reynolds numbers 8, 16, and 32 million, respectively. The airfoil section was selected as the basic airfoil for the hybrid laminar flow control airfoil study, which is described. The test was executed in the NAL two dimensional transonic wind tunnel with a test section of 0.3 x 1.0 m where measurements of the static pressure on the airfoil surfaces and the wake traverse were made. The test has shown that natural laminar airfoil characteristics are maintained for a flow condition of Mach numbers as high as 0.8 and angles of incidence up to 1 degree, and that the lift to drag ratio for the condition takes very high values of 72 to 85 depending on the Reynolds number. Also, it shows that for the flow condition, the drag divergence Mach number is about 0.82 and drag creep phenomena are rarely observed. Comparisons with the flight data shows quite satisfactory agreement. Also, comparison with some supercritical airfoil with almost the same thickness ratio as the present airfoil confirms the superiority of the aerodynamic characteristics of the NLAM 78 airfoil. Author

N91-25343*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A NUMERICAL STUDY OF HYPERSONIC FOREBODY/INLET INTEGRATION PROBLEM
AJAY KUMAR *In* JHU, Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions p 131-154 Jan. 1991
Avail: NTIS HC/MF A06 CSCL 01/1

A numerical study of hypersonic forebody/inlet integration problem is presented in the form of the view-graphs. The following topics are covered: physical/chemical modeling; solution procedure; flow conditions; mass flow rate at inlet face; heating and skin friction loads; 3-D forebogy/inlet integration model; and sensitivity studies. Author

N91-26117# Virginia Polytechnic Inst. and State Univ., Blacksburg. Interdisciplinary Center for Applied Mathematics.
STATE SPACE MODELS FOR AEROELASTIC AND VISCOELASTIC SYSTEMS Final Report, 1 Jan. 1988 - 31 Dec. 1990
T. L. HERDMAN 6 Mar. 1991 10 p
(Contract AF-AFOSR-0074-88; AF PROJ. 2304)
(AD-A234730; AFOSR-91-0272TR) Avail: NTIS HC/MF A02 CSCL 01/1

We develop state space models for aeroelastic systems including unsteady aerodynamics. We establish the applicability of semigroup theory for these systems on weighted product spaces by showing well-posedness and obtaining a dissipative estimate for the infinitesimal generator of the associated Cauchy problem. Numerical techniques are developed for the singular neutral functional differential equation that model the aeroelastic systems. Also, we present a technique based on quasilinearization for identifying unknown coefficients in parabolic partial differential equations. This technique is applied to both linear and nonlinear equations with spatially varying unknown coefficients. GRA

N91-26120# Massachusetts Inst. of Tech., Cambridge.
CALCULATED AERODYNAMICS OF WINGS IN SEVERE MANEUVER Final Report, 1 May 1986 - 30 Nov. 1990
J. E. MCCUNE 18 Mar. 1991 6 p
(Contract AF-AFOSR-0157-86; AF PROJ. 2307)
(AD-A235241; AFOSR-91-0380TR) Avail: NTIS HC/MF A02 CSCL 01/1

This report briefly summarizes the overall effort concerning the aerodynamics and basic fluid mechanics of slender wings with leading-edge separation, including cases involving severe unsteady maneuver. New and efficient methods have been developed and important new insights gained in the understanding of intense wing-wake interaction. Two just-completed Ph.D. theses, which are noted, document many of the principal new contributions of this research. A complete list of publications and theses completed under the grant is included in the report. GRA

N91-26123*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
VISCOUS FLOW SIMULATIONS OF INTERNAL STORE CARRIAGE AND SEPARATION Final Report, 15 May 1991
OKTAY BAYSAL Jul. 1991 35 p
(Contract NAG1-664)
(NASA-CR-185343; NAS 1.26:185343) Avail: NTIS HC/MF A03 CSCL 01/1

The internal carriage of stores by the military aircraft is an option for possible reductions in the aerodynamic drag and the observability. Trade studies of this option require considering the aircraft and the stores together. In an effort to develop a computational fluid dynamic (CFD) code for such studies, an investigation was conducted from 1986 to 1990. The study was divided into five building-block steps. First, a full Navier-Stokes code was developed to simulate the unsteady, three-dimensional cavity flow. As the second step, this code was then used to simulate the flows past various missile configurations at angles of attack up to 44 deg. The effects of incidence as well as the turbulence on the leeside flows were computationally captured. The objective of this study has involved the interference flows of rather complex configurations with multiple, joint or disjoint, components of nonsimilar geometries. Hence, a hybrid domain decomposition (HDD) method was developed as the third step of the investigation. The strengths of the multiblock, zonal, and overlapped grids were judiciously combined and employed for the present problem. In the fourth step, the interference flow past a missile near a flat-plate wing was simulated using the HDD method. Finally, the fifth step involved the simulation of the internal store carriage and separation. Four different cases for two different configurations were simulated. The computational results of all five steps were successfully compared with the available wind tunnel test data. The unsteady aerodynamic forces on the separating store were computationally predicted. The CFD code developed for this project is called Viscous Internal Store Carriage Code (VISCC). Author

N91-26124# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
EXPERIMENTAL TECHNIQUES IN THE FIELD OF LOW DENSITY AERODYNAMICS
J. ALLEGRE, M. RAFFIN, and J. J. BERNARD, ed. (Paris VI Univ., France) Apr. 1991 60 p Original contains color illustrations
(AGARD-AG-318(E); ISBN-92-835-0613-8) Copyright Avail: NTIS HC/MF A04; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Over the course of the past few decades, space programs have engendered a great deal of experimental and theoretical research aimed at improving the understanding of the characteristics and properties of flows in rarefied gas dynamics. A few of the more common measurement techniques used in low-density wind tunnels and altitude simulation chambers, for subsonic, supersonic, and hypersonic flows at low Reynolds numbers, chiefly compatible with spacecraft reentry flight conditions, are discussed. The instrumentation used in low-density testing is fundamentally different from that which is used in conventional wind tunnels, because of the level of rarefaction of the flows, which limits the forces, pressures, and mass densities to be measured and modifies the flow viscosity and interaction conditions. The rarefaction of flows generally tends to thicken the boundary layers and changes the structure of the shock waves. Author

03

AIR TRANSPORTATION AND SAFETY

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

A91-41448
ACAS IN EUROPE - A U.K. VIEW
A. G. THORNING (Civil Aviation Authority, London, England) Journal of Navigation (ISSN 0373-4633), vol. 43, Sept. 1990, p. 404-408.
Copyright

The paper discusses the principles of the Traffic Alert and Collision Avoidance System (TCAS), which is the U.S. implementation of the Automatic Collision Avoidance System (ACAS). Special attention is given to the scope of TCAS program, the UK ACAS research program, and the various potential problems of certification. International activities for producing standards and recommended practices for airborne collision avoidance systems are briefly discussed. I.S.

A91-42783
TABS - AN AUTOMATED PRE-FLIGHT PLANNING SYSTEM
ICAO Journal (ISSN 0018-8778), vol. 46, April 1991, p. 21-24.
Copyright

The Total Aviation Briefing System (TABS) located in Toronto is a Transport Canada-approved system for automated weather and NOTAM retrieval, and computerized flight plan filing. This system obtains world-wide NOTAM and weather data from the national and international circuits and makes the processed information available in real-time to airlines, to business and general aviation, and to other governments. Attention is given to the various data links that are employed, examples of typical data products, Ethernet networks, and hardware and software configurations. The TABS software is designed in a modular manner, whereby the overall system comprises a number of logical subsystems. R.E.P.

N91-25119# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
TECHNICAL EVALUATION REPORT ON THE FLIGHT MECHANICS PANEL SYMPOSIUM ON PROGRESS IN MILITARY AIRLIFT
F. MARY May 1991 26 p Symposium held in Lisbon, Portugal, 28-31 May 1990
(AGARD-AR-300; ISBN-92-835-0619-7) Copyright Avail: NTIS HC/MF A03; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Although military transport aircraft and helicopters continue to be of increasing importance in future military operations, military transport aircraft technology has not received the same level of attention that has been directed, for example, to combat aircraft. In-service fleets of transport aircraft are also becoming physically old and technically outdated, and are less and less capable of fulfilling the more demanding mission requirements. It was therefore important and timely to review the area of military airlift and assess: the present and perceived future military roles and requirements; the required developments in technology; the extent to which civil technology applications can enhance capability; technologies for real cost reduction; and to what extent the current and future development programs in this field embody the new technologies. To accomplish this review and assessment, a Symposium was held that included sessions on operational experience and requirements; cockpit design and aircrew performance; specific technologies such as fuel, powerplant and aerodynamic design; and a review of current and new programs. Author

N91-25120# Department of the Navy, Washington, DC.
PIVOTING SEAT FOR FIGHTER AIRCRAFT Patent Application
CHI TUNG, inventor (to Navy) 26 Sep. 1990 14 p
(AD-D014822; US-PATENT-APPL-SN-589703) Avail: NTIS HC/MF A03 CSCL 01/3

A high-performance aircraft seat is disclosed that automatically reacts to recline the pilot as the aircraft experience higher G's in the vertical direction, or along the pilot's Z-axis. The seat, consisting of a seat pan joined to a seat back, is hingedly fixed, at a point forward of the pilot/seat combination center of gravity, to the surface. An hydraulic cylinder is fixed between the surface, aft of the hinge point, and the seat back and will react to return the seat to its initial position, from a G-force induced reclining position, whenever the G forces subside. GRA

N91-26125# Aeronautical Systems Div., Wright-Patterson AFB, OH.
KC-135 GROUND COLLISION AVOIDANCE SYSTEM QUESTIONNAIRE Final Report, Dec. 1989 - Mar. 1990
JUSTIN D. RUEB and JOHN A. HASSOUN Aug. 1990 40 p
(AD-A234385; ASD-TR-90-5010) Avail: NTIS HC/MF A03 CSCL 01/2

Crew Station Evaluation Facility engineers collected subjective data from a sample of 82 operational SAC crew members. The data provide information needed in the design of the Ground Collision Avoidance System (GCAS) for all KC-135 aircraft. The

GCAS is designed to alert aircrews of an impending ground impact, should current flight conditions/aircraft configuration remain unchanged. This study found that KC-135 aircrews would prefer a multi-faceted, bimodal GCAS warning system. This should consist of a light/tone or light/voice warning. The light nomenclature, altitude, and the voice message, pullup were the most preferred warning messages. The GCAS warning should be present for as long as the warning conditions exist or until the pilot activates a GCAS system reset switch. The GCAS should begin coverage from 200 ft (AGL) and remain active until 5000 ft (AGL). It should cover roll angles from zero degrees to a minimum upper limit of 45 degrees. Subject data and comments are discussed in further detail. GRA

N91-26126*# Boeing Commercial Airplane Co., Seattle, WA.
CIVIL TILTROTOR MISSIONS AND APPLICATIONS. PHASE 2: THE COMMERCIAL PASSENGER MARKET Final Report
P. THOMPSON, R. NEIR, R. REBER, R. SCHOLES, H. ALEXANDER, D. SWEET, and D. BERRY, ed. Feb. 1991 58 p
Original contains color illustrations
(Contract NAS2-12393)
(NASA-CR-177576; NAS 1.26:177576; D6-55699-1-PHASE-2)
Avail: NTIS HC/MF A04 CSCL 01/3

The commercial passenger market for the civil tiltrotor was examined in phase 2. A market responsive commercial tiltrotor was found to be technically feasible, and a significant worldwide market potential was found to exist for such an aircraft, especially for relieving congestion in urban area-to-urban area service and for providing cost effective hub airport feeder service. Potential technical obstacles of community noise, vertiport area navigation, surveillance, and control, and the pilot/aircraft interface were determined to be surmountable. Nontechnical obstacles relating to national commitment and leadership and development of ground and air infrastructure were determined to be more difficult to resolve; an innovative public/private partnership is suggested to allow coordinated development of an initial commercial tiltrotor network to relieve congestion in the crowded US Northeast corridor by the year 2000. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A91-41437
AN OMEGA/VLF RADIO COMPASS
JOHN F. KEMP Journal of Navigation (ISSN 0373-4633), vol. 43, Jan. 1990, p. 118-124. refs
Copyright

This paper discusses techniques for extracting both the positional and the directional information from the Omega network. Several approaches for using Omega-derived directional information are described. It is suggested that an Omega compass will be most useful in the case of ships, aircraft, or land vehicles operating at high latitudes where the conventional magnetic and gyro compasses are unsatisfactory. I.S.

A91-41438
GROUND-BASED 4-D GUIDANCE OF FLIGHTS IN STRONG WINDS
ANDRE BENOIT and SIP SWIERSTRA (EUROCONTROL, Brussels, Belgium) Journal of Navigation (ISSN 0373-4633), vol. 43, May 1990, p. 176-186.
Copyright

An account is given of test results bearing on the extent to which a ground-based computer program generating advisories that are fully integrated in the radar label can assist the air traffic controller in maintaining the predicted landing-timer sequence; an accuracy of more than 10 sec for each arrival is desired. Four incoming flights, landing after a U-shaped turning approach, were performed in series: two in still air, and two encountering a 50-kt head wind on the localizer (equivalent to a 100-kt wind variation in the last and most critical part of the flight). All flights met the 10-sec accuracy criterion for landing; the respective errors for a B-737 and B-757 were 3 and 9 sec in still air and 4 and 1 sec in the head wind. O.C.

A91-41439
THE EUROPEAN ATC SYSTEM - CONSTRAINTS AND TRAFFIC MANAGEMENT
PETER BROOKER (Civil Aviation Authority, London, England) (Royal Institute of Navigation, Meeting on Management of Air Traffic Flow in Europe, London, England, Nov. 15, 1989) Journal of Navigation (ISSN 0373-4633), vol. 43, May 1990, p. 187-194.
Copyright

Current problems of the air traffic control system in Europe are examined. Ideas and measures that will yield benefits in the short and medium term by the mid-1990s are explored. These include ATC sector capacity estimation, area navigation, computer-based data processing interfacing between states and Eurocontrol, more accurate short-term traffic flow rate projections, more airport capacity and airport routings, complete restructuring of the airspace to simplify air traffic control, use of airborne collision avoidance systems, ACAS, and computer simulation system modelling. V.I.

A91-41440
THE PROGRESSIVE IMPROVEMENT OF EUROPEAN FLOW-MANAGEMENT
BRIAN EDWARDS (National Air Traffic Services, London, England) (Royal Institute of Navigation, Meeting on Management of Air Traffic Flow in Europe, London, England, Nov. 15, 1989) Journal of Navigation (ISSN 0373-4633), vol. 43, May 1990, p. 195-203.
Copyright

Developments in European air traffic flow-management, techniques being used, present organization, and existing problems are defined. The question of how air traffic control system capacity is currently assessed is answered, covering topics such as the availability of new capacity, the optimization of the use of the existing route structure, and alternatives. The paper discusses the present European flow organization and its problems and central flow-management unit development as the ultimate solution. The Eurocontrol Data Bank and its functions are also discussed, and interim development phases are described. V.I.

A91-41441
THE AIRLINE'S PERCEPTION OF AIR TRAFFIC MANAGEMENT
COLIN HUME (British Airways, PLC, London, England) (Royal Institute of Navigation, Meeting on Management of Air Traffic Flow in Europe, London, England, Nov. 15, 1989) Journal of Navigation (ISSN 0373-4633), vol. 43, May 1990, p. 204-208.
Copyright

The very frustrating present situation of air traffic flow-management (ATFM) is described. Problems such as the ability to use published ATS routes and the limitations set by the European traffic orientation system, and significant improvements made within the last 18 months, such as the introduction of the Central Executive Unit, are covered. Qualified as important for the future of air traffic management are the development of a central flow-management unit under Eurocontrol, the creation of a central executive unit, internationally staffed, acting as the decision maker and executive for European traffic flows, and the establishment of a program targeted to harmonize ATC and ATFM into a single, integrated service. V.I.

A91-41442
ALTERNATIVE STRATEGIES FOR TRAFFIC FLOW-MANAGEMENT IN EUROPE
S. RATCLIFFE (Royal Institute of Navigation, Meeting on

Management of Air Traffic Flow in Europe, London, England, Nov. 15, 1989) Journal of Navigation (ISSN 0373-4633), vol. 43, May 1990, p. 209-214. refs
Copyright
Some of the principles on which en-route airspace is presently allocated are challenged, and the practical difficulties of implementing any alternative strategy are pointed out. The possibility of an alternative system in which air traffic is self-regulating when in cruise, provided that there is a means for air-to-air exchange, not only of position data but also of intention for the next 15 minutes or so of flight is considered, in addition to the possible need for an extra pilot, which includes provision of airborne data links having a capacity exceeding that of SSR Mode S or that comtemplated by the ICAO FANS study. Therefore, it is made clear that a considerable time must elapse before such a self-regulating system could be adopted. Automation of traffic surveillance and collision avoidance do not offer increase in capacity, except on a very extended time-scale. A centralized flow facility is offered as the possibility of diminishing the difficulties of airspace congestion as a semipermanent characteristic. The need for safety is considered ATC's dominant problem. V.I.

A91-41443
INTEROPERABILITY VERSUS INTEGRATION OF OMEGA AND GPS
HENRY B. SCHLACHTA and JOHN STUDENNY (Canadian Marconi Co., Montreal, Canada) (International Omega Association, Annual Meeting, 14th, Long Beach, CA, Oct. 1989) Journal of Navigation (ISSN 0373-4633), vol. 43, May 1990, p. 229-237.
Copyright
A method is proposed for the further improvement of overall accuracy and reliability of Omega-GPS navigation which encompasses the two sensors' integration, interoperability, operational modes, and Kalman filter data fusion. Interoperability makes use of data information available from all of the subsystems in order to help improve the reliability or accuracy of the entire system. Attention is given to four interoperability modes: full Omega/full GPS, full Omega/partial GPS, partial Omega/full GPS, and partial Omega/partial GPS. O.C.

A91-41446
COMPUTER-DRAWN CHARTS FOR EROPS FLIGHTS
W. P. LAWRENCE Journal of Navigation (ISSN 0373-4633), vol. 43, Sept. 1990, p. 385-390.
Copyright
A computer program, called the Extended Range Operation Planning Aid (EROPA), was developed for the use of drawing charts for extended-range operations (Erops) flights. The paper describes the rules of Erops and the way in which the EROPA program is used. The chart-drawing procedure using a desktop computer is described, with attention given to the computer requirements, the language, the chart scale, the projection, and the formulas. Particular consideration is given to the details of plotting the coastline and the meridians and parallels. A quarter-size EROPA chart for a hypothetical North Atlantic Erops flight by an aircraft with a certified rule distance of 792 n.m. is included. I.S.

A91-41447
A NEW THREAT DETECTION CRITERION FOR AIRBORNE COLLISION AVOIDANCE SYSTEMS
R. L. FORD and D. L. POWELL Journal of Navigation (ISSN 0373-4633), vol. 43, Sept. 1990, p. 391-403. Research supported by Civil Aviation Authority. refs
Copyright
A new threat detection criterion is described which provides a better match to the requirements than the well-known modified tau criterion for a civil air transport collision avoidance system. Experimental evidence is given to show that it also reduces the number of undesirable alerts. Author

A91-41825
EXPERIMENTAL X-BAND SYNTHETIC APERTURE RADAR IN AIRCRAFT [EXPERIMENTELLES X-BAND SYNTHETIK APERTUR RADAR IM FLUGZEUG]
RALF HORN and MARIAN WERNER (DLR, Institut fuer Hochfrequenztechnik, Oberpfaffenhofen, Federal Republic of Germany) IN: Radar Symposium, 7th, Ulm, Federal Republic of Germany, Oct. 10-12, 1989, Reports. Duesseldorf, Deutsche Gesellschaft fuer Ortung und Navigation, 1989, p. 59-63. In German.
Copyright
An experimental aircraft SAR for the X-band is described. The overall system, technical specifications, and experimental results are briefly reported. A block switching diagram of the system is shown. C.D.

A91-41828
CONCEPT AND RESULTS OF THE AZIMUTH QUICK-LOOK PROCESSOR FOR AIRCRAFT SAR OF THE DLR [KONZEPT UND ERGEBNISSE DES AZIMUT QUICK-LOOK PROZESSORS FUER DAS FLUGZEUG SYNTHETIK APERTUR RADAR DER DLR]
ALBERTO MOREIRA (DLR, Institut fuer Hochfrequenztechnik, Wessling, Federal Republic of Germany) IN: Radar Symposium, 7th, Ulm, Federal Republic of Germany, Oct. 10-12, 1989, Reports. Duesseldorf, Deutsche Gesellschaft fuer Ortung und Navigation, 1989, p. 113-126. In German. refs
Copyright
A real time azimuth processor has been built for the aircraft-borne E-SAR system (Experimental Radar System with Synthetic Aperture). The processor uses an unfocused correlation procedure which greatly simplifies the data processing and permits operation in real time without much use of hardware. A new algorithm has been developed which improves image parameters except for resolution and is comparable with available focused processor procedures. A number of real time images with postprocessing are shown which meet expectations and validate the algorithm. C.D.

A91-41829
SPECIFICATION OF AN INERTIAL NAVIGATION SYSTEM FOR EXPERIMENTAL SAR [SPEZIFIKATION EINES INERTIALEN NAVIGATIONSSYSTEMS FUER DAS EXPERIMENTELLE SYNTHETIK APERTUR RADAR]
STEFAN BUCKREUSS (DLR, Institut fuer Hochfrequenztechnik, Oberpfaffenhofen, Federal Republic of Germany) IN: Radar Symposium, 7th, Ulm, Federal Republic of Germany, Oct. 10-12, 1989, Reports. Duesseldorf, Deutsche Gesellschaft fuer Ortung und Navigation, 1989, p. 135-146. In German. refs
Copyright
An experimental radar system with SAR which will be operated in the L, C and X bands is discussed. The determination of allowable umcompensated disturbing motions by the system is examined, and the ways in which the strapdown inertial navigation system works are outlined. Sources of error in the motion compensation are considered, and the results of testing of an INS associated with the SAR are summarized. C.D.

A91-41834
THE DEVELOPMENT OF 'RADAR DATA QUALITY CONTROL AND RADAR ANALYSIS SUPPORT SYSTEM RDQC/RASS' [ENTWICKLUNG 'RADARDATENQUALITAETSKONTROLLE UND RADAR ANALYSIS SUPPORT SYSTEM RDQC/RASS']
B. CLOOS (Bundesanstalt fuer Flugsicherung, Frankfurt am Main, Federal Republic of Germany) IN: Radar Symposium, 7th, Ulm, Federal Republic of Germany, Oct. 10-12, 1989, Reports. Duesseldorf, Deutsche Gesellschaft fuer Ortung und Navigation, 1989, p. 283-300. In German. refs
Copyright
The U.S. FAA, together with Eurocontrol and its member states, have together developed a Radar Analysis Support System (RASS) which may develop into a standard system for radar data

evaluations. A broad overview of RASS is given and its functioning is described. The RASS software and the development status of RASS are addressed. C.D.

A91-41835
DETERMINATION OF ORIENTATION ACCURACY IN CURVED FLIGHT PATHS [ERMITTLUNG DER ORTUNGSGENAUIGKEIT BEI GEKRUEMMTEN FLUGWEGEN]
WOLFGANG MANZ (Luftwaffenamt, Cologne, Federal Republic of Germany) IN: Radar Symposium, 7th, Ulm, Federal Republic of Germany, Oct. 10-12, 1989, Reports. Duesseldorf, Deutsche Gesellschaft fuer Ortung und Navigation, 1989, p. 301-304. In German.
Copyright

The two-dimensional orientational accuracy of a long-range radar can be determined in the absence of a reference device only when the flight path is straight over large distances. As a result, there are uncertainties in the scatter and the evaluation of the radar performance. Here, a method is discussed which permits the scatter to be determined for curved paths. C.D.

A91-41851
A KNOWLEDGE-BASED TRACKER FOR AIRCRAFT FORMATIONS [WISSENSBASIERTER PULKTRACKER]
ANDREAS MUELLER (Siemens AG, Unterschleissheim, Federal Republic of Germany) IN: Radar Symposium, 7th, Ulm, Federal Republic of Germany, Oct. 10-12, 1989, Reports. Duesseldorf, Deutsche Gesellschaft fuer Ortung und Navigation, 1989, p. 539-543. In German.
Copyright

The application of knowledge-based systems (KBSs) employing fuzzy and symbolic logic to the problem of tracking close formations of aircraft (pulks) is described. The difficulties encountered by standard algorithms in the detecting a pulk, predicting its extent, recognizing the formation and assigning the individual plots to it, and extrapolating the pulk track are recalled. The KBS method, programmed in LISP and C for implementation on a computer workstation, derives new 'facts' from the target data by deduction (involving object-oriented representation with structural primitives) and then incorporates incoming plot data to treat 'missing' and 'excess' situations by applying rules based on previous knowledge of formation flight (typical pulk types, geometries, and maneuvers) and data on the current environment (sensors and local situation). D.G.

A91-41853
A RADAR-DATA COMMUNICATION NETWORK FOR ATC IN THE BENELUX NATIONS AND NORTHERN GERMANY [RADARDATENUEBERTRAGUNGSNETZ DER FLUGSICHERUNG IN BENELUX/NORDDEUTSCHLAND]
H.-J. BATZER and J. C. SHULSTAD (Bundesanstalt fuer Flugsicherung, Frankfurt am Main, Federal Republic of Germany) IN: Radar Symposium, 7th, Ulm, Federal Republic of Germany, Oct. 10-12, 1989, Reports. Duesseldorf, Deutsche Gesellschaft fuer Ortung und Navigation, 1989, p. 551-562. In German.
Copyright

Plans being developed for the rapid exchange of radar data (including target, weather, radar-station situational, and control information) among ATC facilities in northern Germany, Belgium, the Netherlands, and Luxembourg are reviewed. The main nodes of the network, scheduled for operational status in 1992, are Maastricht (Eurocontrol), Amsterdam, Brussels, Bremen, and Duesseldorf, with possible later extension to southern Germany (Frankfurt, Munich, and Karlsruhe). Particular attention is given to the ATC improvements possible with the network, alternative configurations and cost estimates, the network topology (based on 64-kb/sec lines), network capacity estimates, the radar data format (based on the Eurocontrol Radar Message Conversion and Distribution Equipment), network accessibility, data filtering, and network management. The proposed use of the same network for flight-plan data is also discussed. D.G.

A91-42780
COMBINED SATELLITE NAVIGATION SYSTEMS COULD LEAD TO MORE RELIABLE AND MORE PRECISE AIR NAVIGATION
RANDOLPH HARTMAN (Honeywell, Inc., Minneapolis, MN) ICAO Journal (ISSN 0018-8778), vol. 46, March 1991, p. 9-12.
Copyright

A joint U.S.-USSR team of technicians is preparing to flight-test integrated GPS and GLONASS equipment on a Northwest Airlines Boeing 747. The first test will begin on a route from Anchorage to Tokyo, and is designed to enable data collection over the Soviet Union. It is hoped that further system development will thus be encouraged. Issues discussed here include the GPS receiver evolution, details of GLONASS, international system integration, and future requirement development. B.J.

A91-42781#
LOW PROFILE SATCOM AIRCRAFT ANTENNA DEVELOPMENT
ICAO Journal (ISSN 0018-8778), vol. 46, March 1991, p. 16, 17.

A special-purpose high-gain aircraft antenna developed to support aeronautical satellite communications (Satcom) is reported. Main areas in which such aeronautical satellite communications will be of value to the aviation industry are outlined: air traffic control, air-ground data communications, global tracking and communications links providing ground guidance to aircraft, transmission of aircraft systems monitoring data to facilitate ground maintenance, and in-flight passenger telephone and other communications services. Constant communications are maintained by directing the antenna beam electronically toward a suitably located satellite. The antenna employs a single top-mounted radiating structure, providing upper-atmosphere coverage, and it features a built-in test equipment for the automatic monitoring and identification of over 95 pct of all possible failure modes. V.T.

N91-25121# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
KNOWLEDGE BASED SYSTEM APPLICATIONS FOR GUIDANCE AND CONTROL
Apr. 1991 259 p In ENGLISH and FRENCH The 51st symposium was held in Madrid, Spain, 18-21 Sep. 1990
(AGARD-CP-474; ISBN-92-835-0610-3) Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The overall state-of-the-art of AI applications in the guidance and control area were assessed. The papers were presented covering the following headings: representative applications; design concepts and synthesis techniques; related methods and techniques; information processing and system architecture; and mechanization and integration issues.

N91-25125# Universitaet der Bundeswehr Muenchen, Neubiberg (Germany, F.R.). Inst. fuer Systemdynamik und Flugmechanik.
KNOWLEDGE-BASED COCKPIT ASSISTANT FOR IFR OPERATIONS
R. ONKEN *In* AGARD, Knowledge Based System Applications for Guidance and Control 9 p Apr. 1991
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A knowledge-based cockpit assistant for IFR (Instrument Flight Rules) operation is presented, aimed at improvement of situation assessment and performance increase by computer aids for flight planning and plan execution. Here, situation assessment also includes monitoring of the pilot's own activities. The modular system structure is described as well as the individual system modules. The cockpit assistant was tested in a flight simulator by professional pilots under realistic IFR-scenarios. The concept of the test design as well as test results are presented. The system design goals are mainly confirmed by these results. Author

N91-25126# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugfuhrung.

CONSTRAINT MANAGEMENT REQUIREMENTS FOR ON-LINE AIRCRAFT ROUTE PLANNING

UWE TEEGEN *In* AGARD, Knowledge Based System Applications for Guidance and Control 9 p Apr. 1991

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In the future, the cooperation of pilot and controller will change. Technical advances contributing to this change are a more intelligent airborne Flight Management System (FMS) and a datalink connecting the FMS and Air Traffic Control (ATC). Against this background, concepts for an Experimental Flight Management System and its human-centered system design approach are described. Combined with a basic scenario of future Air Traffic Management (ATM) the requirements for an airborne constraint management subsystem are developed. The fundamentals of aircraft route planning and system operation including considerations on the interaction between constraint management and man-machine interface are discussed and an on-line algorithm for aircraft route planning is presented. The present state of a software prototype and the software and hardware employed are also described. Author

N91-25128# Boeing Military Airplane Development, Seattle, WA.

INTELLIGENT REAL-TIME KNOWLEDGE BASED INFLIGHT MISSION MANAGEMENT

GEORGE F. WILBER *In* AGARD, Knowledge Based System Applications for Guidance and Control 9 p Apr. 1991

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The problems and issues of developing a tactical mission manager are described. Development aspects of intelligent real-time avionics are discussed and an efficient real-time AI methodology and implementation for the development of the intelligent systems are outlined. Advanced software development techniques are also outlined and an overview of related Boeing research efforts provided. Author

N91-25137# Societe d'Applications Generales d'Electricite et de Mecanique, Cergy-Pontoise (France).

SEAN: A NAVIGATION AID EXPERT SYSTEM FOR COMBAT AIRCRAFT

D. MORILLON, T. CONTER, and M. DECREMIERS *In* AGARD, Knowledge Based System Applications for Guidance and Control 13 p Apr. 1991 In FRENCH; ENGLISH summary

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Technology of fighter aircraft equipment is in constant evolution. Increases in precision of navigation equipment, in number of available means of navigation updating and in onboard computer performance, has increased aircraft capabilities to satisfy modern mission requirements but also has complicated the copilot's tasks. SEAN (Expert System for Navigation Aiding) aboard fighters was designed to assist copilots in their choices and supervise the inertial hybrid navigation system. Use of KOD (Knowledge Oriented Design), a powerful cognitive methodology, associated with robust knowledge validation principles, has allowed development of a prototype of the expert system working with a realistic complete simulation of its onboard environment. Author

N91-25141# Synetics Corp., Wakefield, MA.

COORDINATION AND SYNCHRONIZATION OF LORAN-C AND GPS TO UNIVERSAL COORDINATED TIME Final Report, Jan. - Aug. 1989

D. H. AMOS, J. D. CATLIN, W. B. MOHIN, R. W. HELDT, and R. B. GODDARD Oct. 1989 501 p

(Contract DTCG23-86-A-20022)

(AD-A233221; R/DC-10/89; USCG-D-13-90) Avail: NTIS HC/MF A22 CSCL 17/7

Public Law 100-223, the Airport and Airway Safety and capacity Act of 1987, requires an analysis and report to Congress on the impact to current users of synchronizing loran-C secondary stations to within 100 Nanoseconds (ns) of Universal Coordinated Time (UTC), and the methods and impact of coordinating the time references of the loran-C and the Global Positioning System (GPS) systems to within 30 ns of each other. The analysis required by law is provided here. The impact on repeatable accuracy of the five loran-C chains covering the United States (excluding Alaska and Hawaii) is analyzed using the Double Range Difference (DRD) model. The model is modified to predict system repeatability in the UTC synchronized environment, when the control regimes synchronizing master and secondary stations to within 0 ns (perfect time-of-emission control), 30 ns (1σ), and 100 ns (1σ) of UTC are shown. GRA

N91-25142*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

COMPUTER AIDING FOR LOW-ALTITUDE HELICOPTER FLIGHT

HARRY N. SWENSON May 1991 24 p Presented at the 47th Annual Forum of the American Helicopter Society, Phoenix, AZ, 6-8 May 1991

(NASA-TM-103861; A-91140; NAS 1.15:103861) Avail: NTIS HC/MF A03 CSCL 17/7

A computer-aiding concept for low-altitude helicopter flight was developed and evaluated in a real-time piloted simulation. The concept included an optimal control trajectory-generated algorithm based on dynamic programming, and a head-up display (HUD) presentation of a pathway-in-the-sky, a phantom aircraft, and flight-path vector/predictor symbol. The trajectory-generation algorithm uses knowledge of the global mission requirements, a digital terrain map, aircraft performance capabilities, and advanced navigation information to determine a trajectory between mission waypoints that minimizes threat exposure by seeking valleys. The pilot evaluation was conducted at NASA Ames Research Center's Sim Lab facility in both the fixed-base Interchangeable Cab (ICAB) simulator and the moving-base Vertical Motion Simulator (VMS) by pilots representing NASA, the U.S. Army, and the U.S. Air Force. The pilots manually tracked the trajectory generated by the algorithm utilizing the HUD symbology. They were able to satisfactorily perform the tracking tasks while maintaining a high degree of awareness of the outside world. Author

N91-26130# Aeronautical Systems Div., Wright-Patterson AFB, OH.

EVALUATION OF THE C/EC/KC-135 GROUND COLLISION AVOIDANCE SYSTEM (GCAS), STUDY 1 Final Report, Jan. 1990 - Jan. 1991

JUSTIN D. RUEB and JOHN A. HASSOUN Mar. 1991 156 p

(AD-A235301; ASD-TR-91-5004-STUDY-1) Avail: NTIS HC/MF A08 CSCL 01/5

In support of the KC-135 Avionics modernization Program, subjective and performance data were collected in order to provide the Government and contractor engineers with information needed in the design of a Ground Collision Avoidance System (GCAS) for all C/EC/KC-135 aircraft. The GCAS will serve to alert the crew of an impending ground impact. This decision will be based on data collected from various aircraft sensors (e.g., radio altimeter). The GCAS, due to the downward looking nature of the radio altimeter, will not be as effective as a forward looking Terrain Following Radar (TFR) and would only serve to complement this system. This evaluation was Study 1 of a two-part study. Study 1 was comprised of four phases. Throughout the four phases, concerns and recommendations were forwarded to the System Program Office and to the Cubic Corporation. This resulted in modification of the algorithm prior to the next phase of the evaluation. GRA

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A91-41535
CONDITION MONITORING OF AIRCRAFT HIGH LIFT SYSTEMS
K. W. CHAN, G. SOUTHCOMBE, G. J. TRMAL, and A. P. H. MAY (British Aerospace, PLC, Bristol, England) Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100), vol. 204, no. G2, 1990, p. 75-82. Research supported by British Aerospace Commercial Aircraft, Ltd. and Dowty Rotol, Ltd. refs
Copyright
Condition monitoring of aircraft mechanical systems is shown to be the next stage in the development of lower cost higher quality maintenance systems. The paper focuses upon mechanical drive systems for the high lift surfaces at the leading and trailing edge of aircraft wings. Monitoring is shown to be feasible and, as well as leading to reduced costs and improved maintenance, could lead to future weight reduction through the approved use of lower safety factors in structural design. The research has shown that mechanical systems of this nature should not be regarded simply as 'black boxes' with inputs and outputs. To obtain the full benefits of condition monitoring at low cost, detailed knowledge of the characteristics and behavior of the system as a whole must be acquired. Author

A91-41543
EFFECT OF SHOCK WAVES UPON SEAT MOUNTED SENSORS IN ESCAPE SYSTEMS
PETER AYOUB (U.S. Navy, Naval Air Development Center, Warminster, PA) and WALTER PECK SAFE Journal, vol. 21, May-June 1991, p. 32-35.
Copyright
Shock waves affecting the total and/or static pressures in a supersonic airstream impacting an open ejection seat are studied, and sequencing systems that can overcome these effects are considered. The controlling relationships of a normal shock wave are set forth with special conditions given for oblique shock waves, as well as methods for computing such conditions. The effects of both shock-wave types are summarized, showing conditions for safe and unsafe ejections. Concepts related to developing sensing and sequencing systems that are immune to shock waves are developed and listed. Mach number effects do not influence sequencing systems in which a set time delay precedes the altitude sensing for parachute deployment. The seat-mounted pressure sensors of newer systems, however, are not immune to Mach number effects. The techniques developed in the investigation show that immunity to Mach number effects can be efficiently achieved in sequencing systems. C.C.S.

A91-41706*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A PARAMETRIC EXPERIMENTAL STUDY OF ISOLATED RECTANGULAR NOZZLES
L. S. BANGERT and G. T. CARSON, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-2136) Copyright
A parametric study has been conducted in the Langley 16-Foot Transonic Tunnel on an isolated nonaxisymmetric fuselage, simulating a twin-engine fighter. The effects of aft-end closure distribution (top/bottom nozzle flap boattail angle vs. nozzle sidewall boattail angle) and afterbody/nozzle corner treatment (sharp or radius) were investigated. Four different closure distributions with three different corner radii were tested. Tests were conducted over a range of Mach numbers from 0.40-1.25 at zero degrees angle of attack. Solid plume simulators were used to simulate the jet exhaust. Author

A91-41714#
MACGS - A ZONAL GRID GENERATION SYSTEM FOR COMPLEX AERO-PROPULSION CONFIGURATIONS
T. D. GATZKE, W. F. LABOZZETTA, G. P. FINFROCK, J. A. JOHNSON, and W. W. ROMER (McDonnell Aircraft Co., Saint Louis, MO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. Research supported by McDonnell Douglas Corp. refs
(AIAA PAPER 91-2156) Copyright
A system which facilitates grid generation for complex aircraft configurations is described in terms of its structure and capabilities. A graphic interface based on various computer platforms forms an interactive environment for system operation. A sequence of steps based on a zonal approach, which includes the generation of farfield boundary shapes and of an entire zone for an isolated forebody or diffuser-type geometry, simplifies the grid generation process. The technique supports zone interfaces regardless of point continuity by determining zone-to-zone coupling parameters for the completed grid. The system is shown to effectively aid in analyzing inlet forebodies and ducts with turning vanes, and in configuring a thrust-vectoring nozzle. Grids can be generated with reduced complexity because the lower number of zones permits the solution to be derived with fewer grid points. This reduces both the time and cost required to generate a grid for complex aeropropulsion configurations. C.C.S.

A91-41796#
ANALYSIS OF PRESSURE DISTRIBUTION ON HYPERSONIC VEHICLES WITH POWER EFFECTS
MARK LEAGUE and SAEED FAROKHI (Kansas, University, Lawrence) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 15 p. refs
(AIAA PAPER 91-2491) Copyright
An interactive computer program is developed to analyze surface pressure distributions on hypersonic vehicles with the power effect. Hypersonic surface inclination techniques of Newtonian, modified Newtonian, tangent-wedge, and tangent-cone as well as Rasmussen's methods are formulated in three dimensions for a hypersonic vehicle. The rotational method of characteristics is applied to a single expansion ramp nozzle to simulate the power effect on a hypersonic vehicle. A powerful graphic postprocessor which generates color-coded pressure distributions on machines with at least eight planes of color is integrated into the program. To verify the methods used to calculate the body pressure distribution, HAPPE (Hypersonic Analysis Program including Power Effects) analysis of two unpowered vehicles - a space-shuttle-like vehicle and the NASA Langley designed Assured Crew Return Vehicle (ACRV) - are compared with flight and wind-tunnel test results, respectively. Author

A91-41813#
A THEORETICAL STUDY ON THE VIBRATION DAMPING OF AIRCRAFT GEARBOX GEARS
KAYAALP BUYUKATAMAN (GE Aircraft Engines, Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 7 p. refs
(AIAA PAPER 91-2558) Copyright
Vibration damping becomes critically important as aircraft gear speeds increase and gear weights decrease. Attention is presently given to the damping of vibration amplitudes for a gear system without changing its slip dampers' design criteria; emphasis is given to the use of damper rings to convert destructive energy into heat energy. Since column dampers' internal dissipation increases with increasing vibration amplitude, damper rings help to maintain long-term reliability and structural integrity. These dissipation capabilities are, however, often limited by gear geometry, ring entrapment, and even the ring's own natural frequency. O.C.

A91-42738

COMBINED ENERGY MANAGEMENT AND CALCULUS OF VARIATIONS APPROACH FOR OPTIMIZING HYPERSONIC VEHICLE TRAJECTORIES

N. VENUGOPAL, R. V. GRANDHI, W. L. HANKEY, and P. J. BELCHER (Wright State University, Dayton, OH) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 591-600. refs
(Contract F33615-87-C-1550)
Copyright

An efficient performance analysis method is developed to evaluate potential hydrogen-fueled turbojet, ramjet, and scramjet propulsion for advanced technology hypersonic aircraft. An algoritm based on energy management and calculus of variations is developed for determining optimal trajectories. The methodology applies both techniques simultaneously in obtaining the optimal trajectory. Many mission, flight, and vehicle-related requirements and constraints are satisfied in the process. In addition, powered hypersonic flight produces unique performance characteristics not encountered at subsonic speeds. With the analysis method, two potential hypersonic vehicles are evaluated, both for maximizing payload and minimizing time to climb, and the resulting optimal trajectories are presented. Author

A91-42818#

RAPID METHODOLOGY FOR DESIGN AND PERFORMANCE PREDICTION OF INTEGRATED SUPERSONIC COMBUSTION RAMJET ENGINE

HIDEO IKAWA (Northrop Corp., Hawthorne, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 437-444. Northrop Corp.-supported research. Previously cited in issue 20, p. 3088, Accession no. A89-47012. refs
(Contract F33615-87-C-3606)
Copyright

A91-43080#

A SIMULATION MODEL OF A SINGLE ROTOR HELICOPTER

Z. BEIGELMAN and A. ROSEN (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Collection of Papers. Haifa, Israel, Technion - Israel Institute of Technology, 1990, p. 27-37. refs

The paper presents a model suitable for helicopter flight mechanics purposes. The different components of the vehicle are treated separately, and thus a modular model is obtained. The complete dynamic model is highly nonlinear and is used for trim calculations and calculations of the dynamic response to arbitray pilot's input, or different external disturbances. Linearization of the model leads to an eigenvalue problem for analyzing the stability of different trim positions. For validation purposes the results of the new model are compared to flight test results and results of other numerical models of the AH-1G Cobra helicopter. Fair agreement is presented, while deviations are discussed and explained. Author

A91-43117

MBB BO 108 - SERIAL CONSTRUCTION BEGINS [MBB BO 108 - SERIENBAU LAEUFT AN]

Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, Mar.-Apr. 1991, p. 8-13. In German.
Copyright

The construction of the MBB Bo 108, a helicopter which is to play a significant role in European industrial cooperation, is discussed. The improvements which the various components provide over those of the predecessor helicopters are pointed out. An update is given on the development of the NATO NH-90 helicopter. C.D.

A91-43119

PIAGGIO P180 AVANTI - EFFICIENCY USING THREE LEVELS OF AERODYNAMIC LIFT [PIAGGIO P180 AVANTI - EFFIZIENZ MIT DREI AUFTRIEBSFLAECHEN]

Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, Mar.-Apr. 1991, p. 20-23. In German.
Copyright

The development of the design of the Piaggio P180 Avanti aircraft, which uses three levels of aerodynamic lift, is reviewed. Attention is given to the design of the propeller, the simplified steering, and the lowered costs involved in the design. Merit factor comparisons with turboprops and turbojets are made. C.D.

A91-43312*# Lockheed Engineering and Sciences Co., Hampton, VA.

CALCULATING TIME-CORRELATED GUST LOADS USING MATCHED FILTER AND RANDOM PROCESS THEORIES

ANTHONY S. POTOTZKY, THOMAS A. ZEILER (Lockheed Engineering and Sciences Co., Hampton, VA), and BOYD PERRY, III (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 28, May 1991, p. 346-352. Previously cited in issue 12, p. 1782, Accession no. A89-30849. refs
Copyright

A91-43511#

A STUDY ON THE STIFFNESS SIMULATION CALCULATION METHOD OF FLUTTER MODELS OF AFTER BODY AND HORIZONTAL TAIL OF A NEW TYPE AEROPLANE

JIAQUAN LUO (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956), vol. 23, June 1991, p. 121-123. In Chinese, with abstract in English.

A stiffness simulation calculation method of low-speed flutter models of an airplane is studied. Using this method, the afterbody and the horizontal tail of a new type airplane are calculated. Experimental results show that the method is feasible. Author

A91-43512#

FAILURE ANALYSIS OF STRUCTURAL SYSTEMS

ZHONG XU (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956), vol. 23, June 1991, p. 124-127. In Chinese, with abstract in English.

This paper discusses a failue analysis which has been used for the design of structural system reliability, using an aircraft landing gear system as an example. The sketch and the mathematical model of the system reliability and the failure distribution curve are deduced. The basic reliability is then calculated. Author

A91-43594#

OPTIMIZED SCRAMJET INTEGRATION ON A WAVERIDER

MARY K. L. O'NEILL and MARK J. LEWIS (Maryland, University, College Park) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 13 p. refs
(AIAA PAPER 91-1693) Copyright

Scramjet integrated waverider airframes optimized for maximum thrust margin, (T-D)/D, are presented. Parameters affecting the success of the scramjet/waverider system are reviewed and the computer code developed to optimize the integrated system is discussed. In this study, conically derived waveriders are specifically designed to supply the scramjet engines with the required properties for effective combustion. The waverider is ideally suited for scramjet integration due to the uniform flowfield properties it provides to the engine inlet. Author

A91-43596*# Colorado Univ., Boulder.

HYPERSONIC WAVERIDER ANALYSIS - A COMPARISON OF NUMERICAL AND EXPERIMENTAL RESULTS

K. D. JONES, F. C. DOUGHERTY (Colorado, University, Boulder), and S. X. S. BAUER (NASA, Langley Research Center, Hampton, VA; Colorado, University, Boulder) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26,

1991. 17 p. refs
(Contract NAG1-880)
(AIAA PAPER 91-1696) Copyright

In this study two waverider configurations are analyzed numerically and experimentally. The geometries are designed using an inverse design and optimization code with the optimization procedure driven by maximized L/D and limited by geometric constraints. Euler and Navier-Stokes numerical simulations are performed with a partially flux-split finite-difference code developed at NASA Ames, F3D. Experimental data is obtained at NASA Langley in the Unitary Plan Wind Tunnel (UPWT) and the 20-Inch Mach 6 wind tunnel for flow visualization, force/moment, and surface pressure measurements at both on- and off-design conditions. Euler simulations are compared with analytic results obtained from conical flow theory, and Navier-Stokes simulations are compared with experimental results both qualitatively and quantitatively for on- and off-design conditions. Author

A91-43597*# Colorado Univ., Boulder.
INTERACTIVE DESIGN OF HYPERSONIC WAVERIDER GEOMETRIES
K. B. CENTER, H. SOBIECZKY, and F. C. DOUGHERTY (Colorado, University, Boulder) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. Research supported by DLR and University of Colorado. refs
(Contract NAG1-880)
(AIAA PAPER 91-1697) Copyright

The paper deals with an inverse design code utilizing the method of oscillating cones; the code integrated into an interactive graphics software package allows manipulation of both the exit-plane shock profile and leading edge of the vehicle. Another interactive feature of the system is the ability to vary freestream conditions and reevaluate the governing conditions. The development of the oscillating cones is shown on five classes each of which is chosen to demonstrate an aspect of improved design flexibility over previous studies. Results are evaluated using a robust flow solver, insuring that the shock shapes specified in the design process are recovered. It is pointed out that the expanded range of waverider geometries that may be generated using the oscillating cones technique may provide insight into visually oriented optimization parameters such as volumetric efficiency and practical planform. V.T.

A91-43673#
AEROPROPULSION ANALYSIS OF TACTICAL AIRCRAFT - STATUS AND PLANS
RAYMOND R. COSNER and AUGUST VERHOFF (McDonnell Aircraft Co., Saint Louis, MO) AIAA, Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-1528) Copyright

The role of Euler and Navier-Stokes analyses in the aerospace engineering environment is discussed, and representative applications illustrating that role are covered. Attention is given to afterbody and jet interactions, inlet spillage, and flight loads. Emphasis is placed on a number of codes available for solving the Euler and Navier-Stokes equations, advances in grid generators, and postprocessing tools. Factors limiting the value of the Euler and Navier-Stokes analysis are considered, including technical capabilities of the component methods, knowledge of effective practices for using the methods, and reluctance to utilize them and to act on their results. The issues of building user support and future needs are explored, and it is noted that the primary obstacles to a wider engineering reliance are the cost of computational fluid dynamics analyses, high user-skill requirements, and long calendar time required to produce quality solutions in realistic high-end applications. V.T.

A91-44345#
SEEKING CRASHWORTHY SEATS
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 29, July 1991, p. 44, 45.
Copyright

A review is presented of current thinking, research and design in the construction and installation of energy-absorbing, crash resistant seats for crew/passengers in both military and commercial transports. The FAA now requires all newly certificated rotorcraft, light aircraft, and airliners to have seats able to withstand dynamic loads even with distorted floor attachment geometry. Energy dissipating linkages are now utilized to accommodate crash loads, with seats translating downward and absorbing the impact energy while keeping spine loads within tolerances. It is noted that airliner crash energy absorption can be an efficient combination of elastic and plastic deformation of the seat structure. R.E.P.

N91-25144 Kansas Univ., Lawrence.
DEVELOPMENT OF A SYSTEM OF INTERACTIVE COMPUTER PROGRAMS FOR AIRPLANE CONCEPTUAL DESIGN AND ADVANCED AIRPLANE ANALYSIS Ph.D. Thesis
SEYYED MOHAMMAD B. MALAEK 1990 302 p
Avail: Univ. Microfilms Order No. DA9110890

Advanced Aircraft Analysis (AAA) is a design environment for the purpose of airplane preliminary design. The characteristics of airplane preliminary design methodologies were the focal point in the development of AAA architecture. The AAA provides a vast variety of help for the designer in the form of descriptions, tables, and graphs to make the decision making process as fast and easy as possible. The most up to date features in computer technology were used to create a user friendly environment which is quite appropriate for the purpose of teaching airplane design. All level-1 preliminary design processes and some level-2 processes were implemented and tested to show the effectiveness of the new design environment. Both analysis of a given airplane and design of a new airplane to meet specified criteria can be performed in the AAA design environment. Dissert. Abstr.

N91-25145# National Aerospace Lab., Tokyo (Japan).
ESTIMATION OF THE AEROELASTIC CHARACTERISTICS FROM FLIGHT TEST DATA OF THE STOL RESEARCH AIRCRAFT ASKA
Oct. 1990 44 p In JAPANESE; ENGLISH summary
(NAL-TR-1083; ISSN-0389-4010) Avail: NTIS HC/MF A03

Flight tests of the short takeoff and landing (STOL) research aircraft ASKA, developed by the National Aerospace Laboratory, were conducted in 1986. Acceleration responses due to turbulence at subcritical speeds were obtained. To estimate the aeroelastic characteristics, the acceleration responses were applied to the method for estimating flutter or divergence boundary from random responses with the aid of the autoregressive process and the mixed autoregressive moving average process. The procedures and results of the estimations are given. Author

N91-25146# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
HANDLING QUALITIES OF UNSTABLE HIGHLY AUGMENTED AIRCRAFT
May 1991 120 p
(AGARD-AR-279; ISBN-92-835-0609-X) Copyright Avail: NTIS HC/MF A06; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Reviewed here are handling quality issues of highly augmented unstable aircraft. Handling qualities criteria for both large and small amplitude longitudinal maneuvers are presented. Basic aerodynamic design, specific issues relating to the feel system and control sensitivity, evaluation techniques, and the handling qualities design process are discussed. The subjects of careful handling, lateral-directional criteria and agility are presented in separate appendices. Author

N91-25481*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SCIENCE REQUIREMENTS AND FEASIBILITY/DESIGN STUDIES OF A VERY-HIGH-ALTITUDE AIRCRAFT FOR ATMOSPHERIC RESEARCH
PHILIP B. RUSSELL, DAVID P. LUX, R. DALE REED (PRC Systems Services Co., Hampton, VA.), MAX LOEWENSTEIN, and STEVEN

WEGENER *In* NASA, Washington, 4th Airborne Geoscience Workshop p 241-242 1991
Avail: NTIS HC/MF A13 CSCL 01/3
The advantages and shortcomings of currently available aircraft for use in very high altitude missions to study such problems as polar ozone or stratosphere-troposphere exchange pose the question of whether to develop advanced aircraft for atmospheric research. To answer this question, NASA conducted a workshop to determine science needs and feasibility/design studies to assess whether and how those needs could be met. It was determined that there was a need for an aircraft that could cruise at an altitude of 30 km with a range of 6,000 miles with vertical profiling down to 10 km and back at remote points and carry a payload of 3,000 lbs. Author

N91-26131# Aeronautical Systems Div., Wright-Patterson AFB, OH. Directorate of Flight Systems Engineering.
A LOOK AT DIGITAL NOSE WHEEL STEERING Final Report, Feb. - Aug. 1990
MARK L. NOWACK 24 Sep. 1990 37 p
(AD-A233944; ASD-TR-90-5018; ENF-TM-90-6) Avail: NTIS HC/MF A03 CSCL 01/3
This report examines the impact of digital control on nose wheel steering of aircraft. The development of steering systems is reviewed from early mechanical systems through integrated brake control systems. The value of digital control is then examined based on unique capabilities, performance improvement, and fault detection. Cost, weight, and maintainability impacts are discussed. GRA

N91-26134# Florida Atlantic Univ., Boca Raton. Dept. of Mechanical Engineering.
DYNAMICS OF ELASTIC BENDING AND TORSION OF HINGELESS ROTORS WITH DYNAMIC STALL
GOPAL H. GAONKAR and DINESH BARWEY 23 Feb. 1991 51 p
(Contract DAAL03-87-K-0037)
(AD-A234775; ARO-24738.7-EG) Avail: NTIS HC/MF A04 CSCL 01/1
The effects of dynamic stall lift and drag on the flap-lag stability of a hingeless rotor are investigated, both experimentally and analytically. The emphasis is on the correlation with measured regressing lead-lag mode damping levels of a soft-inplane, three-bladed model rotor, operated untrimmed. The correlation covers a wide range of test conditions for several values of rotor speed, collective pitch angle, shaft tilt angle and advance ratio. It includes cases that vary from near zero thrust conditions in hover to highly stalled forward flight conditions with advance ratios as high as 0.55 and shaft tilt angles as high as 20 deg. Both the experimental and analytical blade models represent a simple model of a hingeless rotor with rigid blades and spring restrained flap-lag hinges. The aerodynamic representation is based on the ONERA dynamic stall models comprising virtually independent unified lift and drag models. The nonlinear equations of blade motion and stall dynamics are perturbed about a periodic forced response, and the damping is evaluated by the Floquet eigenanalysis. In comparison to the linear and quasisteady stall aerodynamic theories, the theory with dynamic stall lift and quasisteady stall drag qualitatively improves the correlation, and adding dynamic stall drag provides further quantitative improvement. GRA

N91-26135# Naval Postgraduate School, Monterey, CA.
ESTABLISHMENT OF A REMOTELY PILOTED HELICOPTER TEST FLIGHT PROGRAM FOR HIGHER HARMONIC CONTROL RESEARCH M.S. Thesis
JAMES G. SCOTT Jun. 1990 71 p
(AD-A234978) Avail: NTIS HC/MF A04 CSCL 01/4
An analytical research study was begun on a helicopter vibration reduction concept known as higher harmonic control (HHC). To supplement this research, a helicopter flight test program was established to generate flight test data in support of the NPS HHC research efforts. To accomplish this task, a remotely piloted helicopter was chosen as the test vehicle. The research efforts encompassed by this thesis are the determination of attributes required of a RPH used for HHC studies, the selection and acquisition of an RPH capable of completing the intended research mission, and the preliminary analysis of the RPH's flight control system for modification to an HHC configuration. A brief overview of helicopter vibrations and HHC fundamentals, along with an in-depth description of the selected RPH, is presented. Preliminary analysis of the RPH's flight control system includes the determination of associated freeplay and torsional constant values for the flight control components and the calculation of the necessary actuator torque requirements for HHC actuation. This research effort is the first stage of a long term program designed to provide NPS with an in house asset capable of generating HHC flight test data in support of analytical research. GRA

N91-26136# School of Aerospace Medicine, Brooks AFB, TX.
REFURBISHING AV-8 ON-BOARD OXYGEN GENERATION SYSTEM BEDS Interim Report, May - Aug. 1990
KENNETH G. IKELS and AARON M. SHAKOCIUS Dec. 1990 26 p
(Contract AF PROJ. 7930)
(AD-A235083; USAFSAM-TP-90-22) Avail: NTIS HC/MF A03 CSCL 23/5
The Crew Systems Branch, Crew Technology Div, USAF SAM, has carefully prepared specific procedures and instructions to provide users of the AV-8 On-Board Oxygen Generation System (OBOGS) with detailed information and requirements on refurbishing OBOGS beds. Included in the instructions on disassembling, repacking, and assembling the OBOGS beds, are specific procedures for determining the activity and, if necessary, activating the molecular sieve before the beds are repacked. In addition, technics and procedures are detailed for testing the repacked beds prior to reassembly of the concentrator to ensure efficient air separation. GRA

N91-26137*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PERFORMANCE OPTIMIZATION OF HELICOPTER ROTOR BLADES
JOANNE L. WALSH Apr. 1991 22 p Presented at the Third Air Force/NASA Symposium on Recent Advances in Multi-Disciplinary Analyses and Optimization, San Francisco, CA, 24-26 Sep. 1990
(NASA-TM-104054; NAS 1.15:104054) Avail: NTIS HC/MF A03 CSCL 01/3
As part of a center-wide activity at NASA Langley Research Center to develop multidisciplinary design procedures by accounting for discipline interactions, a performance design optimization procedure is developed. The procedure optimizes the aerodynamic performance of rotor blades by selecting the point of taper initiation, root chord, taper ratio, and maximum twist which minimize hover horsepower while not degrading forward flight performance. The procedure uses HOVT (a strip theory momentum analysis) to compute the horse power required for hover and the comprehensive helicopter analysis program CAMRAD to compute the horsepower required for forward flight and maneuver. The optimization algorithm consists of the general purpose optimization program CONMIN and approximate analyses. Sensitivity analyses consisting of derivatives of the objective function and constraints are carried out by forward finite differences. The procedure is applied to a test problem which is an analytical model of a wind tunnel model of a utility rotor blade. Author

N91-26138# RAND Corp., Santa Monica, CA.
HOW LOW CAN AN UNMANNED AIR VEHICLE FLY? Thesis
WILLIAM E. DEAN Oct. 1990 36 p
(RAND-P-7680-RGS) Avail: NTIS HC/MF A03
The issue of unmanned air vehicles (UAVs) as candidates for reconnaissance platforms was studied. A model was constructed to simulate preprogrammed smooth paths from peak to peak in hilly terrain. Some commaned altitude was added to all the points of the flight path. Then the clobber probability was calculated by introducing navigational error, so that the UAV could encounter

hills unexpectedly. Finally, the intervisibility between a radar site and the UAV was calculated. As an excursion, a downward-looking altimeter was simulated. The true altitude above ground level (AGL) was compared with the expected AGL. The case runs are described and the results presented. The modeling environment, the models, and the limitations are discussed. B.G.

N91-26139*# Boeing Helicopter Co., Philadelphia, PA.
TECHNOLOGY NEEDS FOR HIGH-SPEED ROTORCRAFT, VOLUME 1
J. B. WILKERSON, J. J. SCHNEIDER, and K. M. BARTIE May 1991 250 p
(Contract NAS2-13041)
(NASA-CR-177585; A-91159; NAS 1.26:177585) Avail: NTIS HC/MF A11 CSCL 01/3

High-speed rotorcraft concepts and the technology needed to extend rotorcraft cruise speeds up to 450 knots (while retaining the helicopter attributes of low downwash velocities) were identified. Task I identified 20 concepts with high-speed potential. These concepts were qualitatively evaluated to determine the five most promising ones. These five concepts were designed with optimum wing loading and disk loading to a common NASA-defined military transport mission. The optimum designs were quantitatively compared against 11 key criteria and ranked accordingly. The two highest ranking concepts were selected for the further study. Author

N91-26140*# G and C Systems, Inc., San Juan Capistrano, CA.
AUTONOMOUS AIRCRAFT INITIATIVE STUDY Final Report
MARLE D. HEWETT Jul. 1991 92 p Prepared in cooperation with PRC Systems Services Co., Edwards, CA
(Contract NAS2-12722; ATD-89-GNC-1504)
(NASA-CR-186013; H-1609; NAS 1.26:186013) Avail: NTIS HC/MF A05 CSCL 01/3

The results of a consulting effort to aid NASA Ames-Dryden in defining a new initiative in aircraft automation are described. The initiative described is a multi-year, multi-center technology development and flight demonstration program. The initiative features the further development of technologies in aircraft automation already being pursued at multiple NASA centers and Department of Defense (DoD) research and Development (R and D) facilities. The proposed initiative involves the development of technologies in intelligent systems, guidance, control, software development, airborne computing, navigation, communications, sensors, unmanned vehicles, and air traffic control. It involves the integration and implementation of these technologies to the extent necessary to conduct selected and incremental flight demonstrations. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A91-42142
ACCURATE AIRBORNE SURFACE TEMPERATURE MEASUREMENTS WITH CHOPPER-STABILIZED RADIOMETERS
DIETER LORENZ (DLR, Institut fuer Physik der Atmosphaere, Oberpfaffenhofen, Federal Republic of Germany) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 8, June 1991, p. 341-351. refs
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A series of airborne trials which included high altitude flight tests in a pressurized aircraft have investigated the accuracy of chopper-stabilized radiometers for meteorological measurement of surface temperatures. It is found that the radiometers need to be frequently calibrated in flight to ensure accurate readings of target IR emissions. A plane mirror installed in front of the radiometer to facilitate aircraft installation was found to be a useful means to compensate for the influence of ambient temperature fluctuations in the immediate vicinity of the radiometer. O.C.

A91-43082#
FCS SKEWED SENSORS ARRAY - PRACTICAL CONSIDERATIONS
D. AGAMI and H. YAHIA (Israel Aircraft Industries, Ltd., Tel Aviv) IN: Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Collection of Papers. Haifa, Israel, Technion - Israel Institute of Technology, 1990, p. 44-50. refs

An aircraft which employs a skewed sensor array (SSA) is studied. Particular attention is given to an arrangement of six angular rate sensors oriented in space on six sides of an imaginary pyramid. According to the authors, the results attest to the main deficiencies of the SSA. It is believed that the effort required for the implementation of the SSA represents a clear development risk that is disproportionate to the claimed advantages. K.K.

A91-43306#
IN-FLIGHT MEASUREMENT OF STATIC PRESSURES AND BOUNDARY-LAYER STATE WITH INTEGRATED SENSORS
E. GREFF (MBB GmbH, Bremen, Federal Republic of Germany) Journal of Aircraft (ISSN 0021-8669), vol. 28, May 1991, p. 289-299. Previously cited in issue 21, p. 3335, Accession no. A89-47667. refs
Copyright

A91-43315
GPS AND AIRBORNE GRAVIMETRY - RECENT PROGRESS AND FUTURE PLANS
JOHN M. BROZENA (U.S. Navy, Naval Research Laboratory, Washington, DC) Bulletin Geodesique (ISSN 0007-4632), vol. 65, May 1991, p. 116-121. refs
Copyright

The logistical difficulties and expense of measuring gravity over the surface of the earth or ocean provides the motivation for developing techniques for airborne data acquisition. To meet this need, the U.S. Naval Research Laboratory has had an active research program in airborne gravimetry since 1979. This paper provides a brief history, current status and proposed future directions of the program. Author

A91-43482*# University of Western Michigan, Kalamazoo.
FAILURE DETECTION OF LIQUID COOLED ELECTRONICS IN SEALED PACKAGES
A. W. HOADLEY and A. J. PORTER (Western Michigan University, Kalamazoo, MI) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 7 p.
(Contract NCC2-493)
(AIAA PAPER 91-1423) Copyright

The theory and experimental verification of a method of detecting fluid-mass loss, expansion-chamber pressure loss, or excessive vapor build-up in NASA's Airborne Information Management System (AIMS) are presented. The primary purpose of this leak-detection method is to detect the fluid-mass loss before the volume of vapor on the liquid side causes a temperature-critical part to be out of the liquid. The method detects the initial leak after the first 2.5 pct of the liquid mass has been lost, and it can be used for detecting subsequent situations including the leaking of air into the liquid chamber and the subsequent vapor build-up. V.T.

A91-43508#
SYNCHRONIZATION DEVICE OF DIGITAL FLIGHT CONTROLLING COMPUTER AND THE ALGORITHM FOR SYSTEM SCHEDULING
JIAN XIA, ZHEN LI, and BAIGUANG QIU (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956), vol. 23, June 1991, p. 69-76. In Chinese, with abstract in English.

This paper describes the synchronization device and the

scheduling algorithm of a digital flight controlling computer (DFCC) system, together with their implementation. In the synchronization algorithm a synchronization cycle of 15 msec is adopted, and the asynchronization is confined to 30 microsec. The technique used to recover the DFCC system from fault by synchronization is described along with the algorithm used for dead-lock prevention.
I.S.

A91-43772
STEALTH AIRCRAFT AND TECHNOLOGY FROM WORLD WAR II TO THE GULF. I - HISTORY AND BACKGROUND
ROGER A. STONIER SAMPE Journal (ISSN 0091-1062), vol. 27, July-Aug. 1991, p. 9-17. refs
Copyright
A development history is presented, and bases in materials technology are explored, for radar-evading/low-observability, or 'stealth' aircraft, exemplified by the F-117A stealth fighter and B-2 stealth bomber. Attention is given to the Northrop 'flying wing' bombers, the SR-71, the operational characteristics of Soviet surveillance radars covering various ranges and altitudes, and the dielectric properties of conventional and low-observability-tailored structural materials and composites. The foundations of radar energy-absorbing materials design for specific radar wavelengths, often employing ferrites in a polymeric matrix, are presented.
O.C.

N91-25138# McDonnell Aircraft Co., Saint Louis, MO.
INTEGRATED CONTROL AND AVIONICS FOR AIR SUPERIORITY: A KNOWLEDGE-BASED DECISION AIDING SYSTEM
DONALD J. HALSKI, ROBERT J. LANDY, and JAMES A. KOCHER (Wright Research Development Center, Wright-Patterson AFB, OH.) *In* AGARD, Knowledge Based System Applications for Guidance and Control 9 p Apr. 1991
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
An ongoing program is described in which is developed an effective, real time, knowledge based, decision aiding system for air combat. The Integrated Control and Avionics for Air Superiority (ICAAS) program is used to develop, integrate, and demonstrate critical technologies which will enable USAF tactical fighter aircraft to kill and survive when outnumbered as much as four to one by enemy aircraft during air combat. Primary emphasis is placed upon beyond visual range (BVR) multiple target attack capability with provisions for effective transition to close-in combat. Knowledge based pilot decision aiding techniques and expert system methods are used to achieve substantially enhanced offensive and defensive capabilities compared to current operational systems. Situation awareness information and recommended actions are computed to aid the pilot in selecting the most effective attack and defend engagement options. The system maximizes opportunities for missile launch against multiple enemy aircraft while maintaining options to defend when necessary. Sufficient integration and automation are provided for application to a single seat fighter.
Author

N91-26142*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FORMAT AND BASIC GEOMETRY OF A PERSPECTIVE DISPLAY OF AIR TRAFFIC FOR THE COCKPIT
MICHAEL WALLACE MCGREEVY and STEPHEN R. ELLIS Jun. 1991 48 p
(NASA-TM-86680; A-85126; NAS 1.15:86680) Avail: NTIS HC/MF A03 CSCL 01/4
The design and implementation of a perspective display of air traffic for the cockpit is discussed. Parameters of the perspective are variable and interactive so that the appearance of the projected image can be widely varied. This approach makes allowances for exploration of perspective parameters and their interactions. The display was initially used to study the cases of horizontal maneuver biases found in experiments involving a plan view air traffic display format. Experiments to determine the effect of perspective geometry on spatial judgements have evolved from the display program. Several scaling techniques and other adjustments to the perspective are used to tailor the geometry for effective presentation of 3-D traffic situations.
Author

N91-26143# RAND Corp., Santa Monica, CA.
VHSIC ELECTRONICS AND THE COST OF AIR FORCE AVIONICS IN THE 1990S
PAUL S. KILLINGSWORTH and JEANNE M. JARVAISE Nov. 1990 101 p
(Contract F49620-86-C-0008)
(RAND-R-3843-AF; ISBN-0-8330-1026-3; LC-89-70202) Avail: NTIS HC/MF A06
Discussed here are the cost issues for avionics systems using very high speed integrated circuits (VHSIC) and VHSIC-like technology. Also given is some background on integrated circuit technology and a method for checking the reasonableness of cost estimates on avionics systems that incorporate highly integrated electronics.
Author

07

AIRCRAFT PROPULSION AND POWER

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

A91-41170
OPTIMIZATION OF THE TURBOFAN ENGINE CONTROL PROGRAM DURING THE CRUISING FLIGHT OF SUBSONIC TRANSPORT AIRCRAFT [OPTIMIZATSIIA PROGRAMMY UPRAVLENIIA TVVD V KREISERSKOM POLETE DOZVUKOVOGO TRANSPORTNOGO SAMOLETA]
S. B. GRIGOR'EV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1991, p. 88-91. In Russian.
Copyright
The use of turbofan engines is believed to be a promising way of improving the fuel efficiency of subsonic transport aircraft. Here, a systems approach is used to optimize the turbofan engine control system during cruising flight operation for maximum fuel efficiency. The optimization is carried out by iteration and mathematical modeling methods using an integrated computer-aided turbofan design system. Details of the solution of the optimization program are presented.
V.L.

A91-41171
THERMODYNAMIC ANALYSIS OF GAS TURBINE ENGINES AND PLANTS AT HIGH AIR PRESSURE LEVELS [TERMODINAMICHESKII RASCHET GAZOTURBINNYKH DVIGATELEI I USTANOVOK PRI VYSOKIKH STEPENIAKH POVYSHENIIA DAVLENIIA VOZDUKHA]
V. P. DOBRODEEV and M. IU. KASATKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1991, p. 91-94. In Russian. refs
Copyright
At high compressed air pressures, the working medium of gas turbine engines does not behave in the same way as an ideal gas with a variable specific heat that is temperature-dependent only. At gas pressure above 2.5-3.0 MPa, consideration of the pressure dependence of the thermodynamic properties is essential. Here, a method for calculating the thermodynamic parameters of gas turbine engines and plants (including those with intermediate air cooling) is proposed which is valid for working medium pressures of 4-50 MPa.
V.L.

A91-41174
CHARACTERISTICS OF THE WORKING CYCLE OF A LOW-PRESSURE PNEUMATIC NOZZLE WITH A SECTOR STRUCTURE OF THE FUEL JET [OSOBENNOSTI RABOCHEGO PROTSESSA NIZKONAPORNOI PNEVMOFORSUNKI S SEKTORNOI STRUKTURNOI TOPLIVNOGO FAKELA]
V. A. KHRISTICH, V. I. SAVCHENKO, V. I. KUZ'MENKO, and S. A. LEVCHUK Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1991, p. 101-103. In Russian.
Copyright

The general design and performance characteristics of a newly developed low-pressure aerating nozzle with a sector structure of the fuel jet are described. The nozzle provides good control of fuel distribution of the cross section of the combustion chamber; the fractionation of the main jet into a system of smaller jets also contributes to fuel mixing and combustion. The experimentally determined performance characteristics of the jet are presented in graphic form. V.L.

A91-41507
INVESTIGATION OF COATINGS AT HIGH TEMPERATURE FOR USE IN TURBOMACHINERY
W. TABAKOFF (Cincinnati, University, OH) IN: Metallurgical coatings 1989; Proceedings of the 16th International Conference, San Diego, CA, Apr. 17-21, 1989. Vol. 1. London and New York, Elsevier Applied Science, 1989, p. 97-115. DOE-sponsored research. refs
Copyright

This paper discusses the results of erosion analysis, at high temperatures and velocities, of different materials and coatings used in turbomachinery along with experimental results obtained in tests conducted in a wind tunnel which simulated the aerodynamic conditions for turbine blades. Equations are presented for the particle motion in the turbomachinery flow field, with particular attention given to the trajectory calculations, correlations for particle blade interactions, and the blade erosion equation. The results of sand and ash particle trajectory calculations in a two-stage turbine are presented and compared with test results. It is shown that the erosion of the blade suction surface near the trailing edge by sand particles, in the intermediate blade rows, has a significant effect on the turbine performance deterioration. High-density bond coats such as those produced by shrouded plasma spray, vacuum plasma spray, and physical vapor deposition can result in significant erosion improvements. I.S.

A91-41536
THE EFFECTS OF BEARING MISALIGNMENT ON THE NON-LINEAR VIBRATION OF AERO-ENGINE ROTOR-DAMPER ASSEMBLIES
J. E. H. SYKES and R. HOLMES (Southampton, University, England) Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100), vol. 204, no. G2, 1990, p. 83-99. Research supported by SERC and Rolls-Royce, PLC. refs
Copyright

The occurrence of nonlinear vibration phenomena in aero-engine rotor-damper assemblies can seriously degrade performance. A range of assemblies incorporating one and two squeeze-film dampers (SFDs) with various static misalignments is investigated. Waterfall diagrams are constructed which demonstrate the effects of such misalignments and of damper support flexibility on the nature and severity of subsynchronous resonance and jump phenomena. Vibration signatures of similar rotor-damper assemblies are shown to contrast strongly due to different accumulations of tolerances during manufacture, fitting and operation. Author

A91-41539
TWENTY-FIRST CENTURY AERO-ENGINE DESIGN - THE ENVIRONMENTAL FACTOR
J. B. JAMIESON (Royal Aerospace Establishment, Farnborough, England) Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100), vol. 204, no. G2, 1990, p. 119-134. refs
Copyright

Issues relating to demands for both increased thrust and quieter, cleaner performance are examined in the fields of aircraft engine manufacture and operation. Technical considerations and current design development regarding noise production are outlined, including the unducted fan, ultrahigh bypass, and SST considerations. Aircraft emissions are then discussed, emphasizing historic reductions in the levels of CO and unburnt hydrocarbons in relation to existing legislation regarding emissions and thrust. The potential of recent research to respond adequately to the community noise problem is doubtful because the retirement of noisier jets will be countered by the growth of commercial fleets. Drastic improvements in emissions control are limited as well because of the uncertainty related to changing the engine's high integrity component. The reduction of NO(x) and the practical reduction of noise are characterized as the most important issues facing combustion technology development. C.C.S.

A91-41641#
PERFORMANCE IMPLICATIONS OF GAS-TURBINE PRESSURE-GAIN COMBUSTORS
J. A. C. KENTFIELD (Calgary, University, Canada) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(Contract NSERC-A-7928)
(AIAA PAPER 91-1879) Copyright

A brief description is given of a pulse, pressure-gain, combustor, used on a small gas turbine as an alternative to the conventional steady flow combustor, that has generated a 4 percent gain in stagnation pressure between the compressor outlet and turbine inlet. A revised design of pulse combustor expected to be able to generate a 10 percent pressure gain is also reviewed. The hypothetical increases were evaluated of compressor or turbine isentropic efficiencies necessary to yield performances, using conventional steady flow combustion, equal to those obtainable with pressure-gain combustion. The performance potential of an idealized pressure-gain combustor employing constant volume combustion was also evaluated and the performance of steady flow and pressure-gain combustors were compared in terms of thermodynamic effectiveness as derived from the availability concept. Major findings are that pressure-gain combustion increases thermodynamic effectiveness and that the realizable pressure gain ratio decreases, for a prescribed cycle temperature ratio, with increasing compressor pressure ratio. Author

A91-41646#
APU EXHAUST PLUME EFFECTS IN UNDERBODY INSTALLATIONS
G. C. ROUSE (Sundstrand Power Systems, San Diego, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 8 p. refs
(AIAA PAPER 91-1904) Copyright

Aircraft use of Auxiliary Power Units (APUs) with exhaust systems discharging on the underside of the aircraft improve APU accessibility and maintenance. In this case, inlet and exhaust ducts are usually in close proximity to each other and the ground. This increases temperatures. Exhaust gas can also be reingested. It was found that peak ground temperature was primarily linked to exhaust gas temperature (EGT) and path length over exhaust diameter (L/D). This paper presents a method to calculate peak ground temperature and that correlates well with test data. It provides general guidelines that will help avoid reingestion and high aircraft surface temperatures. Author

A91-41652#
A WESTERN ENGINE FOR AN EASTERN AIRCRAFT - RE-ENGINING OF CSFR LET 610 TURBOPROP TRANSPORT WITH THE GE CT7-9
N. J. ISLER and S. L. MORANDI (GE Aircraft Engines, Lynn, MA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th,

Sacramento, CA, June 24-26, 1991. 7 p.
(AIAA PAPER 91-1911) Copyright

The paper concentrates on a study carried out in order to confirm the technical merits of reengining a Czechoslovakian 19-passenger twin-engine airliner with GE turboprop engines. Engine and aircraft performance data is discussed as well as the mechanical and electrical integration required in each major subsystem. Focus is placed on such aspects of engine installation as the propeller, engine mounting, inlet, exhaust, cooling, drains, vents, and controls. Differences in design approach and standards are presented and analyzed, and attention is given to the challenges involved in working with differing product requirements, organizations, and personnel from two different cultures. Comparative and competitive aircraft performance data is outlined and discussed. V.T.

A91-41653*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

CFD ANALYSIS OF A HYDROGEN FUELED RAMJET ENGINE AT MACH 3.44

BEVERLY DUNCAN (NASA, Lewis Research Center; Sverdrup Technology, Inc., Brook Park, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-1919)

The full Navier-Stokes solver, RPLUS, has been used to compute the flow field of a ramjet engine in the low supersonic operating regime. Computations have been made for the case where hydrogen is transversely injected and ignited using nine species and eighteen reactions to model the combustion process. The flow fields for two methods of hydrogen injection have been computed and compared to the available experimental data. The purpose of these computations was to assess the mixing effectiveness of the injected hydrogen with the primary supersonic stream. Results indicate significant ignition delay resulting from the poor mixing dynamics in the combustor section. Author

A91-41671*# Case Western Reserve Univ., Cleveland, OH.

FEEDBACK LINEARIZATION FOR CONTROL OF AIR BREATHING ENGINES

STEPHEN PHILLIPS (Case Western Reserve University, Cleveland, OH) and DUANE MATTERN (NASA, Lewis Research Center, Cleveland; Sverdrup Technology, Inc., Brook Park, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(Contract NAG3-1232)
(AIAA PAPER 91-2000) Copyright

The method of feedback linearization for control of the nonlinear nozzle and compressor components of an air breathing engine is presented. This method overcomes the need for a large number of scheduling variables and operating points to accurately model highly nonlinear plants. Feedback linearization also results in linear closed loop system performance simplifying subsequent control design. Feedback linearization is used for the nonlinear partial engine model and performance is verified through simulation. Author

A91-41672#

DESIGN OPTIMIZATION OF AN ELECTRONIC FUEL CONTROL UNIT FEATURING TWO DIGITAL ACTUATORS

A. I. GEORGANTAS, T. KREPEC, and R. M. H. CHENG (Concordia University, Montreal, Canada) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p.
(AIAA PAPER 91-2003) Copyright

This paper investigates an electronic fuel control unit for small gas turbine engines, offering control functions not possible with conventional fuel control units or single actuator electronic units. The unit employs two linear digital actuators operating a metering valve and a by-pass valve. The two valves assist each other to achieve faster fuel flow rate response. A control strategy involving two digital controllers operating in parallel on the fuel flow error is employed. The parameters of both controllers are optimized simultaneously for particular step-sizes of the two actuators. The optimization is extended to select the best step-size combination for the two actuators. Author

A91-41684#

AERODYNAMIC LOSSES DUE TO PRESSURE SIDE COOLANT EJECTION IN A TRANSONIC TURBINE CASCADE

HAL L. MOSES (Virginia Polytechnic Institute and State University, Blacksburg), BRENT A. GREGORY (GE Aircraft Engines, Cincinnati, OH), TIBOR KISS, and REMI BERTSCH AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. GE Aircraft Engines-supported research. refs
(AIAA PAPER 91-2032) Copyright

Experiments were conducted in a blow-down-type wind tunnel on two-dimensional cascades of cooled, transonic turbine blades, in the exit Mach number range of 0.7 through 1.4 and blowing rate range of 0 through 1.7. The coolant, which was CO_2 to obtain the proper density ratio with cold flow, entered the blades through holes on the spanwise ends, and exited tangentially through slots on the pressure side, near the trailing edge. Only aerodynamic aspects of the flow were studied. The measured data, which was reduced to the mass averaged total pressure loss as a function of isentropic Mach number, show only a slight effect of the coolant flow rate. Generally, the effect of cooling on the losses was within the experimental uncertainty. Author

A91-41696#

TWO-DIMENSIONAL THRUST VECTOR CONTROL NOZZLE

J. L. CATON and M. E. FRANKE (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-2101)

Axial and vectored flow characteristics of a two-dimensional confined jet thrust vector control nozzle are described. Vectoring of the primary flow is accomplished by secondary flow injection in the diverging region of the nozzle. Schlieren photography and video recordings are used to study steady state and transient behavior. Flow separation and shock structures within the confined region are observed through flow visualization, and correlations are made with pressure measurements. Nozzle forces, vector angles. thrust efficiencies, and flow-switching response times are examined. Variations in nozzle design are investigated. Author

A91-41705*# Texas A&M Univ., College Station.

A ROW-BY-ROW OFF-DESIGN PERFORMANCE CALCULATION METHOD FOR TURBINES

T. SCHOBEIRI and M. ABOUELKHEIR (Texas A & M University, College Station) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 7 p. refs
(Contract NAG3-1144)
(AIAA PAPER 91-2132) Copyright

The turbine component of a gas turbine engine is frequently subjected to extreme operation conditions associated with significant changes in mass flow, turbine inlet temperature, pressure and rotational speed. These off-design operation conditions significantly affect the flow deflection within the turbine stage, which consists of individual stator and rotor rows. As a result, the stage parameters representing the velocity diagram will change and affect the efficiency and performance of the stage and, thus, the turbine. A row-by-row calculation method is presented for predicting the performance behavior of turbines under extreme off-design conditions. The method is applied to a multistage turbine for which the off-design performance is calculated and compared with the measurement. Author

A91-41707*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

STATIC PERFORMANCE OF A MULTIAXIS THRUST VECTORING CRUCIFORM NOZZLE

DAVID J. WING and SCOTT C. ASBURY (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint

Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 15 p. refs
(AIAA PAPER 91-2137) Copyright

A multiaxis thrust vectoring nozzle designed to have equal flow turning capability in pitch and yaw is investigated, and methods for obtaining large multiaxis thrust vector angles without physical vectoring flap interference are studied. These methods include restricting the pitch flaps from the path of the yaw flaps, and shifting the flow path at the throat off the nozzle centerline in order to permit larger pitch flap deflections without interfering with operation of the yaw flaps. The results obtained show that unvectored performance of the cruciform nozzle is only slightly lower (0.5 to 1.0 percent) than that of previously tested axisymmetric and nonaxisymmetric nozzles, despite the complex internal geometry. The shifted-throat nozzle design has larger thrust vector angles at the nozzle pressure ratio of peak resultant thrust efficiency, but has 1 to 2 percent lower peak thrust performance than the restricted-flap nozzle design. O.G.

A91-41709*# McDonnell-Douglas Helicopter Co., Mesa, AZ.
HIGH-SPEED ROTORCRAFT PROPULSION
JOHN W. RUTHERFORD and ROBERT E. FITZPATRICK (McDonnell Douglas Helicopter Co., Mesa, AZ) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(Contract NAS2-13070)
(AIAA PAPER 91-2147) Copyright

Recently completed high-speed rotorcraft design studies for NASA provide the basis to assess technology needs for the development of these aircraft. Preliminary analysis of several concepts possessing helicopter-like hover characteristics and cruise capabilities in the 450 knot regime, led to the selection of two concepts for further study. The concepts selected included the Rotor/Wing and the Tilt Wing. The two unique concepts use turbofan and turboshaft engines respectively. Designs, based on current technology for each, established a baseline configuration from which technology trade studies could be conducted. Propulsion technology goals from the IHPTET program established the advanced technolgy year. Due to high-speed requirements, each concept possesses its own unique propulsion challenges. Trade studies indicate that achieving th IHPTET Phase III goals significantly improves the effectiveness of both concepts. Increased engine efficiency is particularly important to VTOL aircraft by reducing gross weight. Author

A91-41733#
AIRCRAFT GAS TURBINE PERFORMANCE FOR THE YEAR 2000
SCOTT R. MCCLENEGHAN (Bridgeport, University; Textron Lycoming, Stratford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 6 p. refs
(AIAA PAPER 91-2233) Copyright

The market demands for greater aircraft gas turbine performance are forecast, in association with an evaluation of the technological improvements that those performance enhancements entail. Current forecasts for (1) turbofans/propfans, (2) military low bypass turbofans, and (3) turboprops/turboshafts, involve a 7-8 percent decrease in specific fuel consumption (SFC), the achievement of pressure ratios above 40, and turbine entry temperatures greater than 2870 for turbofans, and a 30-40 percent SFC reduction for propfans. In military engines, power/weight ratios of the order of 20-30:1 are expected. Turboprops/turboshafts are expected to experience a 40-100 percent increase in specific power. O.C.

A91-41758#
DYNAMICS OF DISCRETE PHASE IN A GAS TURBINE CO-AXIAL, COUNTER-SWIRLING, COMBUSTOR DOME SWIRL CUP
H. Y. WANG, W. A. SOWA, V. G. MCDONELL, and G. S. SAMUELSEN (California, University, Irvine) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 15 p. GE Aircraft Engines-supported research. refs
(AIAA PAPER 91-2353) Copyright

Phase-Doppler interferometry has been used to measure the droplet sizes, as well as droplet axial, radial, and tangential velocities, in a three-dimensional model combustor's swirl cup in the absence of reaction. Bimodal distributions of axial and tangential velocity are observed in the shear layer at the exit plane of the swirl cup; bimodal radial velocity distributions are also seen around the closing point of the on-axis recirculation zone, as well as at the periphery of the spray. Correlations among droplet size and velocity, individual velocity components, and droplet size and flow angle, reveal intermittent flowfield structures that are superimposed on the local and global turbulence. O.C.

A91-41759*# Los Alamos National Lab., NM.
HEAT PIPE RADIATION COOLING OF ADVANCED HYPERSONIC PROPULSION SYSTEM COMPONENTS
R. A. MARTIN, M. KEDDY, M. A. MERRIGAN (Los Alamos National Laboratory, NM), and C. C. SILVERSTEIN (CCS Associates, Bethel Park, PA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. DOE-supported research. refs
(Contract NASA ORDER C-30002-M)
(AIAA PAPER 91-2358)

Heat transfer, heat pipe, and system studies were performed to assess the newly proposed heat pipe radiation cooling (HPRC) concept. With an HPRC system, heat is removed from the ramburner and nozzle of a hypersonic aircraft engine by a surrounding, high-temperature, heat pipe nacelle structure, transported to nearby external surfaces, and rejected to the environment by thermal radiation. With HPRC, the Mach number range available for using hydrocarbon fuels for aircraft operation extends into the Mach 4 to Mach 6 range, up from the current limit of about Mach 4. Heat transfer studies using a newly developed HPRC computer code determine cooling system and ramburner and nozzle temperatures, heat loads, and weights for a representative combined-cycle engine cruising at Mach 5 at 80,000 ft altitude. Heat pipe heat transport calculations, using the Los Alamos code HTPIPE, reveal that adequate heat trasport capability is available using molybdenum-lithium heat pipe technology. Results show that the HPRC system radiator area is limited in size to the ramburner-nozzle region of the engine nacelle; reasonable system weights are expected; hot section temperatures are consistent with advanced structural materials development goals; and system impact on engine performance is minimal. Author

A91-41761#
THRUST VECTORING USING NON-AXISYMMETRIC NOZZLES WITH FLEXIBLE CONTOURS
KEVIN W. WHITAKER, NOSHIR S. GOWADIA, and STEPHEN C. FORDYCE (Alabama, University, Tuscaloosa) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 7 p. General Motors Corp.-supported research.
(AIAA PAPER 91-2368) Copyright

A study was undertaken to investigate the feasibility of using exhaust nozzles with flexible walls to vector thrust. The hypothesis was that a thrust vector could be manipulated fluid dynamically instead of using some post-exit apparatus. The advantage to be gained by such a concept would be a thrust vectoring system which is considerably lighter than current designs. A two-dimensional baseline nozzle was designed and then the wall contours were systematically modified. In all cases nozzle performance was predicted using a code based on the method of characteristics. Results show that subtle changes in nozzle wall contours can cause a significant change in the thrust vector angle, anywhere from -12 to +15 degrees. Contour changes near the nozzle throat caused the largest amount of vectoring. It was also found that for off-design conditions the thrust vectoring obtained was highly dependent on the nozzle pressure ratio. Author

A91-41764#
AN APPROACH TO MODELING CONTINUOUS TURBINE ENGINE OPERATION FROM STARTUP TO SHUTDOWN
M. A. CHAPPELL (Sverdrup Technology, Inc., Arnold AFB, TN) and P. W. MCLAUGHLIN (Simulation and Modelling Workshop, Glastonbury, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-2373) Copyright

ATEST-V3, a novel capability in turbine engine modeling, is developed and demonstrated. This engine start process simulation capability makes it possible to quantitatively understand the combined effects of operating line excursions, turbine temperature fluctuations, engine control operation, and component interactions, in addition to power and air extraction effects during the engine start process. Test data for steady-state windmilling operation, windmill starts, spooldown starts, and starter-assisted starts were used to validate ATEST-V3 results. K.K.

A91-41767#
ANALYSIS OF EXTERNAL BURNING ON INCLINED SURFACES IN SUPERSONIC FLOW
J. A. SCHETZ, F. S. BILLIG, and S. FAVIN (Johns Hopkins University, Laurel, MD) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-2390) Copyright

Earlier analysis of a viscous mixing region with heat addition interacting with a supersonic external flow has been extended to include cases with a sloped wall beneath the viscous region. Also, cases with a supersonic to subsonic transition at the viscous throat have been studied for the first time. Limitations on the allowable heating value of the fuel that correspond to smooth subsonic to supersonic or supersonic to subsonic transitions are delineated and explained. The effects of wall slope at the throat and external Mach number on these limitations are shown. The results of calculations for representative cases show that it is possible to cancel base drag and even produce net thrust for cases with downward sloped walls if the initial Mach number in the viscous zone is supersonic prior to addition of heat. This corresponds to a supersonic to subsonic transition. For an initially subsonic flow, the results indicate pressures below the freestream static pressure throughout the flowfield. This means that only very limited drag from flameholders such that the flow remains supersonic before heat addition are advisable. Finally, some directions for future work are outlined. Author

A91-41768*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MACH 2 AND MACH 3 MIXING AND COMBUSTION IN SCRAMJETS
G. B. NORTHAM (NASA, Langley Research Center, Hampton, VA), D. P. CAPRIOTTI (Analytical Services and Materials, Hampton, VA), C. S. BYINGTON (Pennsylvania State University, University Park), and I. GREENBERG (Rafael Armament Development Authority, Haifa, Israel) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 15 p. refs
(AIAA PAPER 91-2394)

Experimental and theoretical studies are being conducted to explore techniques to enhance mixing in scramjet combustors using parallel fuel injection from the base of swept and unswept wall-mounted ramps. Parallel injection may be useful in high speed scramjets due to the thrust contributed by the momentum of expanding fuel that has been heated in the vehicle cooling cycle. The experiments reported herein were conducted using Mach 2 and 3 combustor inlet conditions. Supporting computational and cold flow studies indicated that the observed enhanced mixing for the swept ramp configuration is primarily due to the substantially higher degree of vorticity and entrainment generated by the swept trailing edges. Author

A91-41788*# CFD Research Corp., Huntsville, AL.
A CFD STUDY OF JET MIXING IN REDUCED FLOW AREAS FOR LOWER COMBUSTOR EMISSIONS
C. E. SMITH, M. V. TALPALLIKAR (CFD Research Corp., Huntsville, AL), and J. D. HOLDEMAN (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 15 p. Previously announced in STAR as N91-23185. refs
(Contract NAS3-25967)
(AIAA PAPER 91-2460) Copyright

The Rich-burn/Quick-mix/Lean-burn (RQL) combustor has the potential of significantly reducing NO(x) emissions in combustion chambers of High Speed Civil Transport aircraft. Previous work on RQL combustors for industrial applications suggested the benefit of necking down the mixing section. A 3-D numerical investigation was performed to study the effects of neckdown on NO(x) emissions and to develop a correlation for optimum mixing designs in terms of neckdown area ratio. The results of the study showed that jet mixing in reduced flow areas does not enhance mixing, but does decrease residence time at high flame temperatures, thus reducing NO(x) formation. By necking down the mixing flow area by 4, a potential NO(x) reduction of 16:1 is possible for annual combustors. However, there is a penalty that accompanies the mixing neckdown: reduced pressure drop across the combustor swirler. At conventional combustor loading parameters, the pressure drop penalty does not appear to be excessive. Author

A91-41791#
TESTING A MODERN TURBOPROP PROPULSION SYSTEM
GREGORY M. BECKER (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p.
(AIAA PAPER 91-2480) Copyright

Allison Gas Turbine provides the Propulsion System Package (PSP) for the Saab 2000 regional turboprop aircraft. The PSP includes the GMA 2100 engine, a modern turboprop engine, and the nacelle comprised of cowls, mounting structure, and systems. Allison has modified one of its turboprop test stands to allow installation and testing of an actual Saab 2000 nacelle. In order to maximize the facility's availability, a two-phase testing program was put into place. The first phase uses a nacelle configured similar to the production aircraft but with various material/hardware substitutions. The second phase uses aircraft production hardware. Both nacelles maintain the aircraft interfaces and configuration allowing maximum compatibility. Author

A91-41799*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THERMAL AND STRUCTURAL ASSESSMENTS OF A CERAMIC WAFER SEAL IN HYPERSONIC ENGINE
MIKE TONG (NASA, Lewis Research Center, Cleveland; Sverdrup Technology, Inc., Brook Park, OH) and BRUCE STEINETZ (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. Previously announced in STAR as N91-13456. refs
(AIAA PAPER 91-2494) Copyright

The thermal and structural performances of a ceramic wafer seal in a simulated hypersonic engine environment are numerically assessed. The effects of aerodynamic heating, surface contact conductance between the seal and its adjacent surfaces, flow of purge coolant gases, and leakage of hot engine flow path gases on the seal temperature were investigated from the engine inlet back to the entrance region of the combustion chamber. Finite element structural analyses, coupled with Weibull failure analyses, were performed to determine the structural reliability of the wafer seal. Author

A91-41801#
NEW CAPABILITIES FOR AEROMECHANICAL TESTING AND EVALUATION OF AIRCRAFT TURBINE ENGINES
T. W. CROMER, K. L. NICHOL (Sverdrup Technology, Inc., Arnold

AFB, TN), and J. S. SCHROEDER (USAF, Arnold Engineering Development Center, Arnold AFB, TN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p.
(AIAA PAPER 91-2498)

Aeromechanical tests are performed on new and modified Air Force aircraft turbine engines in altitude test facilities to establish aeromechanical operational margins, verify structural integrity throughout the flight envelope, and qualify proposed changes to the engine hardware. Two new test data processing and analysis computer programs have been developed at the Arnold Engineering Development Center (AEDC) to meet current and future challenges of aeromechanical testing and evaluation of turbine engines (i.e., expansion and extension of processing and analysis capabilities for dynamic stress test data). In addition, a new system is under development which will provide capabilities to expand online, real-time monitoring of dynamic data and to expedite and extend offline processing of dynamic data. Author

A91-41808#
AN EXPERT SYSTEM FOR PREDICTING FLUTTER IN TURBOMACHINES
WIN G. LIU (Portland State University, OR) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-2527) Copyright

A framework is presented for the construction of a knowledge-based turbomachine flutter-prediction system which will simultaneously (1) allow the explicit use of aeroelasticity principles derived from empirical rules and experts' experiences, (2) furnish an effective approach to the sharing of flutter-related knowledge among researchers in diverse organizations, and (3) facilitate the design of flutter-free blades. The ontological analysis method used is a three-step process which first concentrates on static physical objects and their relationships, proceeds to dynamic operations that can change the task world, and finally arrives at an epistemic knowledge structure which will guide feature selections. O.C.

A91-41810#
AN EJECTOR PERFORMANCE CORRELATION FACTOR
V. P. ROAN (Florida, University, Palm Beach Gardens) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 5 p. refs
(AIAA PAPER 91-2545) Copyright

Ejectors can furnish mass entrainment and compression through a much wider range of flight Mach numbers than conventional turbomachinery and are generally lighter, smaller, and less expensive than turbomachinery. Unlike turbomachines, however, ejectors possess no universally accepted definition of efficiency. A novel correlation parameter is presented with a view to more realistic projections of ejector performance with different working fluids and operating conditions; the parameter is based on the effectiveness of momentum transfer from primary to secondary fluid, reduced to stagnation properties. The appropriateness of the parameter is demonstrated through a review of published test results. O.C.

A91-41815*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A THREE-DIMENSIONAL NAVIER-STOKES STAGE ANALYSIS OF THE FLOW THROUGH A COMPACT RADIAL TURBINE
JAMES D. HEIDMANN (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. Previously announced in STAR as N91-23186. refs
(AIAA PAPER 91-2564) Copyright

A steady, three-dimensional Navier-Stokes average passage computer code is used to analyze the flow through a compact radial turbine stage. The code is based upon the average passage set of equations for turbomachinery, whereby the flow fields for all passages in a given blade row are assumed to be identical while retaining their three-dimensionality. A stage solution is achieved by alternating between stator and rotor calculations, while coupling the two solutions by means of a set of axisymmetric body forces which model the absent blade row. Results from the stage calculation are compared with experimental data and with results from an isolated rotor solution having axisymmetric inlet flow quantities upstream of the vacated stator space. Although the mass-averaged loss through the rotor is comparable for both solutions, the details of the loss distribution differ due to stator effects. The stage calculation predicts smaller spanwise variations in efficiency, in closer agreement with the data. The results of the study indicate that stage analyses hold promise for improved prediction of loss mechanisms in multi-blade row turbomachinery, which could lead to improved designs through the reduction of these losses. Author

A91-42556*# McDonnell-Douglas Research Labs., Saint Louis, MO.
FLOW VISUALIZATION STUDIES OF THE INTERNAL FLOW CHARACTERISTICS IN A SIMULATED MIXED FLOW VECTORED THRUST ASTOVL ENGINE CONFIGURATION
K. R. SARIPALLI (McDonnell Douglas Research Laboratories, Saint Louis, MO), P. J. FERRARO, J. D. FLOOD (McDonnell Aircraft Co., Saint Louis, MO), R. E. GREY (NASA, Lewis Research Center, Cleveland, OH), and J. A. WAZYNIAK (Pratt and Whitney Group, East Hartford, CT) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 13 p.
(AIAA PAPER 91-1689) Copyright

The characteristics of internal flowfields in a Mixed Flow Vectored Thrust (MFVT) propulsion system for Short Take Off and Vertical Landing (STOVL) fighter aircraft were investigated using flow visualization techniques. A highly parametric 14 percent scale transparent model was used to simulate the MFVT propulsion system. The working medium was water. The mixing between the fan and core flow was studied using flow visualization for a variety of geometrical and flow parameters including three bypass ratio variations. The flow visualization technique involves the use of laser light sheet for illumination and fluorescent dye or air bubbles as tracers. Results indicate the existence of a strong vortex flowfield in the hover mode of operation that is responsible for good mixing between the fan and core flows. Author

A91-42805#
REGRESSION AND COMBUSTION CHARACTERISTICS OF BORON CONTAINING FUELS FOR SOLID FUEL RAMJETS
D. NETZER (U.S. Naval Postgraduate School, Monterey, CA), A. GANY (Technion - Israel Institute of Technology, Haifa), A. KARADIMITRIS, and C. SCOTT, II Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 341-347. Previously announced in STAR as N90-27928. refs
(Contract N60530-87-WR-30009)
Copyright

A windowed, two-dimensional solid fuel ramjet motor was utilized with high speed motion picture cameras to study the effects of fuel composition, pressure and air mass flux on the surface behavior of metallized fuels within both the recirculation and boundary layer combustion regions. The objective was to determine if observed surface behavior and near-surface combustion characteristics could be used to help explain the regression rate and/or performance characteristic observed in actual motor hardware. Fuels containing no combustion catalyst tested at a nominal air mass flux of 0.5 lbm/sq in. sec exhibited the characteristic of having lower combustion pressure limits with lower values of Shore A hardness. Previous observed effects of carbon black, and the observed surface reactions with bimetallic fuels indicated that ignition/flammability limits are a strong function of surface pyrolysis processes within the recirculation region. Multi-compositionied fuel grains may prove beneficial for obtaining the best combination of ignition/flammability limits and motor performance. Most metallized fuels exhibited shedding of flakes of (unburned) material from the fuel surface. Flake thickness for boron fuels was typically 200 microns, independent of pressure, and surface areas varied from less that one sq mm to approximately 22 sq mm. The mass losses attributable to the flaking process play a major role in the overall fuel mass loss mechanism. Bimetallic fuels and fuels containing a combustion catalyst apparently had surface reactions which increase the surface temperature. This should be beneficial for obtaining more complete combustion of the metals within the motor. Author

A91-42806#
EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF ISOTHERMAL SWIRLING FLOW IN AN AXISYMMETRIC DUMP COMBUSTOR
S. C. FAVALORO (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia), A. S. NEJAD, and S. A. AHMED (USAF, Aero-Propulsion and Power Laboratory, Wright-Patterson AFB, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 348-356. USAF-supported research. Previously cited in issue 09, p. 1293, Accession no. A89-25491. refs
Copyright

A91-42807#
BURNING AND FLAMEHOLDING CHARACTERISTICS OF A MINIATURE SOLID FUEL RAMJET COMBUSTOR
ALON GANY (Technion - Israel Institute of Technology, Haifa) and AMNON NETZER Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 357-363. Previously cited in issue 23, p. 3764, Accession no. A88-53131. refs
Copyright

A91-42812#
NUMERICAL INVESTIGATION OF THE FLOW WITHIN A TURBOFAN LOBED MIXER
P. KOUTMOS, J. J. MCGUIRK, M. N. SODHA (Imperial College of Science, Technology, and Medicine, London, England), and C. H. PRIDDIN (Rolls-Royce, PLC, Derby, England) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 389-395. Research supported by Rolls-Royce, PLC. refs
Copyright

A computational procedure is described for the calculation of the flowfield within a multilobed turbofan mixer. The predictions have been obtained by using a finite-volume solution procedure for the three-dimensional elliptic equations of fluid flow extended to allow the modeling of flows within complex geometries. Turbulence is modeled using the two equation k-epsilon eddy viscosity model. The present work demonstrates the capability of the current method to predict the flow characteristics within the lobes and hence the formation of these secondary velocities. Parametric studies of the effect of changes in the fan-side geometry are reported to investigate how these influence the flow structure, in particular the generation and amplification of the secondary flow patterns. The calculations demonstrate how the procedure may be used to examine the likelihood of flow separation and the influence of the thickening of upstream boundary layers. Author

A91-42815#
IMPROVED METHODS OF CHARACTERIZING EJECTOR PUMPING PERFORMANCE
JOE DER, JR. (Northrop Corp., Pico Rivera, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 412-419. Previously cited in issue 09, p. 1292, Accession no. A89-25004. refs
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A91-42817#
PARAMETRIC STUDY OF AIRFRAME-INTEGRATED SCRAMJET COOLING REQUIREMENT
TAKESHI KANDA, GORO MASUYA, YOSHIO WAKAMATSU, NOBUO CHINZEI, and AKIO KANMURI (National Aerospace Laboratory, Kakuda, Japan) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 431-436. refs
Copyright

The cooling requirement of a hydrogen-fueled airframe-integrated scramjet engine as well as an airframe is examined, and effects of various parameters including flight Mach number, flight dynamic pressure, engine wall temperature, and engine scale, on the engine characteristics are analyzed. The coolant required for the airframe is about 20 percent of the total coolant. Simple equations that correlate coolant flow rate with those parameters are derived. Author

A91-42819#
THREE-DIMENSIONAL ANALYSIS OF GAS TURBINE COMBUSTORS
N. K. RIZK and H. C. MONGIA (General Motors Corp., Indianapolis, IN) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 445-451. Previously cited in issue 20, p. 3095, Accession no. A89-47153. refs
Copyright

A91-42821*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PERFORMANCE CHARACTERISTICS OF AN UNDEREXPANDED MULTIPLE JET EJECTOR
M. S. CHANDRASEKHARA (NASA, Ames Research Center, Moffett Field; U.S. Naval Postgraduate School, Monterey, CA), A. KROTHAPALLI (Florida State University, Tallahassee), and D. BAGANOFF (Stanford University, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 462-464. Previously cited in issue 08, p. 1051, Accession no. A87-22510. refs
(Contract F49620-79-C-0189)
Copyright

A91-43118
IAE V2500 - TECHNOLOGY FOR THE ENVIRONMENT [IAE V2500 - TECHNOLOGIE FUER DIE UMWELT]
Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, Mar.-Apr. 1991, p. 14-16, 18. In German.
Copyright

A program to reduce nitric oxide pollution from the IAE V2500 engine is discussed. The two phases of the improvement, one involving improved fuel-air management and the other the design of a radially staged combustor, are examined. The nitric oxide reductions expected to be gained by these improvements are pointed out. C.D.

A91-43585#
A NUMERICAL STUDY ON WIND TUNNEL INTERFERENCE EFFECTS IN EXTERNAL BURNING TEST AT M = 1.5
YANN-FU HSU and SCOTT D. HALLORAN (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 9 p. refs
(Contract F33657-87-C-2214)
(AIAA PAPER 91-1675) Copyright

This paper presents an efficient engineering methodology developed for the study of wind tunnel interference effects that may occur in supersonic external burning tests. This methodology employs an 'Euler+Q' CFD approach to analyze the wind tunnel flow fields with external burning. The computed flow fields are then carefully examined to help understand and quantify any tunnel interference effects. A case study on a test at Mach number 1.5 is then presented in the paper. Study results revealed that the downstream hardware supporting the test model had introduce some blockage effects. One effect of this blockage is to cause the measured pressure level on the model aftbody surface to be higher than the level which would be measured in an interference-free wind tunnel test. The tunnel walls, however, did not introduce any significant interference effect on the aftbody pressure. The feasibility of the external burning concept to reduce or eliminate transonic aftbody drag of an overexpanded expansion ramp nozzle is also supported by these study results. Author

A91-43586#
NUMERICAL ANALYSIS OF SCRAMJET FLOWS IN A DUMP COMBUSTOR
WEN H. LIN (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, Fluid Dynamics, Plasma Dynamics and

Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 15 p. refs
(Contract F33657-87-C-2214)
(AIAA PAPER 91-1676) Copyright

This paper mainly deals with numerical analysis, by means of CFD, of scramjet flows in an abrupt-expansion dump combustor. The objectives of the study are (1) to obtain detailed flow structures in such a configuration for understanding the complicated flowfield in the scramjet combustor, and (2) to provide numerical data of aerodynamics to assess mixing and combustion effects in such a combustor. Two types of nonreacting flows and one kind of reacting flow were computed with the aid of the unified solution algorithm. Results indicate that the turbulent mixing layer and the recirculation zone are greatly altered by the processes of injection and combustion. Author

A91-44045#
CERAMIC COMPOSITES FOR AIRCRAFT GAS TURBINE ENGINES
GAIL H. CULLUM (MSNW, Inc., Cape Coral, FL) and THOMAS E. SCHMID (Pratt and Whitney Group, West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p.
(AIAA PAPER 91-1892) Copyright

The potential benefits from high use temperatures and low densities of ceramic composities have made them attractive candidates for a variety of aircraft gas turbine engine components. However, the payoffs that results from implementation can vary significantly from component to component and from engine to engine. Understanding the sources of the payoffs and the material properties that drive the designs is essential to gaining acceptance for ceramic composite materials. The design system changes that must be accomplished to support implementation of ceramic composites are discussed along with the material property enhancements needed over current state-of-the-art. Author

A91-44046#
ADVANCED TECHNOLOGY ENGINE CASING DESIGNS
AHMAD ZAHEDI and STEPHEN C. MITCHELL (GE Aircraft Engines, Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-1893) Copyright

The use of concurrent engineering techniques to integrate the materials, design, and manufacturing of aircraft engine casings is discussed. The novel structural concepts, advanced metal matrix composites, and IPD/concurrent engineering environment involved in such applications are addressed. An example of the concurrent engineering of an aircraft engine duct is presented. C.D.

A91-44049*# Purdue Univ., West Lafayette, IN.
TRANSIENT PERFORMANCE OF FAN ENGINE WITH WATER INGESTION
S. N. B. MURTHY (Purdue University, West Lafayette, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 33 p. refs
(Contract NAG3-481)
(AIAA PAPER 91-1897) Copyright

In a continuing investigation on effects of rain-water ingestion into bypass fan engines, it is shown that the performance of axial-flow compressors and fans is fundamentally time-dependent during ingestion of water. A code named WINCOF-I has been developed for establishing the performance of axial-flow turbomachinery operating with air-water vapor-water droplet-water film mixture. Illustrative examples of predictions and effects are provided for the case of the air-compression system of a generic bypass fan engine. Utilizing performance maps so-generated, the effects of water ingestion into the generic engine have been determined under test cell conditions simulating ingestion, flight operation (altitude and flight Mach number), and power-demand setting. Author

A91-44050*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STATIC PERFORMANCE TESTS OF A FLIGHT-TYPE STOVL EJECTOR
WENDY S. BARANKIEWICZ (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. Previously announced in STAR as N91-24201. refs
(AIAA PAPER 91-1902) Copyright

The design and development of thrust augmenting STOVL ejectors has typically been based on experimental iteration (i.e., trial and error). Static performance tests of a full scale vertical lift ejector were performed at primary flow temperatures up to 1560 R (1100 F). Flow visualization (smoke generators and yarn tufts) were used to view the inlet air flow, especially around the primary nozzle and end plates. Performance calculations are presented for ambient temperatures close to 480 R (20 F) and 535 R (75 F) which simulate seasonal aircraft operating conditions. Resulting thrust augmentation ratios are presented as functions of nozzle pressure ratio and temperature. Author

A91-44051*# George Washington Univ., Washington, DC.
A NEW CONCEPT FOR A HUBLESS ROTARY JET
C. A. GARRIS, K. H. TOH, and L. XIE (George Washington University, Washington, DC) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. refs
(Contract NAG3-860)
(AIAA PAPER 91-1903)

The 'hubless rotary-jet' thrust augmentor primary-stream configuration is proposed as a way of overcoming problems encountered with hubbed rotary-jet ejectors while retaining sufficient geometrical simplicity to facilitate performance characterization and prediction via such commercially available CFD methods as FLOTRAN, as well as verification via LDV mapping. The present discussion is conducted with a view to the contributions of more realistic performance models incorporating turbulent mixing and compressibility. Attention is given to thrust augmentation ratio vs. spin angles for various area ratios with and without mixing. O.C.

A91-44053#
COMPUTER MODELLING OF IMPLANTED COMPONENT FAULTS IN A GAS TURBINE ENGINE
J. D. MACLEOD (National Research Council of Canada, Ottawa) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-1912) Copyright

The Engine Laboratory of the National Research Council of Canada (NRCC) has established a program for the evaluation of component deterioration on gas turbine engine performance. The effort is aimed at investigating the effects of typical in-service faults on the performance characteristics of each individual engine component. The program involves physically embedding faults into an engine when on test. At the same time, the effect of the fault is simulated using a component-based computer model. Simulated performance data are compared to actual test data, and the accuracy of the fault simulation is assessed. To date, the following faults were analyzed: the 1st stage turbine nozzle erosion damage, the 1st stage turbine rotor blade untwist, the compressor seal wear, the 1st and the 2nd stage compressor-blade-tip-clearance. This paper describes the project objectives, the experimental installation, the computer model, and a comparison of the model and test results of implanted faults on engine performance. Author

A91-44055*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MIXING ENHANCEMENT OF REACTING PARALLEL FUEL JETS IN A SUPERSONIC COMBUSTOR
J. P. DRUMMOND (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference,

27th, Sacramento, CA, June 24-26, 1991. 15 p. refs
(AIAA PAPER 91-1914) Copyright

Pursuant to a NASA-Langley development program for a scramjet HST propulsion system entailing the optimization of the scramjet combustor's fuel-air mixing and reaction characteristics, a numerical study has been conducted of the candidate parallel fuel injectors. Attention is given to a method for flow mixing-process and combustion-efficiency enhancement in which a supersonic circular hydrogen jet coflows with a supersonic air stream. When enhanced by a planar oblique shock, the injector configuration exhibited a substantial degree of induced vorticity in the fuel stream which increased mixing and chemical reaction rates, relative to the unshocked configuration. The resulting heat release was effective in breaking down the stable hydrogen vortex pair that had inhibited more extensive fuel-air mixing. O.C.

A91-44059*# Rensselaer Polytechnic Inst., Troy, NY.

EXPERIMENTAL INVESTIGATION OF A UNIQUE AIRBREATHING PULSED LASER PROPULSION CONCEPT

L. N. MYRABO, H. T. NAGAMATSU (Rensselaer Polytechnic Institute, Troy, NY), C. MANKA (U.S. Navy, Naval Research Laboratory, Washington, DC), P. W. LYONS, and R. A. JONES AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. Research supported by NASA, SDIO, and Lawrence Livermore National Laboratory. refs
(AIAA PAPER 91-1922) Copyright

Investigations were conducted into unique methods of converting pulsed laser energy into propulsive thrust across a flat impulse surface under atmospheric conditions. The propulsion experiments were performed with a 1-micron neodymium-glass laser at the Space Plasma Branch of the Naval Research Laboratory. Laser-induced impulse was measured dynamically by ballistic pendulums and statically using piezoelectric pressure transducers on a stationary impulse surface. The principal goal was to explore methods for increasing the impulse coupling performance of airbreathing laser-propulsion engines. A magnetohydrodynamic thrust augmentation effect was discovered when a tesla-level magnetic field was applied perpendicular to the impulse surface. The impulse coupling coefficient performance doubled and continued to improve with increasing laser-pulse energies. The resultant performance of 180 to 200 N-s/MJ was found to be comparable to that of the earliest afterburning turbojets. Author

A91-44075#

LOW NOX RICH-LEAN COMBUSTION CONCEPT APPLICATION

N. K. RIZK and H. C. MONGIA (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-1962) Copyright

The rich/quench/lean (RQL) combustion concept has demonstrated a significant reduction in NOx formation in gas turbine applications. The success of this approach relies on the effective and rapid mixing that is required for the transportation of the rich mixture to the lean zone of the combustor. It is realized that better design tools are required to achieve further reduction of NOx to meet the goal for high speed civil transport application. In the present investigation, a 3-D analysis was performed to evaluate its capability to detect the features of the mixing process. The analysis also help to point to regions of the combustor where NOx could form in larger quantities. A calculation approach was developed, based on chemical reaction concepts, to evaluate the NOx formation and destruction in various combustor zones. The calculated values agreed fairly well with the measurements obtained for the RQL combustor. Author

A91-44077#

PREDIFFUSER-COMBUSTOR MODEL STUDIES UNDER CONDITIONS OF WATER INGESTION IN ENGINES

T. MINSTER and S. N. B. MURTHY (Purdue University, West Lafayette, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 20 p. Research supported by GE Aircraft Engines. refs
(AIAA PAPER 91-1965) Copyright

Water ingestion into an engine, arising during flight under conditions of rainfall, is known to affect the matched performance of the engine due to modifications in the performance of various components. An experimental investigation has been performed with three two-dimensional, model configurations of a prediffuser-combustor with (1) different geometries and (2) nonswirl and swirl flow in the injector cups, utilizing a number of mixture and flow conditions in a tunnel operating with a two-phase, air-liquid film-droplet mixture. Entry conditions to the diffuser can be set up so as to correspond to exit conditions of a compressor in an engine undergoing water ingestion. Flow visualization and measurements of water flow and droplet size in different locations of the configurations have been undertaken to obtain data that serve (1) to illustrate the influence of design parameters and air-water mixture state on the flowfield in the primary zone of the models and (2) to provide a basis for estimating the performance of a combustor, especially the occurrence of flameout. Author

A91-44089*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

PRELIMINARY FLIGHT EVALUATION OF AN ENGINE PERFORMANCE OPTIMIZATION ALGORITHM

H. H. LAMBERT, G. B. GILYARD (NASA, Flight Research Center, Edwards, CA), J. D. CHISHOLM (McDonnell Aircraft Co., Saint Louis, MO), and L. J. KERR (Pratt and Whitney Group, West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 17 p. refs
(AIAA PAPER 91-1998) Copyright

A performance-seeking control (PSC) algorithm has undergone initial flight test evaluation in subsonic operation of a PW 1128-engined F-15; this algorithm is designed to optimize the quasi-steady performance of an engine for three primary modes: (1) minimum fuel consumption, (2) minimum fan-turbine inlet temperature (FTIT), and (3) maximum thrust. The flight test results have verified a thrust-specific fuel consumption reduction of 1 percent, up to 100 R decreases in FTIT, and increases of as much as 12 percent in maximum thrust. PSC technology promises to be of value in next-generation tactical and transport aircraft. O.C.

A91-44090#

COMPRESSOR EXIT TEMPERATURE ANALYSIS. II

CONSTANCE A. DOWLER and DAWN M. DOWNEY (USAF, Wright Laboratory, Wright-Patterson AFB, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-2008)

An investigation was conducted to determine the impact of aircraft mission constraints on the selection of optimum engine cycle characteristics. The aircraft/engine combination selected for this study was an air superiority class fighter with an augmented turbofan engine incorporating current state-of-the-art turbine engine technology. The analysis focused on optimizing overall compression system pressure ratio (i.e., compressor exit temperature), but also looked at the effect of increased turbine rotor inlet temperature. Uninstalled engine performance data was first generated, varying both compressor exit temperature and turbine rotor inlet temperature to assess the influence of these parameters on the engine's performance. These data were then used as input for the analysis of the installed engine performance and the aircraft/engine interaction, with the figure of merit being takeoff gross weight. Author

A91-44092#

SUPERSONIC AIR-INTAKE STUDY AIMING AT FUTURE AIRBREATHING ENGINE

K. SAKATA (National Aerospace Laboratory, Tokyo, Japan), S. HONAMI (Tokyo, Science University, Japan), and A. TANAKA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan)

AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 7 p. refs
(AIAA PAPER 91-2012) Copyright

A development status evaluation is presented for Japanese efforts toward development of SST/HST airbreathing propulsion system air intakes featuring a minimum cruise Mach number of 3.0 and mixed compression operation within a two-dimensional ramp-type geometry framework. Experimental investigations have thus far encompassed a three-shock ramp system, multishock ramps with bleed systems, variable-geometry inlets, and inlets optimized for SST airframe integration. The avoidance of boundary-layer separation and the minimization of bleed airflow rates are identified as the most important steps toward achievement of performance goals. O.C.

A91-44094#

UPGRADED T55 ENGINE FOR SPECIAL FORCES MH-47E AIRCRAFT

R. A. DIGIOVANNI (Textron Lycoming, Stratford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p.
(AIAA PAPER 91-2024) Copyright

The way in which stringent cost-reduction and technical risk-minimization criteria were met in the upgrading of the T55 turboshaft into the T55-L-714 engine of the MH-47E helicopter is discussed. The most significant change from previous practice that was instituted in the creation of the -714 variant is the replacement of the hydromechanical fuel control with a full-authority digital electronic control (FADEC) for surge detection/avoidance, engine torque-matching, isochronous rotor speed governing, and automatic health checks. A large portion of the qualification cost was driven by FADEC proof testing. O.C.

A91-44095#

PROPULSION SYSTEMS FOR UPGRADES OF CURRENT FIGHTER AIRCRAFT

SID PARKER (Pratt and Whitney Group, West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 5 p.
(AIAA PAPER 91-2026) Copyright

Budgetary pressures on DOD procurements entail that existing aircraft remain operationally effective well into the next century; currently emerging aircraft will be in operation until 2050. An approach is presented for gas turbine design and development in this historical period, in the context of tactical fighter/attack-aircraft propulsion-system requirements. Higher commonality between initial and follow-on versions of engines is called for, as is a thrust-growth potential in excess of 50 percent. Attention is given to the contributions toward these goals that are expected from the Integrated High Performance Turbine Engine Technology Initiative. O.C.

A91-44096#

ADVANCED HIGH WORK TURBINE TECHNOLOGY

R. BOZZOLA (Textron Lycoming, Stratford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-2028) Copyright

The development of an advanced single stage, high work axial turbine in the one-pound-per-second corrected flow class, for high temperature gas generator application has been undertaken. A full scale aerodynamic model has demonstrated in rig testing 2.5 percent efficiency increase at 14 percent higher work output with respect to previous Lycoming's experience. High temperature capability was achieved by incorporating complex cooling schemes into airfoils approximately one-inch long chordwise and less than one-inch high. Further gains in efficiency and temperature capability are sought through the adoption of advanced technologies, specifically three-dimensional viscous CFD and single-crystal blade fabrication process. Results are presented to demonstrate that such technologies are sufficiently mature for application in the high work turbine research program. Author

A91-44098#

CONCEPTS FOR REDUCTION OF TURBINE ROTOR INERTIA

J. K. BUSSICHELLA (GE Aircraft Engines, Lynn, MA), S. ANTOLINE, C. KAUS, J. L. HADDER (Allied Signal Aerospace Co., Garrett Engine Div., Phoenix, AZ), and S. M. HOFF (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 7 p.
(AIAA PAPER 91-2031) Copyright

Results of an analysis conducted under contract to Aviation Applied Technology Directorate investigating methods of reducing core turbine rotor inertia while improving turbine efficiency and engine performance are presented. In particular, the discussion includes, effects on rotor moment of inertia resulting from the use of lower density blade materials reduced-wall thickness blades, a lightweight cooling air delivery system utilizing a high speed brush seal, and a lightweight boltless blade retainer system. The effects on rotor inertia resulting from varying aerodynamic parameters are also presented. Results of inertia reduction of 40 percent were achieved with reference to a baseline configuration. Author

A91-44133#

A COMPARISON OF THE ANALYTICAL AND EXPERIMENTAL PERFORMANCE OF THE SOLID VERSION OF A COOLED RADIAL ROTOR

LIZET TIRRES (Sverdrup Technology, Inc., Brook Park, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-2133)

An evaluation of the aerodynamic performance of the solid version of an Allison-designed cooled radial turbine was conducted at NASA-Lewis' Warm Turbine Test Facility. The resulting pressure and temperature measurements are used to calculate vane, rotor, and overall stage performance. These performance results are then compared to the analytical results obtained by using NASA's MTSB (MERIDL-TSONIC-BLAYER) code. Author

A91-44134*# General Electric Co., Cincinnati, OH.

SCALE MODEL TEST RESULTS OF SEVERAL STOVL VENTRAL NOZZLE CONCEPTS

B. E. MEYER (GE Aircraft Engines, Cincinnati, OH), R. J. RE, and J. A. YETTER (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. Research supported by Lockheed Aeronautical Systems Co.
(AIAA PAPER 91-2134)

Short take-off and vertical landing (STOVL) ventral nozzle concepts are investigated by means of a static cold flow scale model at a NASA facility. The internal aerodynamic performance characteristics of the cruise, transition, and vertical lift modes are considered for four ventral nozzle types. The nozzle configurations examined include those with: butterfly-type inner doors and vectoring exit vanes; circumferential inner doors and thrust vectoring vanes; a three-port segmented version with circumferential inner doors; and a two-port segmented version with cylindrical nozzle exit shells. During the testing, internal and external pressure is measured, and the thrust and flow coefficients and resultant vector angles are obtained. The inner door used for ventral nozzle flow control is found to affect performance negatively during the initial phase of transition. The best thrust performance is demonstrated by the two-port segmented ventral nozzle due to the elimination of the inner door. C.C.S.

A91-44135#

HIGH SPEED ROTORCRAFT PROPULSION SYSTEM STUDIES

J. L. BETTNER, R. E. YOUNT, T. J. RONAN, and D. S. PESETSKY (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 20 p. refs
(AIAA PAPER 91-2150) Copyright

An advanced technology 8000 shp class turboshaft engine has been configured for high speed rotorcraft applications. The engine features a two-concentric-shaft core with a front drive power turbine. Recent high speed rotorcraft airframe studies have identified a desired turboshaft engine constant power/variable output speed operating characterisitic. This paper presents the study results of incorporating variable geometry turbines in the engine to accomplish this power/speed characteristics. Author

A91-44139#
THEORETICAL STUDY OF SUPERSONIC FLOW SEPARATION OVER A REARWARD FACING STEP
A. S. YANG, W. H. HSIEH, and K. K. KUO (Pennsylvania State University, University Park) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-2161) Copyright

A detailed theoretical examination of the flow structure in a supersonic flow over a rearward facing step is presented. The governing equations, comprising conservation of mass, energy, and momentum are solved numerically using a flux-vector splitting lower-upper symmetric successive overrelaxation scheme. Calculated results are given in terms of mean velocity profile, pressure and temperature contours, Mach number and surface pressure distribution. Reasonable agreement was obtained between calculated results and the reported data of laser-Doppler velocimetry and surface static pressure distribution. R.E.P.

A91-44141#
PERFORMANCE EVALUATION OF SEMI-FREEJET TESTS OF THE GENERIC HIGH SPEED ENGINE
DAVID A. BEMENT, MICHAEL W. THOMPSON, and JAMES R. STEVENS (Johns Hopkins University, Laurel, MD) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-2163) Copyright

An integral analysis technique for modeling a step-constant-area combustor followed by a diverging combustor is presented. This technique is only applicable to cases where the diverging combustor does not create any upstream disturbances. Comparison of the experimental data with model predictions shows a good agreement. It is found that, in the step-constant-area combustor analysis, the isolator shock pressure rise cannot be predicted unless correlated to the pressure acting on the base area of the step or some other predictable combustor quantity. The test results show that the shock pressure rise is approximately equal to the base pressure. O.G.

A91-44153*# Florida Univ., Gainesville.
EFFECTS OF NOZZLE LIP GEOMETRY ON SPRAY ATOMIZATION AND EMISSIONS ADVANCED GAS TURBINE COMBUSTORS
GERALD J. MICKLOW, SUBIR ROYCHOUDHURY (Florida, University, Gainesville), and H. L. NGUYEN (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-2201) Copyright

A parametric study is conducted to investigate the effect of nozzle lip geometry on nozzle fuel distribution, emissions and temperature distribution for a rich burn section of a rich burn/quick quench/lean burn combustor. It is seen that the nozzle lip geometry greatly affects the fuel distribution, emissions and temperature distribution. It is determined that at an equivalence ratio of 1.6 the NO concentration could be lowered by a factor greater than three by changing the nozzle lip geometry. R.E.P.

A91-44168#
ADVANCED HIGH BYPASS MIXED-FLOW EXHAUST SYSTEM DESIGN STUDY
R. R. BABBITT, J. A. COHN, and K. J. FLEMING (GE Aircraft Engines, Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-2242) Copyright

A study was carried out to determine and quantify the important mixer and exhaust nozzle design parameters for high-bypass mixed-flow exhaust systems. The model test program demonstrates that high mixer and exhaust system performance can be achieved with a long-duct mixed-flow (LDMF) exhaust system. With proper mixer design and mixer/bifurcation integration, an LDMF system is shown to be a viable means of improving the fuel efficiency of high-bypass engines. V.L.

A91-44169#
MIXER/EJECTOR NOISE SUPPRESSORS
WALTER M. PRESZ, JR. (Western New England College, Springfield, MA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-2243) Copyright

Ejector schemes provide a simple means of reducing jet noise by mixing high velocity exhaust gases with cool ambient air. This paper describes developments in ejectors which increase their attractiveness for suppressor application. New data are presented on using low-loss mixer lobes to improve ejector efficiencies. Model test data are presented which show that properly designed mixer/ejectors perform at near-ideal prediction levels. Also, the optimum mixing duct lengths of such devices have a length-to-diameter ratio of one or less. This means that mixer/ejector exhaust components can provide a light, compact jet noise suppressor for aircraft operation. Engine test stand data for an optimized mixer/ejector exhaust suppressor are presented. The test data show that the mixer/ejector suppressor provides design noise reduction with a 5-percent thrust gain at static takeoff conditions. Author

A91-44208#
REDUCED PRESSURE OSCILLATIONS IN A DUMP COMBUSTOR WITH TAPERED CORRUGATIONS
H. L. BOWMAN, K. J. WILSON, E. GUTMARK, K. C. SCHADOW, and R. A. SMITH (U.S. Navy, Naval Weapons Center, China Lake, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-2354)

Pressure oscillations in a compact ramjet dump combustor utilizing both a standard circular dump and one containing tapered corrugations were studied and compared. Use of the tapered corrugations resulted in a significant reduction in rms pressure level in the combustor at operating conditions where the circular dump was highly unstable. The dump with tapered corrugations generates streamwise vorticity which improves fine scale mixing and may reduce periodic heat release from the large scale structures in the combustor. Effects of varying fuel/air ratio, air mass flow ratio, and fuel injection location were studied. Results were found to be sensitive to all of these variables. The dump combuster with tapered corrugations had higher pressure losses than the circular dump. Author

A91-44209#
GRID GENERATION FOR THREE-DIMENSIONAL TURBOMACHINERY GEOMETRIES INCLUDING TIP CLEARANCE
B. LAKSHMINARAYANA (Pennsylvania State University, University Park), A. H. BASSON, and R. F. KUNZ AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 13 p. University of Stellenbosch-supported research. refs
(AIAA PAPER 91-2360) Copyright

This paper describes an efficient technique for the generation of grids for viscous flow computations in two-dimensional and three-dimensional turbomachinery blade rows, together with a specialized embedded H-grid for application to tip clearance flows. The technique uses a combination of algebraic and elliptic methods to obtain smooth grids while maintaining strict control over grid spacing and orthogonality at the domain boundaries. It was found that the embedded H-grid topology provides good resolution of tip clearance effects and produces better results than an H-grid using the thin tip approximation. I.S.

A91-44216#

COMPARATIVE ANALYSIS OF TURBOFAN EFFECTIVE THRUST WITH MIXED AND SEPARATED FLOWS ENGINES

S. P. ANDREEV and L. N. DRUZHININ (Tsentral'nyi Nauchno-Issledovatel'skii Institut Aviatsionnogo Motorostroeniia, Moscow, USSR) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 5 p.
(AIAA PAPER 91-2376) Copyright

The effective thrust variations of several turbofan versions with separated flows are compared with turbofans with mixed flows. All these versions have the same core. In turbofans with separated flows, there are additional thrust losses and drag that are absent in turbofans with mixed flow. Due to optimization of the nacelle contours, it is possible to decrease such difference approximately down to 1.0-1.5 percent. Author

A91-44217#

COMBINED CYCLE AIRCRAFT ENGINES

L. N. DRUZHININ and M. I. MOLCHANOVA (Tsentral'nyi Nauchno-Issledovatel'skii Institut Aviatsionnogo Motorostroeniia, Moscow, USSR) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-2377) Copyright

The paper discusses one of the alternative ways to improve the thermal efficiency of aircraft engines. Considered here are some schemes for turbofans and propfans with an additional utilization of a steam cycle. The heat recovery steam generators and condensers must be made using the water or steam tubes of very small diameter (d = 3 mm; the wall thickness is about 0.1 mm). It is possible in principle to meet the weight and size requirements of aircraft engines. Two versions of the combined cycle engines are considered: an integrated engine system with a condenser placed in the additional fan duct, and an installation with a separate condenser unit mounted in a special nacelle. Preliminary analysis shows that significant improvement in fuel efficiency can be achieved: the cruise SFC decreases down to a value of between 0.455 and 0.475 lb/lb-hr for combined cycle turbofans and down to 0.37 to 0.38 lb/lb-hr for combined cycle propfans. Author

A91-44218#

TURBOFAN ENGINE BIRD INGESTION TESTING

W. D. HOWARD (GE Aircraft Engines, Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 7 p. refs
(AIAA PAPER 91-2380) Copyright

The paper describes the equipment and the procedure used for bird-ingestion testing of large turbofan engines and discusses the reasons for bird-ingestion testing. The testing facilities, the cameras and lights, and the test sequence are discussed in detail. Schematic diagrams of the testing facility and the camera and lighting system are included. I.S.

A91-44219#

HOT-SURFACE IGNITION AND FIRE-SUPPRESSION TESTS IN AN AIRCRAFT ENGINE BAY

W. H. GEYER (U.S. Navy, Naval Weapons Center, China Lake, CA) and N. A. MOUSSA (Blaze Tech Corp., Winchester, MA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 8 p.
(AIAA PAPER 91-2382)

The conditions in an engine bay that promote the ignition of flammable fluids, and the suppression of subsequent fires, were investigated. Ignition by hot surfaces has been studied in the past under laboratory conditions or in simulated aircraft engine bays. This test was conducted under full-scale and realistic engine-bay conditions using an operable turbofan engine installed in an aircraft. The engine consisted of a forward zone (fan, compressor, and accessories) and an aft zone (combustor, turbine, and exhaust plenum). In the aft zone, key metal surface temperatures exceeded the fluid autoignition temperature (AIT), and ignition was observed. In the forward zone, surface temperatures exceeded the AIT but not the hot-surface ignition temperature (HSIT), and ignition was not observed. These ignition results, coupled with an examination of the heating conditions of each zone, suggest that suitable temperature criteria for ignition are the AIT in the aft zone and the HSIT in the forward zone. Fires in the engine bay were repeatedly extinguished by an automatic suppression system. When a manually actuated suppression system was used, with its inherent time delays, the fire was not extinguished. Author

A91-44225#

A DEMONSTRATION OF MODE TRANSITION IN A SCRAMJET COMBUSTOR

G. A. SULLINS, D. A. CARPENTER, M. W. THOMPSON, F. T. KWOK, and L. A. MATTES (Johns Hopkins University, Laurel, MD) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 8 p.
(AIAA PAPER 91-2395) Copyright

Direct-connect combustor hardware has been assembled to investigate a hydrogen-fueled scramjet combustor. The test hardware was designed to perform tests at simulated Mach 5 to Mach 8 flight conditions. This is done using a combustion heater with H_2 fuel and make-up O_2. The air, H_2, and O_2 flowrates are all supplied through computer-controlled digital valves. This system allows rapid changes in conditions, and very steady flowrates can be maintained throughout the test. Recently, tests were performed in which the flowrates were changed during the test in order to simulate an acceleration from $M = 5.9$ to $M = 6.2$. During this acceleration, the combustor transitioned from a scramjet with a precombustion shock system having a high-pressure ratio, to a scramjet with no precombustion shock system. Author

A91-44250*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

FUEL-RICH, CATALYTIC REACTION EXPERIMENTAL RESULTS

JIM ROLLBUHLER (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 22 p. Previously announced in STAR as N91-24203. refs
(AIAA PAPER 91-2463) Copyright

Future aeropropulsion gas turbine combustion requirements call for operating at very high inlet temperatures, pressures, and large temperature rises. At the same time, the combustion process is to have minimum pollution effects on the environment. Aircraft gas turbine engines utilize liquid hydrocarbon fuels which are difficult to uniformly atomize and mix with combustion air. An approach for minimizing fuel related problems is to transform the liquid fuel into gaseous form prior to the completion of the combustion process. Experimentally obtained results are presented for vaporizing and partially oxidizing a liquid hydrocarbon fuel into burnable gaseous components. The presented experimental data show that 1200 to 1300 K reaction product gas, rich in hydrogen, carbon monoxide, and light-end hydrocarbons, is formed when flowing 0.3 to 0.6 fuel to air mixes through a catalyst reactor. The reaction temperatures are kept low enough that nitrogen oxides and carbon particles (soot) do not form. Results are reported for tests using different catalyst types and configurations, mass flowrates, input temperatures, and fuel to air ratios. Author

A91-44261#

CFD-BASED 3D TURBOFAN EXHAUST NOZZLE ANALYSIS SYSTEM

B. D. KEITH, K. UENISHI, and D. A. DIETRICH (GE Aircraft Engines, Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-2478) Copyright

A three-dimensional turbofan exhaust nozzle analysis system based on computational fluid dynamics (CFD) has been developed. This system has been established to aid exhaust designers in the efficient assessment and screening of their design concepts, with the prospects of a reduction in both design cycle time and wind tunnel test costs. A reliable CFD flow solver, user-friendly grid generator, and post-processing solftware are included in the system. The system is easy to use for exhaust designers who are not particularly familiar with the inner workings of CFD. Validation and applicability studies have been performed using different exhaust nozzle configurations at on-design and off-design engine operating conditions. This work demonstrates that a CFD code integrated with automatic grid generation and postprocessing can be a useful analytical tool in the practical exhaust nozzle design process. Author

A91-44265#
WIND TUNNEL RESULTS OF COUNTER ROTATION PROP-FANS DESIGNED WITH LIFTING LINE AND EULER CODE METHODS
TODD E. HANNIGAN and HARRY S. WAINAUSKI (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 8 p. Research supported by United Technologies Corp. refs
(AIAA PAPER 91-2499) Copyright

Advanced Euler code analytical methods have become available for the analysis of comparative performance in single- and counter-rotation propfans; their use affords designers more detailed view of flow characteristics than the conventional lifting-line methods. A wind tunnel model has been designed on the basis of the Euler-code method and tested in a large subsonic wind tunnel. It has been shown by the results obtained that the Euler code-based design yields higher performance than lifting-line method-based designs. O.C.

A91-44303#
A NEW CONCEPT ON COMPRESSOR AND TURBINE FOR AEROSPACE PROPULSION
ZEYAN PENG and YANFANG LIN (Beijing University of Aeronautics and Astronautics, People's Republic of China) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 6 p.
(AIAA PAPER 91-2591) Copyright

This paper presents new concepts for counter-rotating transonic/supersonic compressor and turbine. The basic idea of this design is to take advantage of previous stage rotor discharge circulation, as a counter-swirl to the next rotor, to do more work and get more static pressure rise by a multioblique-shock-wave. Numerical results show that significant reduction both in the number of blade rows and in weight may be achieved through this conceptual aerodynamic design. Author

A91-44329#
THE PC AS A GENERIC DEVELOPMENTAL FUEL CONTROL FOR EXPENDABLE TURBOJET ENGINES
J. S. LILLEY (U.S. Army, Missile Command, Redstone Arsenal, AL), S. L. PENGELLY, and P. FISHER (Boeing Defense and Space Group, Huntsville, AL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 23 p. refs
(AIAA PAPER 91-3399)

A PC-based generic developmental fuel control system for expendable turbojet engines is described, and its applicability is demonstrated. It is shown that the system can be used for experimentally evaluating the engine hardware, fuel-metering devices, control sensors, and control logic of turbojet missile propulsion systems, all independently of installation in the flight vehicle. The software structure and the function of various programs are described togeher with the engine fuel-control-logic algorithms. Results of evaluating an experimental system are presented. I.S.

A91-44339#
COMPOSITES MOVE INTO JET ENGINE DESIGN
RICHARD J. PIELLISCH Aerospace America (ISSN 0740-722X), vol. 29, July 1991, p. 18-21, 29.
Copyright

A review is presented of current state-of-the-art development and production of composite materials applied to advanced jet engines. In both the military and commercial sectors, nacelles and thrust reversers are routinely made with composites, and they are steadily becoming the material of cowls, ducts, and fans. However, though engineers are enthusiastic about the low mass of composites and their corrosion resistance and fatigue, the materials have yet to be accepted for flight-critical engine parts. For these critical areas, the entire body of power plant design knowledge, and practically all of the analytical design tools, are currently oriented toward isotropic metals. Consideration is given to areas where researchers are investigating possible composites applications, including forward fan blades, fan core fairings, vane inlets, air splitters and inner ducts. R.E.P.

N91-25147*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A SIMULATION STUDY OF TURBOFAN ENGINE DETERIORATION ESTIMATION USING KALMAN FILTERING TECHNIQUES
HEATHER H. LAMBERT Jun. 1991 47 p
(NASA-TM-104233; H-1616; NAS 1.15:104233) Avail: NTIS HC/MF A03 CSCL 21/5

Deterioration of engine components may cause off-normal engine operation. The result is an unecessary loss of performance, because the fixed schedules are designed to accommodate a wide range of engine health. These fixed control schedules may not be optimal for a deteriorated engine. This problem may be solved by including a measure of deterioration in determining the control variables. These engine deterioration parameters usually cannot be measured directly but can be estimated. A Kalman filter design is presented for estimating two performance parameters that account for engine deterioration: high and low pressure turbine delta efficiencies. The delta efficiency parameters model variations of the high and low pressure turbine efficiencies from nominal values. The filter has a design condition of Mach 0.90, 30,000 ft altitude, and 47 deg power level angle (PLA). It was evaluated using a nonlinear simulation of the F100 engine model derivative (EMD) engine, at the design Mach number and altitude over a PLA range of 43 to 55 deg. It was found that known high pressure turbine delta efficiencies of -2.5 percent and low pressure turbine delta efficiencies of -1.0 percent can be estimated with an accuracy of + or - 0.25 percent efficiency with a Kalman filter. If both the high and low pressure turbine are deteriorated, the delta efficiencies of -2.5 percent to both turbines can be estimated with the same accuracy. Author

N91-25148*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE DESIGN/ANALYSIS OF FLOWS THROUGH TURBOMACHINERY: A VISCOUS/INVISCID APPROACH
D. P. MILLER and D. R. REDDY (Sverdrup Technology, Inc., Brook Park, OH.) 1991 12 p Presented at the 27th Joint Propulsion Conference, Sacramento, CA, 24-27 Jun. 1991; sponsored by AIAA, SAE, ASME, and the American Society for Electrical Engineers
(NASA-TM-104447; E-6288; NAS 1.15:104447; AIAA-91-2010) Avail: NTIS HC/MF A03 CSCL 21/5

The development of a design/analysis flow solver at NASA Lewis Research Center is discussed. The solver is axisymmetric and can be run inviscidly with assumed or calculated blockages, or with the viscous terms computed. The blade forces for each blade row are computed from blade-to-blade solutions, correlated data or force model, or from a full three dimensional solution. Codes currently under development can be separated into three distinct elements: the turbomachinery interactive grid generator energy distribution restart code (TIGGERC), the interactive blade element geometry generator (IBEGG), and the viscous/inviscid multi-blade-row average passage flow solver (VIADAC). Several experimental test cases were run to validate the VIADAC code. The tests, representative of typical axial turbomachinery duct axisymmetric wind tunnel body problems, were conducted on an SR7 Spinner axisymmetric body, a NASA Rotor 67 Fan test bed, and a transonic boatail body. The results show the computations to be in good agreement with test data. L.K.S.

N91-25150# Oak Ridge National Lab., TN.
FIBER-SENSOR DESIGN FOR TURBINE ENGINES

K. W. TOBIN, JR., D. L. BESHEARS, B. W. NOEL, W. D. TURLEY, and W. LEWIS, III 1991 13 p Presented at the 5th Annual Fiber Optics Review Conference, Blacksburg, 1-4 Apr. 1991
(Contract DE-AC05-84OR-21400)
(DE91-010787; CONF-9104214-1) Avail: NTIS HC/MF A03

Turbine engine systems present a challenging environment for applications of fiber-optic-based probes and sensors. High temperatures, large vibrations, strong black-body emission backgrounds, and optical path haziness, represent some of the obstacles that characterize these environments. This paper discusses the design philosophy and implementation of a fluorescence-based, extrinsic, fiber-optic sensor. This technique utilizes the temperature-dependent fluorescent emission of a ceramic phosphor coating to discern the temperature of the interrogated surface. Surface temperature measurements to 1500 K are achievable in the combustion environment using these methods. DOE

N91-26144# Coordinating Research Council, Inc., Atlanta, GA.
SURVEY OF CURRENT AIRCRAFT ENGINE CONDITIONS
KURT STRAUSS Feb. 1991 20 p
(AD-A235143; CRC-573) Avail: NTIS HC/MF A03 CSCL 21/4

In the letter of March 15, 1989, concern was expressed over the fact that existing specification test methods did not detect a thermal stability problem when fuel was used in an advanced turbine engine. The same letter, which is attached as Appendix B, suggested several research approaches to resolve the problem. As a result the CRC Group on Oxidation Stability of Gas Turbine Fuels formed a panel to develop a plan to meet the ASTM request. Panel membership is shown in Appendix A. The detailed plan was prepared by panel leader and is given in Appendix C. The first item in the plan was to conduct a survey of engine/airframe manufacturers to develop fuel system parameters for typical past, present and future aircraft. GRA

N91-26145# United Technologies Research Center, East Hartford, CT.
INVESTIGATION OF HOT STREAK MIGRATION AND FILM COOLING EFFECTS ON THE HEAT TRANSFER IN ROTOR/STATOR INTERACTING FLOWS Quarterly Progress Report, 1 Jan. 1990 - 31 Mar. 1991
DANIEL J. DORNEY and ROGER L. DAVIS 31 Mar. 1991 22 p
(Contract N00140-88-C-0677)
(AD-A235420) Avail: NTIS HC/MF A03 CSCL 20/13

This effort extended the three-dimensional unsteady rotor/stator interaction code, ROTOR3, to investigate hot streak migration and film cooling effects on the passage flow and blade surface heat transfer for an axial flow turbine stage. These objectives are part of an overall plan to extend the capabilities of this numerical procedure and to determine the potential of this technique to impact the design of future rotating turbomachinery components. The principal benefits that will result from this effort are: (1) a diagnostic analysis and code which can be used to help design turbine blades with increased efficiency and reduced cooling requirements; (2) an open literature demonstration on the use of computational simulation and scientific visualization for gaining insight into complex turbomachinery flows; (3) acceleration of the transition of large-scale computational analyses to the turbomachinery design process through joint involvement between UTRC and Pratt and Whitney turbine engineers; and (4) a useful and proven design tool which can be used with existing and future engine design procedures. GRA

N91-26146*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CFD ANALYSIS OF JET MIXING IN LOW NOX FLAMETUBE COMBUSTORS
M. V. TALPALLIKAR, C. E. SMITH, M. C. LAI (Wayne State Univ., Detroit, MI.), and J. D. HOLDEMAN 1991 11 p Presented at the 36th International Gas Turbine and Aeroengine Congress and Exposition, Orlando, FL, 3-6 Jun. 1991; sponsored by ASME Original contains color illustrations
(Contract NAS3-25834)
(NASA-TM-104466; E-6313; NAS 1.15:104466; ASME-91-GT-217) Avail: NTIS HC/MF A03; 1 functional color page CSCL 21/5

The Rich-burn/Quick-mix/Lean-burn (RQL) combustor was identified as a potential gas turbine combustor concept to reduce NO(x) emissions in High Speed Civil Transport (HSCT) aircraft. To demonstrate reduced NO(x) levels, cylindrical flametube versions of RQL combustors are being tested at NASA Lewis Research Center. A critical technology needed for the RQL combustor is a method of quickly mixing by-pass combustion air with rich-burn gases. Jet mixing in a cylindrical quick-mix section was numerically analyzed. The quick-mix configuration was five inches in diameter and employed twelve radial-inflow slots. The numerical analyses were performed with an advanced, validated 3-D Computational Fluid Dynamics (CFD) code named REFLEQS. Parametric variation of jet-to-mainstream momentum flux ratio (J) and slot aspect ratio was investigated. Both non-reacting and reacting analyses were performed. Results showed mixing and NO(x) emissions to be highly sensitive to J and slot aspect ratio. Lowest NO(x) emissions occurred when the dilution jet penetrated to approximately mid-radius. The viability of using 3-D CFD analyses for optimizing jet mixing was demonstrated. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A91-41156
A CHART OF UNSTABLE AIRCRAFT MOTIONS DUE TO CROSS CONSTRAINTS OF VARIOUS ORIGINS [KARTA OBLASTEI NEUSTOICHIVYKH DVIZHENII SAMOLETA, OBUSLOVLIVAEMYKH PEREKRESTNYMI SVIAZIAMI RAZLICHNOGO PROISKHOZHDENIIA]
V. F. NATUSHKIN and A. V. PASHKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1991, p. 11-15. In Russian. refs
Copyright

The stability of aircraft motion relative to a spatial angle of attack is investigated analytically with allowance for inertial gyroscopic, aerodynamic, and kinematic cross constraints. The analysis is based on a system of rotational equations in nontraditional phase variable space and on the theory of differential equations with variable periodic coefficients. The results of the study are generalized in the form of a chart of motion instabilities in the plane of complex aircraft characteristics and external perturbations. V.L.

A91-41169
STABILIZATION OF THE SLING LOAD OF A HELICOPTER [STABILIZATSIIA GRUZA NA VNESHNEI PODVESKE VERTOLETA]
S. V. SIPAROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1991, p. 84-87. In Russian. refs
Copyright

The problem of the stabilization of a helicopter sling load is formulated as an inverse problem consisting of determining the stabilization parameters of the system helicopter-sling-load for which no increase is observed in the load swing amplitude. The inverse problem can be linearized, since only the critical values of the parameters are of interest. An example of calculations is presented. In flight tests, the approach proposed here has made it possible to increase the transportation speed by more than a factor of 2 due to load stabilization. V.L.

A91-41731*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A PRELIMINARY INVESTIGATION OF THE USE OF THROTTLES FOR EMERGENCY FLIGHT CONTROL

F. W. BURCHAM, JR., C. G. FULLERTON, GLENN B. GILYARD, THOMAS D. WOLF, and JAMES F. STEWART (NASA, Flight Research Center, Edwards, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 22 p. refs
(AIAA PAPER 91-2222) Copyright

A preliminary investigation was conducted regarding the use of throttles for emergency flight control of a multiengine aircraft. Several airplanes including a light twin-engine piston-powered airplane, jet transports, and a high performance fighter were studied during flight and piloted simulations. Simulation studies used the B-720, B-727, MD-11, and F-15 aircraft. Flight studies used the Lear 24, Piper PA-30, and F-15 airplanes. Based on simulator and flight results, all the airplanes exhibited some control capability with throttles. With piloted simulators, landings using manual throttles-only control were extremely difficult. An augmented control system was developed that converts conventional pilot stick inputs into appropriate throttle commands. With the augmented system, the B-720 and F-15 simulations were evaluated and could be landed successfully. Flight and simulation data were compared for the F-15 airplane. Author

A91-43095#
ESTIMATION OF AIRCRAFT ATTITUDE BY ANGULAR RATE MEASUREMENTS
S. J. MERHAV (Technion - Israel Institute of Technology, Haifa) and M. KOIFMAN IN: Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Collection of Papers. Haifa, Israel, Technion - Israel Institute of Technology, 1990, p. 141-152. Research supported by Ministry of Defence of Israel and Precision Instrument Industries. refs

This paper presents a method for on-board aircraft attitude estimation based on the measurements of an orthogonal triad of strapdown low cost rate gyros, airspeed, barometric altitude and magnetic heading sensors. A reduced order, computationally simplified, Extended Kalman Filter is shown to provide on-line attitude estimates with bounded errors not exceeding 0.5 deg at output rates in the order of 20 Hz. Considerations for order reduction and computational simplifications which facilitate on-line operation are presented. Off-line computer simulations including uncertain atmospheric turbulence and time-varying gyro drift demonstrate precision and robustness. Actual on-line simulations including real rate gyros are described. The results validate the feasibility of the concept. Author

A91-43932
FUZZY LOGIC FOR CONTROL OF ROLL AND MOMENT FOR A FLEXIBLE WING AIRCRAFT
STEPHEN CHIU, SUJEET CHAND (Rockwell International Science Center, Thousand Oaks, CA), DOUG MOORE, and ASHWANI CHAUDHARY (Rockwell International Corp., Los Angeles, CA) (IEEE International Symposium on Intelligent Control, 5th, Philadelphia, PA, Sept. 5-7, 1990) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 11, June 1991, p. 42-48. refs
Copyright

A fuzzy-logic-based multi-input/multi-output roll controller designed for the Advanced Technology Wing (ATW) aircraft model is presented. The ATW integrates active controls with a flexible wing structure to provide optimal wing shapes to meet particular flight performance criteria. Because of the large variations in the dynamic model of the wing as a function of flight condition, the use of a fuzzy controller for roll rate and load alleviation control was investigated. Fuzzy rules were developed to determine the appropriate control surface deflections to achieve the desired roll rate while ensuring that wing loads are within safe bounds. A novel departure of the rules from conventional control heuristics is in the modulation of the damping factor according to the distance of the system state from the goal state. This damping modulation technique allows full utilization of the vehicle's acceleration capability and resulted in an improvement of the response time by a factor of two. When the wing loads are close to the bounds, control rules derived from a qualitative analysis of the plant model provide load alleviation with minimal degradation in roll performance. The resultant fuzzy controller commands six surface deflections to control the roll rate and four torsion moments. I.E.

A91-44162*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A SIMULATION EVALUATION OF A FOUR-ENGINE JET TRANSPORT USING ENGINE THRUST MODULATION FOR FLIGHTPATH CONTROL
GLENN B. GILYARD, JOSEPH L. CONLEY, JEANETTE LE, and FRANK W. BURCHAM, JR. (NASA, Flight Research Center, Edwards, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 20 p. refs
(AIAA PAPER 91-2223) Copyright

The use of throttle control laws to provide adequate flying qualities for flightpath control in the event of a total loss of conventional flight control surface use was evaluated. The results are based on a simulation evaluation by transport research pilots of a B-720 transport with visual display. Throttle augmentation control laws can provide flightpath control capable of landing a transport-type aircraft with up to moderate levels of turbulence. The throttle augmentation mode dramatically improves the pilots' ability to control flightpath for the approach and landing flight condition using only throttle modulation. For light turbulence, the average Cooper-Harper pilot rating improved from unacceptable to acceptable (a pilot rating improvement of 4.5) in going from manual to augmented control. The low frequency response characteristics of the engines require a considerably different piloting technique. The various techniques used by the pilots resulted in considerable scatter in the data. Many pilots readily adapted to a good piloting technique while some has difficulty. The research demonstrates a new and viable approach to providing an independent means of redundancy or increasing the redundancy capability of transport aircraft flightpath control. Author

N91-25139# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A KNOWLEDGE-BASED SYSTEM DESIGN/INFORMATION TOOL FOR AIRCRAFT FLIGHT CONTROL SYSTEMS
DALE A. MACKALL and JAMES G. ALLEN (Draper, Charles Stark Lab., Inc., Cambridge, MA) *In* AGARD, Knowledge Based System Applications for Guidance and Control 14 p Apr. 1991
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 01/3

Research aircraft have become increasingly dependent on advanced electronic control systems to accomplish program goals. These aircraft are integrating multiple disciplines to improve performance and satisfy research objective. This integration is being accomplished through electronic control systems. Systems design methods and information management have become essential to program success. The primary objective of the system design/information tool for aircraft flight control is to help transfer flight control system design knowledge to the flight test community. By providing all of the design information and covering multiple disciplines in a structured, graphical manner, flight control systems can more easily be understood by the test engineers. This will provide the engineers with the information needed to thoroughly ground test the system and thereby reduce the likelihood of serious design errors surfacing in flight. The secondary object is to apply structured design techniques to all of the design domains. By using the techniques in the top level system design down through the detailed hardware and software designs, it is hoped that fewer design anomalies will result. The flight test experiences are reviewed of three highly complex, integrated aircraft programs: the X-29 forward swept wing; the advanced fighter technology integration (AFTI) F-16; and the highly maneuverable aircraft technology (HiMAT) program. Significant operating technologies, and the design errors which cause them, is examined to help identify what functions a system design/informatin tool should provide to assist designers in avoiding errors. Author

N91-25151*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DEVELOPMENT OF AN ADAPTIVE FAILURE DETECTION AND IDENTIFICATION SYSTEM FOR DETECTING AIRCRAFT CONTROL ELEMENT FAILURES
W. THOMAS BUNDICK 1990 150 p Sponsored in part by Planning Research Corp., Hampton, VA
(NASA-TP-3051; L-16801; NAS 1.60:3051) Avail: NTIS HC/MF A07 CSCL 01/3

A methodology for designing a failure detection and identification (FDI) system to detect and isolate control element failures in aircraft control systems is reviewed. An FDI system design for a modified B-737 aircraft resulting from this methodology is also reviewed, and the results of evaluating this system via simulation are presented. The FDI system performed well in a no-turbulence environment, but it experienced an unacceptable number of false alarms in atmospheric turbulence. An adaptive FDI system, which adjusts thresholds and other system parameters based on the estimated turbulence level, was developed and evaluated. The adaptive system performed well over all turbulence levels simulated, reliably detecting all but the smallest magnitude partially-missing-surface failures. Author

N91-26148# Air Force Inst. of Tech., Wright-Patterson AFB, OH. Foreign Technology Div.
APPLICATION OF TRANSFORMATIONAL IDEAS TO AUTOMATIC FLIGHT CONTROL DESIGN
LI WENHUA and LIANG FENG 21 Mar. 1991 17 p Transl. into ENGLISH from Acta Aeronautica et Astronautica Sinica (China), v. 11, no. 4, p 165-170
(AD-A234758; FTD-ID(RS)T-1276-90) Avail: NTIS HC/MF A03 CSCL 01/4

To opt to use geometrical methods to design actual nonlinear systems, one must, first of all, resolve the problems of the complexity of transformations, the great amount of calculations, and other similar problems. Because of this, simplifying the design process is extremely important. In this article, based on transformational ideas, we have obtained two methods and used them in the design of the U.S. F-8 Crusader fighter plane's vertical control system. The simulation results clearly demonstrate that the new control laws are obviously superior to the original nonlinear optimization control laws. Moreover, it is possible to guarantee that aircraft can make high angle attack flights. GRA

N91-26149# Naval Air Development Center, Warminster, PA. Air Vehicle and Crew Systems Technology Dept.
FLIGHT CONTROL LAW SYNTHESIS USING NEURAL NETWORK THEORY Interim Report, Oct. 1989 - Sep. 1990
ROBERT D. DIGIROLAMO and SHAWN T. DONLEY 31 Oct. 1990 20 p
(AD-A234990; NADC-91004-60) Avail: NTIS HC/MF A03 CSCL 01/4

A commonly used technique for advanced fighter aircraft control law development involves a lengthy process of linearizing the aircraft model and calculating many control system gains via conventional linear methods. This process must be repeated for a number of trim points within the flight envelope to achieve the aircraft stability and flying qualities mandated by various military specifications. Neural networks have been used extensively in many applications such as pattern recognition and optimization because of their ability to create nonlinear mappings of continuous valued inputs through supervised learning. This report outlines a concept which incorporates emerging neural network technology with present-day control theory to produce a system by which optimal controller gains can be automatically generated. The research completed to date and the results contained in this report are intended to provide a proof of concept by applying the neural network synthesis technique to some simplified linear and nonlinear examples. GRA

N91-26150# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
MANUAL ON THE FLIGHT OF FLEXIBLE AIRCRAFT IN TURBULENCE
JOHN C. HOUBOLT, ed. May 1991 173 p In FRENCH and ENGLISH
(AGARD-AG-317; ISBN-92-835-0617-0) Copyright Avail: NTIS HC/MF A08; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

In the course of the past few years, the Structures and Materials Panel of AGARD has considered a number of aspects of the turbulence problem as it affects aircraft. The presented publication constitutes a review document in which is distilled the experience of specialists from amongst the aircraft manufacturing nations of NATO. It is aimed at those in design offices concerned with the problems of turbulences and resultant loads.

N91-26152# National Aerospace Lab., Emmeloord (Netherlands).
ACQUISITION OF STATISTICAL GUST LOAD DATA BY COMMERCIAL AIRPLANES
J. B. DEJONGE *In* AGARD, Manual on the Flight of Flexible Aircraft in Turbulence p 31-40 May 1991
Copyright Avail: NTIS HC/MF A08; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Knowledge about the nature and properties of atmospheric turbulence was and is being obtained from measurements with specially instrumented 'research' aircraft. On the other hand, statistical information on the frequency of occurrence and intensity of gusts is largely based on relatively simple measurements, using simple recording devices, obtained over a period of more than half a century in commercial aircraft during normal operations. These measurements are of an indirect nature, that means not the gust velocity itself but the aircraft response due to the gust is measured. Universally, the c.g vertical acceleration was taken as the response quantity to be measured. This choice is quite understandable: in the first place the incremental vertical acceleration is directly proportional to the incremental lift force due to the gust and thus an obvious measure of gust strength; in the second place, the c.g acceleration is easy to measure with simple and reliable instrumentation. A brief review is presented of 'historical' acceleration recording programs carried out by NACA (and its successor NASA) and the RAE. Next, more recent recording programs making use of acceleration data recorded with so-called ACMS (Aircraft Collision Monitoring System) is discussed. The methods used to reduce the acceleration data to 'gust velocities' is briefly described with specific reference to the differences in the various programs. In a summarizing discussion the possibility and desirability to extend the gust data base using 'routine' ACMS recorded c.g acceleration data will come forward. To compared data from different sources it is essential that agreement on data reduction procedures be reached. It is argued that for this, a reduction method based on a continuous gust concept and an aircraft response including pitch appears the most appropriate. Author

N91-26153# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
IMPROVED REDUCTION OF GUST LOADS DATA FOR GUST INTENSITY
GABRIEL COUPRY *In* AGARD, Manual on the Flight of Flexible Aircraft in Turbulence p 41-57 May 1991
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The reduction of load factor data to turbulence data, in view of proposing improved statistics of gusts is examined. The different methods available to achieve this process are reviewed. A comprehensive analysis is made to highlight the shortcomings and their consequences on the regulations. The renewal of interest in turbulence comes from the new problems industry has to face: large aspect ratio commercial aircraft, penetration of military aircraft at low altitude and high velocity, active control of flight and of loads, and justification of increased fatigue life of existing commercial aircraft. The philosophy underlying the data reduction is examined, and it raises the question of the meaning of a gust deduced from acceleration data. Some of the methods are then described. Finally, the shortcomings (especially those due to the effect of pilot maneuvers) and their impact on the requirements are highlighted. Author

N91-26154# Federal Aviation Administration, Seattle, WA.
CERTIFICATION PROCEDURES AND REQUIREMENTS
TERENCE J. BARNES and VICTOR CARD (Civil Aviation Authority, Redhill, England) *In* AGARD, Manual on the Flight of Flexible Aircraft in Turbulence p 58-65 May 1991
Copyright Avail: NTIS HC/MF A08; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The mathematical models of aircraft and atmospheric turbulence and their rationale are described. Emphasis is given to the revisions and refinements made starting in the 1920s up to the present time. The major steps, beginning with the sharp edged gust formulate, are traced through the modified formula specifying ramp-platform gusts and later to one-minus-cosine gusts and finally to criteria for continuous gust analyses. The influence of aircraft design developments on design criteria development needs is also addressed. A brief summary of military criteria is included. Significant discussion is devoted to measurements that have been made, including onboard recordings, to provide an extensive data base of: (1) atmospheric turbulence experience in routine flight operations; (2) specifically-instrumented research aircraft measurements to provide atmospheric characterization for various flight and meteorological conditions; and (3) comparisons of measured and calculated aircraft responses in turbulence. Author

N91-26155# Deutsche Airbus G.m.b.H., Hamburg (Germany, F.R.).
GUST DESIGN PROCEDURES
HELMUT LUSEBRINK and RAINER SONDER *In* AGARD, Manual on the Flight of Flexible Aircraft in Turbulence p 66-116 May 1991
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One of the most important structural design conditions for civil and military transport aircraft are the vertical and lateral gust loads, which the aicraft experiences, when flying in a turbulent atmosphere. Complying with U.S. and European Airworthiness Regulations, the aircraft manufacturer has to consider two basic gust concepts or models: the discrete gust model, and the continuous turbulence power spectrum density (PSD) gust models. During the years of application, the gust shape and intensities changed and are now the well-known truncated 1-cos shape with a constant gust gradient distance (USA/Europe) or a variable one for U.K. The aircraft manufacturer has to apply both the Discrete and one of the PSD methods to find the most critical one for each aircraft component and then design the structure for the envelope loads. The dynamic gust load analysis should be performed in the frequency domain by means of transfer or frequency response functions. The PSD methods cannot be directly applied to nonlinear dynamic models. Approximative methods which have the statistical characteristics given in the requirements have to be applied. Acceptance of the airworthiness authorities will be obtained, if the linearization methods provide conservative design loads. The influence of automatic control systems on structural loads due to discrete gust and PSD methods, including their failed and degraded states, has to be investigated. From the variety of unsteady aerodynamic theories, the 3-dimensional doublet lattice method was selected. Time plane analysis of the dynamical gust problem has to be performed for modern aircraft with digital flight control and alleviation systems containing a variety of nonlinear elements. For this purpose, the unsteady aerodynamic forces have to be transformed from the frequency plane to the time plane. This is achieved by approximating the elements of the modalized unsteady aerodynamic force matrix by PADE-type approximants, which allow generations of the Delta-pulse response matrix kernels used in the convolution integral representation of the unsteady aerodynamic forces in the time plane. B.G.

N91-26156# Boeing Canada, Toronto (Ontario).
ANALYSIS BY THE STATISTICAL DISCRETE GUST METHOD
JOHN GLASER *In* AGARD, Manual on the Flight of Flexible Aircraft in Turbulence p 117-134 May 1991
Copyright Avail: NTIS HC/MF A08; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The general formulation of the Statistical Discrete Gust (SDG) model for atmospheric turbulence proposed by J. Glynn Jones for the von Karman spectrum in its higher frequency range is defined and illustrative results are presented. The equivalence of the two models, SDG PSD (power spectrum density), is confirmed by showing that the dynamic response ratios, bar gamma/bar A, for both rigid and elastic aircraft loads are reasonably constant and approximately equal to the expected value of 10.4 ft.(sup 1/3). Although the SDG method is more complex to implement and more costly to run than the PSD method of FAR/JAR 25, its implementation for routine calculations of linear aircraft structures is confirmed by the present study. The SDG model offers an alternative time domain analysis method for calculating response loads to continuous turbulence for both linear and nonlinear aircraft structures (active controls). In addition, the ADG method can potentially provide a more representative model for extreme gust processes, but this requires further development. Author

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A91-40637
A NEW VERTICAL SHOCK TUBE FOR RAYLEIGH-TAYLOR INSTABILITY MEASUREMENTS
C. CAVAILLER, P. MERCIER, G. RODRIGUEZ (CEA, Centre d'Etudes de Vaujours-Moronvilliers, Courtry, France), and J. F. HAAS (CEA, Centre d'Etudes de Limeil-Valenton, Villeneuve-Saint-Georges, France) IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 564-569. refs
Copyright

A vertical shock tube built for the study of Rayleigh-Taylor instability induced turbulent mixing is described. The first results obtained by schlieren visualization concern the interaction between a Mach 1.45 shock wave and subsequent reflected waves and a 1.7-cm-wide diffusive SF6-air mixing zone. The mixing zone behavior is compared to the evolutions obtained in other analogous experiments with the help of a turbulence model in a one-dimensional code. Author

A91-40638
A COMPRESSION IGNITION DRIVER FOR A FREE PISTON SHOCK TUNNEL
T. M. CAIN and R. J. STALKER (Queensland, University, Brisbane, Australia) IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 570-575. refs
Copyright

The stagnation pressure of the test gas supplying the hypersonic nozzle in a free piston driven reflected shock tunnel is greatly reduced by pressure losses that occur at high driver compression ratios. Drivers that rely solely on compression to increase the driver gas temperature must use high compression ratios to attain high tailored interface shock speed. An investigation of a compression ignition driver which uses a combination of compression and combustion to increase the gas temperature at low compression ratios, thus avoiding the pressure losses while maintaining the shock speeds, is conducted. It is calculated that gains in stagnation pressure of a factor of 2 to 2.5 are obtainable at useful stagnation enthalpy levels if a stoichiometric mixture of hydrogen and oxygen is added to the helium driver gas and allowed to spontaneously ignite during the compression. This estimate was supported by experimental measurements. Author

A91-40640*
NEW GENERATION OF FREE-PISTON SHOCK TUNNELS
W. R. B. MORRISON, R. J. STALKER (WBM-Stalker Pty., Ltd., Brisbane, Australia), and J. DUFFIN IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 582-587. Research supported by Rockwell International Corp., California Institute of Technology, NASA, et al.
Copyright

Consideration is given to three free-piston driven hypersonic tunnels under construction that will greatly enhance existing test capabilities. The tunnel being built at Caltech will feature energy capabilities about 40 percent higher than those of the world's largest operational free-piston tunnel to date. The second tunnel under construction will allow full-size engine hardware at near-orbital speeds. The third facility is a high-performance expansion tube that will be capable of generating high enthalpy flows at speeds of up to 9 km/sec. It will provide flows with dissociation levels much lower than are attainable with a reflected shock tunnel, approaching actual flight conditions. A table shows the tunnels' characteristics. P.D.

A91-40641
MULTI-CASCADE COMPRESSION - EFFECTIVE MEANS TO OBTAIN HIGH TEMPERATURE DENSE GAS IN PISTON GAS DYNAMIC UNITS (PGU)
N. A. ANFIMOV and V. V. KISLYKH (Tsentral'nyi Nauchno-Issledovatel'skii Institut Mashinostroeniia, Kaliningrad, USSR) IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 588-593.
Copyright

Consideration is given to different schemes of experimental facilities for the production of high-temperature dense gases, with emphasis on a new type of facility - a piston-gas dynamic unit with multicascade compression. The proposed facility appears promising for the production of gas flows with high parameters; namely, temperature, and Mach and Reynolds numbers. PGU operation in a three-cascade compression regime is examined here. The features of the new compression method and a set of equations for defining the real-gas state in PGU cavities in quasi-static approximation are presented. Calculated values of temperature and pressure for the three-cascade compression process in PGU or helium are presented along with and the distribution of the heat flux on the windward surface of the Buran space vehicle model. P.D.

A91-40649
APPLICATION OF SHOCK TUNNEL AT PRESSURE AND HEAT TRANSFER EXPERIMENTS ON TURBINE BLADE
JINGMEI LI, RUMING ZHAO, JINMING HU (Chinese Academy of Sciences, Institute of Mechanics, Beijing, People's Republic of China), and SUQING DEN (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 648-652. NNSFC-supported research.
Copyright

This paper describes a shock tunnel used to conduct the experiments for linear cascade of turbine. The surface pressure distributions on the turbine blades are measured at exit Mach number M = 0.57, 0.67, 0.86, 0.94, and 1.08. The surface heat flux distributions on blades are measured at enter Reynolds number Re infinity, b = 5.6 x 10 to the 6th, 3.16 x 10 to the 6th, and 8.55 x 10 to the 6th. The interferogram of cascade flow is performed by a Welston prism differential interferometer. The density field of the cascade flow is given from integrating the density gradient which is in proportion to the fringe shift. The calculated values for the surface Mach number distributions on the turbine blades basically agree with the measured data. Author

A91-41164
DESIGN OF A LANGUAGE PROCESSOR FOR AVIATION ENGINE TESTING [PROEKTIROVANIE IAZYKOVOGO PROTSESSORA ISPYTANII AVIATSIONNYKH DVIGATELEI]
IU. V. KOZHEVNIKOV and I. A. ZALIAEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1991, p. 65-68. In Russian.
Copyright

The problem of the design of a language processor for the testing of aviation engines in the man-machine interactive mode is defined. A design approach is proposed which is based on the principles of matrix decomposition, standardization, and parametric adaptability of the language processor. An example of processor element design is presented. V.L.

A91-41538
GROUND SUPPORT EQUIPMENT MAINTENANCE DATA ANALYSIS
R. E. SOWDEN (RAF, England) Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100), vol. 204, no. G2, 1990, p. 111-117.
Copyright

The Ground Support Equipment Maintenance Analysis Center (GMAC) is proposed to improve the analysis of ground support equipment (GSE) by means of computerized records and assessment. GSE is divided into two categories, standard or special-to-type, and called Major GSE or Minor GSE when requiring preventive maintenance or periodic safety checks, respectively. The GMAC data system collates and processes stored representative statistics of fleet- or type-based items, with three reporting categories for Major GSE indicating the depth of analysis required to control data output. Tables and graphs describe statistics relating to failure rates, the time to repair failures, maintenance man-hours versus time, and trends in rectification. Station management computers can provide important data for fleet-wide performance assessments and analyses related to the replacement of equipment, thereby ensuring the GSE reliability and cost reductions. C.C.S.

A91-41741*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LEAST-SQUARES/PARABOLIZED NAVIER-STOKES PROCEDURE FOR OPTIMIZING HYPERSONIC WIND TUNNEL NOZZLES
JOHN J. KORTE, AJAY KUMAR (NASA, Langley Research Center, Hampton, VA), D. J. SINGH (Analytical Services and Materials, Inc., Hampton, VA), and B. GROSSMAN (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-2273) Copyright

A new procedure is demonstrated for optimizing hypersonic wind-tunnel-nozzle contours. The procedure couples a CFD computer code to an optimization algorithm, and is applied to both conical and contoured hypersonic nozzles for the purpose of determining an optimal set of parameters to describe the surface geometry. A design-objective function is specified based on the deviation from the desired test-section flow-field conditions. The objective function is minimized by optimizing the parameters used to describe the nozzle contour based on the solution to a nonlinear least-squares problem. The effect of the changes in the nozzle wall parameters are evaluated by computing the nozzle flow using the parabolized Navier-Stokes equations. The advantage of the new procedure is that it directly takes into account the displacement effect of the boundary layer on the wall contour. The new procedure provides a method for optimizing hypersonic nozzles of high Mach numbers which have been designed by classical procedures, but are shown to produce poor flow quality due to the large boundary layers present in the test section. The procedure is demonstrated by finding the optimum design parameters for a Mach 10 conical nozzle and a Mach 6 and a Mach 15 contoured nozzle. Author

A91-41802#
DEVELOPMENT OF A VITIATED AIR HEATER FOR ENGINE TEST FACILITIES
T. HASHIMOTO (Hitachi, Ltd., Mechanical Engineering Research Laboratory, Japan) and M. YOSHIDA (Hitachi, Ltd., Hitachi Works, Japan) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 7 p.
(AIAA PAPER 91-2501) Copyright

The basic design parameters for large-scale vitiated air heaters are examined by means of a small-scale model burner with a total mass-flow rate of approximately 2 kg/s. Hydrogen is burned in four coaxial injectors, and a liner divides the combustion chamber into mixing and combustion regions. The oxidizer/fuel-mass flow ratio is maintained close to 60 for stable burning, with the extra oxidizer injected into a region between the liner and the combustion chamber's inner wall. The combustion gas is found to mix effectively with the remaining oxidizer which promotes stable combustion. Wide ranges of total pressure (0.8-6.0 MPa) and total temperature (250-1400 C) can be achieved in the vitiated air heater, and the heat-release rate is demonstrated to approach 10 to the 8th MJ/h/Nm exp 3. The radial temperature profile of the exhaust gas at the burner exit is minimized, and stable combustion is reported for the small-order model. C.C.S.

A91-42560#
AN INVESTIGATION OF HYPERSONIC SHOCK TUNNEL TESTING AT AN EQUILIBRIUM INTERFACE CONDITION OF 4100 K - THEORY AND EXPERIMENT
M. A. S. MINUCCI (Centro Tecnico Aeroespacial, Sao Jose dos Campos, Brazil) and H. T. NAGAMATSU (Rensselaer Polytechnic Institute, Troy, NY) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 18 p. refs
(AIAA PAPER 91-1707) Copyright

Results are presented on tests of the Rensselaer Polytechnic Institute Hypersonic Shock Tunnel operated at an equilibrium interface condition of 5.8 MPa and 4100 K. Measurements of pressure, ionization, and radiation intensity indicated useful test times in the 3-8 millisec range depending on the nozzle throat used. A computer code for equilibrium air was written to model the shock wave end wall reflections and intersections of the shock wave with the interface. A reasonably good agreement was obtained between the predicted pressure history and the experimental data. I.S.

A91-42789
ATC SIMULATORS DO NOT HAVE TO REPLICATE OPERATIONAL SYSTEMS PHYSICALLY
VINCENT P. GALOTTI, JR. and ANDREW KORNECKI (Embry-Riddle Aeronautical University, Daytona Beach, FL) ICAO Journal (ISSN 0018-8778), vol. 46, May 1991, p. 6-8.
Copyright

A review is presented of the continuing demand in the field of air traffic control that requires a significant improvement in the quantity and quality of ATC specialists. In the U.S.A. the FAA supports a number of parallel activities leading to an advanced ATC system that is expected to be fully operational by the beginning of the next century. Professional systems are presently available that were developed to use low-cost microcomputer-based work stations. Their functionality provides for flight-data and radar display which allows the student the opportunity to control air traffic in a dynamically simulated environment. An instructors station is capable of changing stations at individual stations, monitoring functions, recording actions and responses, and modifying scenarios to include malfunctions and emergencies. Consideration is given to audio technology, enhanced graphic resolution, and artificial intelligence. R.E.P.

A91-42792
VISUAL SYSTEMS FOR ATC TRAINING
GERALD F. G. RATZER (McGill University, Montreal, Canada) ICAO Journal (ISSN 0018-8778), vol. 46, May 1991, p. 22-24.
Copyright

It is seen that simulation is increasingly becoming the preferred method of training air traffic controllers at both the ab initio and refresher levels. Simulators for training ATC personnel can range from very simple to complex instruments and can utilize a very wide range of techniques. Current training simulators include table top airfield models, airport floor models with remotely controlled ground vehicle and aircraft models, wall projectors of aircraft images, and overhead airfield image displays. With the great progress made in visual systems and in the price/performance of microelectronics, educational institutions and aviation authorities can benefit from the application of this all-electronic technology to the training of ATC students. R.E.P.

A91-43592#
PLANAR LASER-INDUCED FLUORESCENCE IMAGING OF UNDEREXPANDED FREE JET FLOW IN A SHOCK TUNNEL FACILITY
J. L. PALMER, B. K. MCMILLIN, and R. K. HANSON (Stanford University, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 13 p.
USAF-supported research. refs
(AIAA PAPER 91-1687) Copyright

Characterization studies of a new reflection-type shock tunnel facility are reported. PLIF and shadow imaging is used to examine the details of the starting process of free jet flow created in the shock tunnel. Preliminary measurements of the radial velocity and temperature fields are performed using PLIF techniques, with the goal of advancing the methods for determining gasdynamic properties in supersonic/hypersonic flowfields. Author

A91-44132#
UNCERTAINTY ANALYSIS OF TURBINE AERODYNAMIC PERFORMANCE MEASUREMENTS IN SHORT DURATION TEST FACILITIES
C. W. HALDEMAN, JR., M. G. DUNN, J. LOTSOF (Calspan Corp., Buffalo, NY), C. D. MACARTHUR, and B. COHRS (USAF, Wright Laboratory, Wright-Patterson AFB, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 16 p. refs
(AIAA PAPER 91-2131)

The problems associated with measuring turbine stage efficiencies in short duration test facilities are considered analytically, including the accuracy of measurement quantities, the use of different definitions of efficiency, and considerations regarding the working fluid. The analysis is developed specifically for the Advanced Turbine Aerothermal Research Rig testing of a cooled nozzle guide vane turbine stage. The equations allow uncertainty predictions for the measured efficiency of any stage configuration, and statistical processing can be used to improve the accuracy of single-sample efficiency measurements. Comparing data from different facilities requires a precise definition of efficiency and the physical basis for its determination. Specific gas properties, the gas-state defining equation, and isentropic relationships have the greatest effects on the efficiency determination. The objectives of the testing program and the turbine configuration determine whether the thermodynamic or mechanical method is more suitable for measuring the efficiencies. C.C.S.

A91-44183#
SUPERSONIC WIND TUNNEL DIFFUSER PERFORMANCE WITH HIGH MODEL BLOCKAGE AT MODERATE TO LOW REYNOLDS NUMBERS
G. J. HANUS, K. L. MIKKELSEN, S. J. OLSTAD (Fluidyne

Engineering Corp., Minneapolis, MN), and S. CARISTIA (Centro Italiano Ricerche Aerospaziali, Naples, Italy) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 18 p. refs
(AIAA PAPER 91-2274) Copyright

A test program was performed to determine the characteristics of a supersonic diffuser operating with high-blockage ratio models at moderate to low Reyolds number conditions. The program was conducted to support the design of a high-enthalpy, arc-driven wind tunnel suitable for evaluating thermal protection system concepts for space shuttle-type vehicles. Model blockage levels from 16 percent to almost 42 percent were tested with leading-edge and hemispherical-cylinder models utilizing conical nozzles. Results demonstrated that diffuser performance is greatly compromised for model blockage conditions exceeding approximately 25 percent. R.E.P.

A91-44264*# Washington Univ., Seattle.
EXPERIMENTS ON HYPERSONIC RAMJET PROPULSION CYCLES USING A RAM ACCELERATOR
G. CHEW, C. KNOWLEN, E. A. BURNHAM, A. HERTZBERG, and A. P. BRUCKNER (Washington, University, Seattle) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. refs
(Contract NAG1-327; NAG1-1061; F08635-89-C-0196)
(AIAA PAPER 91-2489) Copyright

Work on hypersonic propulsion research using a ram accelerator is presented. Several different ram accelerator propulsive cycles have been experimentally demonstrated over the Mach number range of 3 to 8.5. The subsonic, thermally choked combustion mode has accelerated projectiles to near the Chapman-Jouguet (C-J) detonation velocity within many different propellant mixtures. In the transdetonative velocity regime (85 to 115 percent of C-J speed), projectiles have established a propulsive cycle which allows them to transition smoothly from subdetonative to superdetonative velocities. Luminosity data indicate that the combustion process moves forward onto the projectile body as it approaches the C-J speed. In the superdetonative velocity range, the projectiles accelerate while always traveling faster than the C-J velocity. Ram accelerator projectiles operating continuously through these velocity regimes generate distinctive hypersonic phenomena which can be studied very effectively in the laboratory. These results would be very useful for validating sophisticated CFD computer codes and in collecting engineering data for potential airbreathing hypersonic propulsive systems. Author

A91-44267*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ENHANCED CAPABILITY OF THE COMBUSTION-HEATED SCRAMJET TEST FACILITY
KENNETH E. ROCK, EARL H. ANDREWS, and JAMES M. EGGERS (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 14 p. refs
(AIAA PAPER 91-2502) Copyright

The Combustion-Heated Scramjet Test Facility (CHSTF) is described together with its modifications. The expanded simulation capabilities of the facility are documented. Nozzle exit surveys and tunnel calibration information are presented. It is noted that these modifications included a new heat-sink nickel liner heater, a new Mach 4.7 nozzle, and a new 70-ft vacuum sphere exhaust system. It is found that the facility in the air ejector mode of operation performed similarly to that prior to the addition of the vacuum sphere ducting. K.K.

A91-44334#
ASYMPTOTIC METHODS FOR THE PREDICTION OF TRANSONIC WIND TUNNEL WALL INTERFERENCE
N. D. MALMUTH (Rockwell International Science Center, Thousand Oaks, CA), H. JAFROUDI (Southern California, University, Los Angeles, CA), C. C. WU (California, University, Los Angeles), R. MCLACHLAN (California Institute of Technology, Pasadena), and J. D. COLE (Rensselaer Polytechnic Institute, Troy, NY) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 11 p. refs
(Contract F40600-82-C-0005; F40600-84-C-0010)
(AIAA PAPER 91-1712) Copyright

Transonic wall interference is predicted asymptotically by means of two limiting cases which can be applied to wall interference assessment/correction (WIAC) procedures. An area rule is employed for slender airplanes whereby the interference of its body of revolution is used to determine the interference of the complete aircraft. When large wall heights are considered in this case an asymptotic triple deck structure is observed. A 'tube vortex' far field is generated by experimentally determined pressure conditions applied to a cylindrical interface. The second case involving a high aspect ratio demonstrates that the imaging effect of the interface on the projection of the Trefftz plane's trailing vortex system produces the interference. A spikelike interference flow field is generated by the shock movement in the slightly subsonic freestream conditions of both limiting cases. The area rule can be used with methods such as WIAC to estimate wall effects on drag and pressures. C.C.S.

N91-25152# Federal Aviation Administration, Atlantic City, NJ.
AIRPORT CAPACITY AND DELAY ANALYSES
DOUGLAS BAART, HELEN MONK, and MARY L. SCHWEIKER Apr. 1991 19 p
(DOT/FAA/CT-TN91/18) Avail: NTIS HC/MF A03

The benefits achievable in terms of reduced delay and capacity gained at several major airports if products of the Wake Vortex Program were implemented resulting in reduced intrail separation standards is addressed. These theoretical separation standards were developed from products of the Wake Vortex Program and were used in a simulation of runway operations at John F. Kennedy (JFK), Boston (BOS), and St. Louis (STL) airports. These products include Vortex Advisory System (VAS), Wake Vortex Avoidance System (WVAS), Wake Vortex Detection/Monitoring System. In addition to site specific airports, generic runway configurations were explored as a means of grouping many airports with similar configurations. The estimates derived include delay time saved in dollars per day and capacity gained in operations per hour for each airport evaluated. Considerable benefits to the airlines and the economy could be achieved if these wake vortex products were implemented resulting in reduced separation standards. Author

N91-25153# Federal Aviation Administration, Atlantic City, NJ.
DEMONSTRATION PRECISION RUNWAY MONITOR (PRM) PROOF OF PERFORMANCE TEST RESULTS
CHARLES DUDAS and RICARDO ASTILLERO Jul. 1991 52 p
(DOT/FAA/CT-TN91/3) Avail: NTIS HC/MF A04

Summarized here is the Federal Aviation Administration's participation in the Demonstration Precision Runway Monitor (Demo PRM) Proof of Performance (POP) test program throughout the early summer of 1990. The system was designed to demonstrate the feasibility of providing faster and more accurate surveillance of aircraft on instrument landing approaches. The system incorporates high resolution displays with specific blunder alarms. The system utilizes a phased array antenna to enable faster update rates than the current rotating antennas. It is hoped that a system with these capabilities will allow an increase in airport runway capacity by allowing simultaneous, independent Instrument Flight Rule (IFR) approaches to parallel runways with less than 4300 feet of separation. The results of the test plan are given. Author

N91-25154# Federal Aviation Administration, Cambridge, MA.
UNIFIED METHODOLOGY FOR AIRPORT PAVEMENT ANALYSIS AND DESIGN. VOLUME 1: STATE OF THE ART Final Report, Jan. 1989 - Jan. 1990
JOHN P. ZANIEWSKI (Arizona State Univ., Tempe.) Jun. 1991 137 p
(DOT/FAA/RD-91/15-VOL-1; DOT-VNTSC-FA1J1-91-7-VOL-1) Avail: NTIS HC/MF A07

An assessment of the state of the art of airport pavement analysis and design is presented. The objective is to identify those areas in current airport pavement analysis methodology that need to be substantially improved from the perspective of airport pavement design and management needs. The foundations of current design practice are examined with emphasis on the last twenty years of research and advancement in the area of pavement response prediction and cross section/layer thickness design. A review is presented of empirical methods of design for rigid and flexible pavement design, and quasi-mechanistic analyses that are based on layered-elastic theory or finite element methods. Weakness of current methods as applied to airport operational needs are discussed. A rational argument is presented for developing a unified pavement analysis and design procedure that can be used for pavements of any material type and that are based on mathematical formulations of the actual stress/strain response processes in airport pavement materials. Author

N91-25155*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
DYNAMIC TESTER FOR ROTOR SEALS AND BEARINGS Patent Application
GEORGE L. VONPRAGENAU, inventor (to NASA) 1 Apr. 1991 14 p
(NASA-CASE-MFS-28493-1; NAS 1.71:MFS-28493-1; US-PATENT-APPL-SN-678780) Avail: NTIS HC/MF A03 CSCL 14/2

A dynamic tester for testing vibration damping seals and bearings is constructed having a hollow shaft extending through the seal or bearing, with the shaft internally supported at each end by fluid bearings on hollow bosses connected to an interior of an enclosure, with no rolling members connected to the shaft is described. A high pressure working fluid is forced through the hollow bosses to operate the bearings. Additionally, the shaft is provided with a reaction turbine that angularly vents a portion of the high pressure working fluid in order to rotate the shaft at high speed, up to 40,000 rpm. The seal or bearing is mounted in a bushing, in turn supported by rods to a shaking device that vibrates the seal or bearing as the shaft is rotated. A plurality of proximity sensors are mounted from outside the enclosure to sense shaft and seal bushing vibrations, and a plurality of pressure ports are disposed in the enclosure to allow sensing of dynamic and static pressures of the testing apparatus. NASA

N91-26160# Army Engineer Waterways Experiment Station, Vicksburg, MS. Geotechnical Lab.
GEOGRID REINFORCED BASE COURSE FOR FLEXIBLE PAVEMENTS FOR LIGHT AIRCRAFT: LITERATURE REVIEW AND TEST SECTION DESIGN Interim Report
STEVE L. WEBSTER May 1991 40 p
(Contract DTFA01-89-Z-02029)
(DOT/FAA/RD-90/28) Avail: NTIS HC/MF A03

The results are presented of a literature review investigating geogrid reinforced base courses for flexible pavements for light aircraft and the design of a geogrid test section for field testing the validity of potential geogrid reinforcement results. The literature review included related areas such as geogrid ballast reinforcement for railroad track bed, reinforcement for aggregate surface pavements, and reinforcement for flexible pavements. Based on the literature review, geogrids have application in ballast reinforcement for railroad track bed and in reinforcement for aggregate surface pavements. Full-scale field tests have verified that for subgrade CBR strengths of 1.5 to 5.0, geogrid reinforced aggregate surface pavement can carry about 3.5 times more traffic repetitions than equivalent nonreinforced pavements before a 1.5-in. rut depth is reached. Author

N91-26161# Illinois Univ., Urbana. Dept. of Civil Engineering.
GUIDELINES FOR DESIGN, CONSTRUCTION, AND EVALUATION OF AIRPORT PAVEMENT DRAINAGE Final Report
BARRY J. DEMPSEY and RICHARD A. PUR Oct. 1990 166 p
(Contract DACA88-85-M-0271; DACA88-85-M-0786; DACW88-85-D-0004)
(DOT/FAA/RD-90/31) Avail: NTIS HC/MF A08

Comprehensive guidelines are provided for the design, construction, and evaluation of airport pavement drainage. Procedures for considering climatic effects on airport drainage are described. Brief summaries of several climatic models which can be used to generate temperature and moisture conditions in pavements are presented. A review of the FAA design procedures for airport surface drainage is presented in order to maintain comprehensive coverage of all aspects of drainage in a single report. Pavement surface drainage is discussed in terms of pavement grooving and the use of porous friction courses. Pavement subsurface drainage is discussed in detail. Methods for determining the sources and quantity of water which enter the pavement are provided. Procedures for designing subbase drainage layers, blankets and filter layers have been presented. Based on the sources and quantity of water which enters the pavement, methods for selecting and sizing the subdrainage collectors and outlets are discussed. Both the used conventional circular pipe systems and prefabricated geocomposite subdrainage (PGS) systems are described. Author

10

ASTRONAUTICS

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

A91-41537
HOTOL SPACE TRANSPORT FOR THE TWENTY-FIRST CENTURY
B. R. A. BURNS Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100), vol. 204, no. G2, 1990, p. 101-110.
Copyright

An unmanned launch vehicle design is reviewed which specifies single stage to orbit (SSTO), hybrid air-breathing/rocket propulsion, horizontal takeoff and landing, and autonomous, unmanned operation in satellite launch and recapture. The mass of the HOTOL is 80 percent propellant which makes engine efficiency important, and the horizontal take-off requires optimization of the power unit scale. The structural design includes a carbon-PEEK liquid hydrogen tank and a large plan area and a titanium fuselage with carbon-carbon panels for thermal protection, and take-off is accomplished with a reusable launch vehicle. Aerodynamic considerations include minimizing drag, and optimizing intake capture area while preserving reduced drag. Continued safe operation of the systems is possible after two failures, and the unmanned operation includes a constant EAS trajectory followed by a steeper rocket climb. C.C.S.

A91-43084#
SIZING SUPERSONIC FREEJET NOZZLE AND INLET LOCATION FOR SIMULATION OF THE TRANSITION PHASE IN INTEGRAL ROCKET RAMJET
I. GREENBERG (Rafael Armament Development Authority, Haifa, Israel) and E. SHOKRON (Israel Aircraft Industries, Ltd., Lod, Israel) IN: Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Collection of Papers. Haifa, Israel, Technion - Israel Institute of Technology, 1990, p. 62-65. refs

The transition from a rocket booster to a ramjet sustainer at a specific flight condition with a maximum model size is demonstrated using a semifreejet testing technique. A technique for sizing a supersonic freejet nozzle and the axial location of a supersonic nose inlet is also presented. It is noted that freejet tests approved proper flight simulations in the transition phase for an integral rocket ramjet. K.K.

A91-43311#

THERMOSTRUCTURAL CONCEPTS FOR HYPERVELOCITY VEHICLES

PETER K. SHIH, JACK PRUNTY (General Dynamics Corp., Convair Div., San Diego, CA), and RICHARD N. MUELLER (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) (Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 2, p. 651-658) Journal of Aircraft (ISSN 0021-8669), vol. 28, May 1991, p. 337-345. Previously cited in issue 12, p. 1837, Accession no. A88-32246. refs
(Contract F33615-85-C-3022)
Copyright

A91-43498#

AEROTHERMAL TEST METHODOLOGY FOR THE DEVELOPMENT OF STRUCTURAL COMPONENTS FOR HYPERSONIC VEHICLES

R. K. MATTHEWS, S. A. STEPANEK, and D. W. STALLINGS (Calspan Corp., Arnold AFB, TN) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-1441) Copyright

The materials/structures test methodology and test techniques used in the development of hypersonic-vehicle components are overviewed. System requirements and issues are covered, and it is noted that though exposed to severe aeroheating and aerodynamic loading, structural components should be reusable, light, and maintainable. Attention is focused on thermal mapping techniques, demonstration of hardware survivability, and the use of analysis tools for designing a test. It is pointed out that a primary deficiency associated with the development of structural components for hypersonic vehicles lies in the area of instrumentation. Emphasis is placed on uniformity, repeatability, and continuous monitoring of the heat source, and the lack of reliable heat-flux gages and high-enthalpy test facilities is cited. V.T.

A91-44338#

DEVELOPMENT OF IR SENSOR WINDOW COOLING REQUIREMENTS FOR ENDOATMOSPHERIC INTERCEPTORS

H. W. MORRIS, J. A. MAJESKI (McDonnell Douglas Space Systems Co., Huntington Beach, CA), and E. G. RAWLINSON (SY Technology, Huntsville, AL) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 11 p. refs
(Contract DASG60-86-C-0013)
(AIAA PAPER 91-1439) Copyright

The present experiment involved developing an active cooling system for a hypersonic endoatmospheric interceptor to provide temperature control for an infrared sensor window. Film cooling was used with nitrogen gas to provide window temperature control. The objectives were to demonstrate window survivability in hypersonic flight and to obtain data to compare film cooling effectiveness in a flight environment with a ground test data base. To determine the minimum coolant flow rates required to control the window temperature, a ground test data base, developed from tests at four facilities, was estabilished. To augment the data base, CFD codes that apply to the film cooling problem were developed. The film-cooling method proved effective in controlling window temperature in the severe hypersonic flight environment. Author

11

CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A91-41173

RELEASE OF BENZ(A)PYRENE WITH THE EXHAUST GASES OF GAS TURBINE ENGINES BURNING NATURAL GAS [O VYBROSE BENZ/A/PIRENA S OTRABOTANNYMI GAZAMI GTD, RABOTAIUSHCHEGO NA PRIRODNOM GAZE]

S. V. LUKACHEV and V. G. ROZNO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1991, p. 98-100. In Russian. refs
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It has been suggested that the use of natural gas as an alternative fuel for aviation gas turbine engines can significantly reduce the amount of cancerogenic compounds released into the atmosphere. The experiments reported in this study were conducted with the aim of testing this hypothesis. A modified version of an aviation gas turbine engine burning natural gas was tested for the amount of benz(a)pyrene, one of the strongest and most stable cancerogens, contained in the exhaust gases. It is found that, at all operating regimes, the relative amount of the released BP is a factor of 3-4 lower than in the case of kerosene-burning engines. V.L.

A91-41511

FLIGHT SERVICE EVALULATION OF THERMAL BARRIER COATINGS BY PHYSICAL VAPOR DEPOSITION AT 5200 H

F. C. TORIZ, A. B. THAKKER, and S. K. GUPTA (Rolls-Royce, Inc., Atlanta, GA) IN: Metallurgical coatings 1989; Proceedings of the 16th International Conference, San Diego, CA, Apr. 17-21, 1989. Vol. 1. London and New York, Elsevier Applied Science, 1989, p. 161-172. refs
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Results are presented on the flight service evaluation of thermal barrier coatings (TBCs), demonstrating that some TBC systems can survive in the turbine environment for over 16,000 h but that particulate erosion is a potential problem. A comparison between the service condition of vanes with TBCs applied by physical vapor deposition (PVD) and those with TBCs applied by plasma spraying showed that the PVD TBCs have the advantage of longer thermal cycle lives, smoother surface finishes, better surface finish retention, and higher erosion resistance. I.S.

A91-41569

FAILURE ANALYSIS AND DAMAGE INITIATION IN CARBON-CARBON COMPOSITE MATERIALS UNDER THREE-POINT BENDING

P. D. COPP (Wright Research and Development Center, Wright-Patterson AFB, OH), J. C. DENDIS (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH), and S. MALL (Air Force Institute of Technology, Wright-Patterson AFB, OH) Journal of Composite Materials (ISSN 0021-9983), vol. 25, May 1991, p. 593-608. refs
Copyright

Carbon-carbon composite materials offer designers a significant improvement over conventional materials for advanced turbine engine applications. However, these composite components must be attached to other components which is usually done using mechanical fasteners. These attachments create contact stresses, which in turn lead to a variety of failure modes and damage. In order to characterize these failure modes and damage mechanisms a three-point bend test was employed. This test has been widely studied by many researchers and provides a wealth of comparative data. In addition, it is the simplest mechanical and experimental model of a contact problem. This study focused on determining damage initiation and failure mechanisms in woven uncoated carbon-carbon composite laminates resulting from the three-point bend test. Failure modes and damage initiation sites for short and long beam geometries were determined. Author

A91-41606
ANALYSIS OF STRUCTURAL DAMPING OF TITANIUM ALLOY SHELL STRUCTURES AS COMPARED WITH THAT OF ALUMINIUM ALLOY STRUCTURES
RADLOJUB TOMIC (Soko Aircraft Industry, Mostar, Yugoslavia) IN: Titanium & aluminium; Proceedings of the International Conference, Paris, France, Feb. 27, 28, 1990. Gournay-sur-Marne, France, IITT-International, 1990, p. 161-167.
Copyright
Titanium shell structural models are used to determine the fundamental dynamic properties of Ti structures versus Al structures, with special attention given to their structural damping characteristics. The generalized Ti structure is considered in a dynamic analysis based on the finite element method for flat shell elements with 20 degrees of freedom. By incorporating elasticity theory, calculations of the frequencies and oscillation modes are employed to express inertial, structural damping, and stiffness characteristics. The natural frequencies and structural damping for the shell model are given for several Ti, Ti-alloy, and Al-alloy materials. Matrices for stiffness and structural damping are presented, indicating that the structural damping for the Ti models is lower than that for Al. Different specific moduli of elasticity are found for the materials considered, accounting for their varied nondimensional damping coefficients. C.C.S.

A91-43752
SPHERICAL PARTICLE IMPACT DAMAGE BEHAVIOUR OF A SIC FIBRE-REINFORCED CHEMICAL VAPOUR INFILTRATED SIC COMPOSITE
Y. AKIMUNE, T. OGASAWARA, T. AKIBA, and N. HIROSAKI (Nissan Motor Co., Ltd., Yokosuka, Japan) Journal of Materials Science Letters (ISSN 0261-8028), vol. 10, June 15, 1991, p. 689-692. refs
Copyright
This paper discusses the mechanical properties of a commercial fiber-reinforced chemical-vapor-infiltrated (CVI) SiC material and examines the fracture behavior of SiC-fiber/CVI SiC composites impacted by a spherical particles. The impact test apparatus and the tests conducted on the composites are described together with the results of optical and electron microscopy of the impacted specimens. It was found that this composite has high fracture toughness (12.5 MPa m esp 1/2) compared with its strength level of 285 MPa, and that the impact resistance behavior of the composite is different from that of other monolithic ceramics. I.S.

A91-43857* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE FATIGUE RESPONSE OF THE ALUMINIUM-LITHIUM ALLOY, 8090
M. J. BIRT (NASA, Langley Research Center, Hampton, VA) and C. J. BEEVERS (Birmingham, University, England) IN: Aluminum-lithium alloys; Proceedings of the 5th International Aluminum-Lithium Conference, Williamsburg, VA, Mar. 27-31, 1989. Vol. 2. Birmingham, England, Materials and Component Engineering Publications, Ltd., 1989, p. 983-992. Research supported by Ministry of Defence Procurement Executive. refs
Copyright
The fatigue response of an Al-Li-Cu-Mg-Zr (8090) alloy has been studied at room temperature. The initiation and growth of small and long cracks has been examined at R = 0.1 and at a frequency of 100 Hz. Initiation was observed to occur dominantly at sub-grain boundaries. The growth of the small cracks was crystallographic in character and exhibited little evidence of retardation or arrest at the grain boundaries. The long crack data showed the alloy to have a high resistance to fatigue crack growth with underaging providing the optimum heat treatment for fatigue crack growth resistance. In general, this can be attributed to high levels of crack closure which resulted from the presence of extensive microstructurally related asperities. Author

A91-43891
ALUMINIUM-LITHIUM WELDABLE ALLOY 1420 - ALLOYING SYSTEM AL-LI-MG-ZR
I. N. FRIDLIANDER (AN SSSR, Moscow, USSR) IN: Aluminum-lithium alloys; Proceedings of the 5th International Aluminum-Lithium Conference, Williamsburg, VA, Mar. 27-31, 1989. Vol. 3. Birmingham, England, Materials and Component Engineering Publications, Ltd., 1989, p. 1359-1364. refs
Copyright
The development of an Al-Li alloy, 1421, is reported and described in terms of advantages over the 1420 alloy. The limitations of the 1420 alloy are presented with the requirements of the aerospace industry as its use was integrated into the fabrication of heavy aircraft. The need to improve the technology of forging and extruded parts was isolated as a significant concern. Welded variance was found to be about 75-85 percent of the material's peak value, and tungsten electrode and inert gas welding as well as electron beam welding have been used to enhance the welding process. A real weight savings of 24 percent was achieved for aircraft using the 1420 alloy. A comparison of the properties of forgings and extrusions for various products made from both 1420 and 1421 is given. Compared to 1420, a 1421 alloy of the same density has a higher ultimate tensile strength and higher yield strength, and the 1421 is more weldable and resistant to corrosion. C.C.S.

A91-43912
A COMPARISON OF LARGE AA8090, AA8091 AND AA7010 DIE FORGINGS FOR HELICOPTER STRUCTURAL APPLICATIONS
A. F. SMITH (Westland Helicopters, Ltd., Yeovil, England) IN: Aluminum-lithium alloys; Proceedings of the 5th International Aluminum-Lithium Conference, Williamsburg, VA, Mar. 27-31, 1989. Vol. 3. Birmingham, England, Materials and Component Engineering Publications, Ltd., 1989, p. 1587-1596.
Copyright
A property comparison of large die forgings in alloys AA7010, AA8090, and AA8091 has been carried out as a preliminary to the incorporation of aluminum-lithium alloys to the EH101 helicopter. Differing degrees of post-solution treatment cold compression have led to noticeable variability in AA8090 and AA8091 strength levels, which although do not generally match those in AA7010, are adequate for this particular application. The aluminum-lithium alloys exhibit significant anisotropy with strength minima at 20-30 deg to the longitudinal direction. Plane strain fracture toughness levels may be ranked in the increasing order AA8090, AA8091, AA7010. Aluminum-lithium fatigue properties are often superior to AA7010. Micro-structural and fractographic features are briefly discussed. Author

A91-43913
FORMING OF ALUMINUM-LITHIUM SHEET FOR FIGHTER AIRCRAFT APPLICATIONS
E. J. TUEGEL, V. M. VASEY-GLANDON, M. O. PRUITT, and K. K. SANKARAN (McDonnell Douglas Corp., Saint Louis, MO) IN: Aluminum-lithium alloys; Proceedings of the 5th International Aluminum-Lithium Conference, Williamsburg, VA, Mar. 27-31, 1989. Vol. 3. Birmingham, England, Materials and Component Engineering Publications, Ltd., 1989, p. 1597-1605.
Copyright
Formed sheet metal structures are extensively used in fighter aircraft construction due to the low material buy-to-fly ratio, low fabrication costs and high structural integrity. Formed sheet metal structures are among the most cost-effective applications for aluminum-lithium alloys. The results of a systematic investigation of the formability of aluminum-lithium alloys under various forming methods used in sheet metal part fabrication, including superplastic forming, are presented. This investigation showed no particular manufacturing problems for aluminum-lithium alloys. The

superplastic formability of aluminum-lithium alloys is a significant advantage for which there are many potential applications.

Author

A91-43916

APPLICATION OF ALUMINUM-LITHIUM ALLOYS TO FIGHTER AIRCRAFT

K. K. SANKARAN, V. M. VASEY-GLANDON, and E. J. TUEGEL (McDonnell Douglas Corp., Saint Louis, MO) IN: Aluminum-lithium alloys; Proceedings of the 5th International Aluminum-Lithium Conference, Williamsburg, VA, Mar. 27-31, 1989. Vol. 3. Birmingham, England, Materials and Component Engineering Publications, Ltd., 1989, p. 1625-1634. refs

Copyright

The method employed to determine applications for Al-Li alloys is described with respect to fighter aircraft. The use of the alloys is assessed by considering the weight savings and the limitations encountered in their application to an F/A-18 aircraft. The substitution is considered feasible only if the properties of the Al-Li alloy are at least equal to those of the original material. The conventional aluminum parts can be replaced by Al-Li alloys in 54 percent of the aluminum applications. The 2090 and other alloy substitutes are found to be unsuitable replacements for the conventional Al materials because of their anisotropic tensile or other mechanical properties. In some cases the cost per kg premium or the buy-weight/fly-weight ratios indicate that the substitution is not cost-effective. No significant obstacle to the use of the alloys is reported, indicating that Al-Li alloys such as 2090, 8090, and 8091 can be effectively used in the production of fighter aircraft.

C.C.S.

A91-43920

PROPERTIES OF COMMERCIALLY AVAILABLE AL-LI ALLOYS' POSSIBLE USE ON CIVIL AIRCRAFT

Y. BARBAUX (Aerospatiale, Suresnes, France) IN: Aluminum-lithium alloys; Proceedings of the 5th International Aluminum-Lithium Conference, Williamsburg, VA, Mar. 27-31, 1989. Vol. 3. Birmingham, England, Materials and Component Engineering Publications, Ltd., 1989, p. 1667-1675.

Copyright

Al-Li alloys are characterized with the objective of making an entire fuselage of A330/340 in Al-Li. Results obtained during the last five years on the following commercially available Al-Li products: 2091 and 8090C T851 sheets, 2091 T851 thin plates, 8090 and 2091 T8511 extrusions, and 8090 and 2091 T7 or T8 precision die forgings, and they are compared with classical 2024 T3 and 7075 T7x alloys. In the range of thicknesses up to 3.5 or 4 mm, 2091 and 8090 present a fully recrystallized structure. They have the same static level and the same fracture toughness. The fatigue crack growth of 2091 is better than the one of 2024 at R ratio of 0.1. The alloys 2091 and 8090 exhibit the same intrinsic behavior in corrosion as 2024 T3. Corrosion and stress-corrosion properties of 2091 T851 thin plates are quite good, even better than those of 2024 T351. The two alloys are in the same range of mechanical properties, quite comparable to 7075 T73.

P.D.

N91-26249# California Univ., Los Angeles. Dept. of Chemistry and Biochemistry.

SIZE DEPENDENCE OF GASEOUS CLUSTER REACTIVITY AND EVAPORATION DYNAMICS AS A MECHANISTIC PROBE

M. A. EL-SAYED 18 Mar. 1991 51 p

(Contract N00014-89-J-1350)

(AD-A233811; TR-68) Avail: NTIS HC/MF A04 CSCL 07/4

Two different types of cluster studies were carried out in the laboratory. In one, gaseous niobium metal clusters are synthesized by laser ablation and supersonic expansion in helium and detected by using excimer one-photon ionization-mass spectrometry methods. The dependence of their chemical reactivity (towards some carbon compounds) on size examined and used as a new mechanistic probe. In the other type of cluster studies, the mechanisms of the evaporation of one and two CsI molecules from individual mass selected (Cs(CsI)n)+ clusters (made by sputtering techniques) are determined from a study of the kinetic energy released and its distribution during evaporation process.

GRA

N91-26281# California Inst. of Tech., Pasadena. Graduate Aeronautical Labs.

AN EXPERIMENTAL INVESTIGATION OF STRUCTURE, MIXING, AND COMBUSTION IN COMPRESSIBLE TURBULENT SHEAR LAYERS Ph.D. Thesis

JEFFERY L. HALL 1991 139 p

(Contract AF-AFOSR-0155-88; AF PROJ. 2308)

(AD-A235278) Avail: NTIS HC/MF A07 CSCL 21/2

Two-dimensional, compressible, turbulent shear layers are studied in a new wind tunnel facility. Both reacting and non-reacting flows are investigated, with one free stream velocity supersonic and the other subsonic. The combustion experiments are based on use of low concentrations of hydrogen, nitric oxide and fluorine gases. Side-view Schlieren photographs of these reacting and non-reacting flows appear devoid of the 2-D, large scale structures seen in incompressible flow. Comparison with all-subsonic flows produced in the same facility suggests that this lack of two-dimensional structure is due to the presence of the supersonic high-speed free stream velocity. Travelling shock and expansion waves are observed in the high compressibility flows, evidently created by turbulent structures convecting at supersonic velocities. Such waves are seen only in the low-speed fluid, with apparent convection velocities much higher than those predicted on the basis of isentropic pressure-matching arguments. The measured shear layer growth rates agree with previous results by other experiments, except for a few cases at low compressibility and low density ratio. The fast chemistry regime is attained in some of the high compressibility flows tested. Flip experiments conducted in this regime indicated that the volume fraction of mixed fluid in the layer is substantially reduced as compared to previous incompressible results.

GRA

N91-26300# Air Force Inst. of Tech., Wright-Patterson AFB, OH. Foreign Technology Div.

TITANIUM ALLOY INTEGRATED CENTRIFUGAL IMPELLER 5 COORDINATE COMPUTER ASSISTED MANUFACTURING TECHNOLOGY

DIANZHONG WEN, YOULIN BAO, and ZHONGSHU REN 29 Nov. 1990 12 p Transl. into ENGLISH from Guoji Hangkong (China), no. 9, 1989 p 37-38

(AD-A234797; FTD-ID(RS)T-0754-90) Avail: NTIS HC/MF A03 CSCL 11/6

In a cooperation between the aerospace industry's No. 608 Aeroengine Research Institute and the South Motive Power and Machinery Complex, there has been successful research and an associated promoting of titanium alloy integrated centrifugal impeller 5 coordinate or axis computer assisted manufacturing (TICAM5NC) technology. Along with this, in November of 1988, it smoothly went through a ministry level technology evaluation. As far as the successful research on this new item of technology is concerned, it breaks through a big stumbling block in the process of production and test manufacture of medium and small model aviation engine centrifugal gas compressors. As far as a speed up in the development of our country's medium and small model aviation motive technology is concerned, the test manufacture of high efficiency, high pressure ratio centrifugal gas compressors will lead to a serious promotional effect.

GRA

N91-26384# Oak Ridge National Lab., TN.

CERAMIC TECHNOLOGY FOR ADVANCED HEAT ENGINES PROJECT

Dec. 1990 462 p

(Contract DE-AC05-84OR-21400)

(DE91-010451; ORNL/TM-11719) Avail: NTIS HC/MF A20

Significant accomplishments in fabricating ceramic components for the Department of Energy (DOE), National Aeronautics and Space Administration (NASA), and Department of Defense (DoD) advanced heat engine programs have provided evidence that the operation of ceramic parts in high-temperature engine environments is feasible. However, these programs have also demonstrated that additional research is needed in materials and processing development, design methodology, and data base and life prediction before industry will have a sufficient technology base from which to produce reliable cost effective ceramic engine components commercially. The objective is to develop the industrial technology base required for reliable ceramics for application in advanced automotive heat engines. The project approach includes determining the mechanisms controlling reliability, improving processes for fabricating existing ceramics, developing new materials with increased reliability, and testing these materials in simulated engine environments to confirm reliability. Although this is a generic materials project, the focus is on the structural ceramics for advanced gas turbine and diesel engines, ceramic bearings and attachments, and ceramic coatings for thermal barrier and wear applications in these engines. This advanced materials technology is being developed in parallel and close coordination with the ongoing DOE and industry proof of concept engine development programs. To facilitate the rapid transfer of this technology to U.S. industry, the major portion of the work is being done in the ceramic industry, with technological support from government laboratories, other industrial laboratories, and universities. DOE

N91-26387# Army War Coll., Carlisle Barracks, PA.
WHAT FUELS OUR FUTURE? Final Report
ROBERT L. JARVIS 26 Mar. 1991 46 p
(AD-A233674) Avail: NTIS HC/MF A03 CSCL 11/7

This study project reviews the recent history of fuels usage and product evolution (since WWII) and presents current doctrine. The conclusion and recommendation of this project is that the Army of 2001 should have a single fuel on the battlefield. This fuel should be readily available at a reasonable cost, worldwide. The fuel chosen should be safe to transport and store while meeting the requirements of a wide variety of military equipment. This project also addresses current misconceptions, perceived problems, and issues to be resolved about a single fuel concept. Both commercial jet fuel (Jet A1) and its military counterpart, jet propulsion fuel (JP8) offer a safe, relatively available, versatile, and logistically supportable compromise to the varying needs of the majority of ground and air equipment. GRA

12

ENGINEERING

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

A91-40645
AN EXPERIMENTAL EVALUATION OF THERMOCHROMIC LIQUID CRYSTALS FOR SURFACE TEMPERATURE AND HEAT FLUX MEASUREMENTS IN SHOCK TUBE FLOWS
Z. C. ZHANG, G. T. ROBERTS, and N. H. PRATT (Southampton, University, England) IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 618-623. Research supported by British Council and China Aerodynamics Research and Development Center. refs
Copyright

Shock tube experiments using air are described in which models coated with thermochromic liquid crystals (LCs) are subjected to short duration (2-10 ms) aerodynamic heating pulses of magnitude q(s) between 100,000-600,000 W/sq m. The optical response of the LCs was found to lag their thermal response by 1-4 ms. Despite this optical lag, a technique utilizing LCs should be effective, with suitable calibration, for heat flux measurement in shock tube flows. Author

A91-40701
AIAA COMPUTATIONAL FLUID DYNAMICS CONFERENCE, 10TH, HONOLULU, HI, JUNE 24-27, 1991, TECHNICAL PAPERS
Washington, DC, American Institute of Aeronautics and Astronautics, 1991, 1003 p. For individual items see A91-40702 to A91-40804.
Copyright

The present conference discusses the development status of CFD applications in such fields as numerical methods, Euler methods, compressible Navier-Stokes methods, incompressible Navier-Stokes methods, viscous flows, high-velocity flows, supercomputer and parallel-processing applications of CFD, grid-generation methods, methods for unsteady flows, numerical boundary conditions, and the numerical simulation of turbulence and transition. Attention is given to multidimensional schemes for scalar advection, design algorithms for a dispersive hyperbolic problem, dissipation additions to flux-difference splitting, a three-dimensional unstructured multigrid for the Euler equations, viscous airfoil computations using the Richardson extrapolation, a fast vortex method in three dimensions, computational aspects of chemically reacting flows, parallel unstructured grid generation, grid-structuring for moving boundaries, grid convergence for adaptive methods, conservative front-tracking for inviscid compressible flow, and a spectral element-Fourier method for transitional flows in complex geometries. O.C.

A91-40725#
FINITE ELEMENT SIMULATION OF COMPRESSIBLE FLOWS WITH SHOCKS
G. FERNANDEZ (INRIA, Le Chesnay, France) and M. HAFEZ (California, University, Davis) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 248-259. refs
(AIAA PAPER 91-1551) Copyright

Solutions of Euler equations for two dimensional flows are presented using several finite element methods. Comparison between upwind and centered schemes is presented and some remarks about the use of limiters and the potential of different centered formulations are discussed. Author

A91-40743#
APPROXIMATE ANALYSIS AND SENSITIVITY ANALYSIS METHODS FOR VISCOUS FLOW INVOLVING VARIATION OF GEOMETRIC SHAPE
ARTHUR C. TAYLOR, III, VAMSHI M. KORIVI, and GENE W. HOU (Old Dominion University, Norfolk, VA) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 456-475. refs
(Contract NSF DMC-86-57917)
(AIAA PAPER 91-1569) Copyright

Changes in steady-state numerical solutions of the thin-layer Navier-Stokes equations in response to small variations in geometric shape are estimated using an approximation method which is developed herein. In addition, this approximation method is extended to become a general procedure for calculating aerodynamic shape sensitivity derivatives by direct differentiation of the algebraic equations which approximate the governing equations. The methods are successfully applied in two-dimensions using an upwind cell-centered finite volume procedure for a low Reynolds number RE(L) = 100 laminar flow through a double-throat nozzle, where the flow is accelerated from Mach 0.10 at the inflow to about Mach 2.80 at the outflow. Calculations reported herein using the approximation method show good agreement between the predicted numerical solutions and the conventional numerical solutions. In addition, the aerodynamic sensitivity derivatives which are calculated using the method of direct differentiation match those calculated using the method of finite differences (i.e., brute force), but are computationally less expensive to obtain. Author

A91-40793*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DEVELOPMENT OF A NEW FLUX SPLITTING SCHEME
MENG-SING LIOU and CHRISTOPHER J. STEFFEN, JR. (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 967, 968.
Copyright
The successful use of a novel splitting scheme, the advection upstream splitting method, for model aerodynamic problems where Van Leer and Roe schemes had failed previously is discussed. The present scheme is based on splitting in which the convective and pressure terms are separated and treated differently depending on the underlying physical conditions. The present method is found to be both simple and accurate. K.K.

A91-40812
HOW FAILURE PREDICTION METHODOLOGY AFFECTS ELECTRONIC EQUIPMENT DESIGN
CHARLES T. LEONARD (Boeing Commercial Airplanes, Seattle, WA) and MICHAEL PECHT (Maryland, University, College Park) Quality and Reliability Engineering International (ISSN 0748-8017), vol. 6, Sept.-Oct. 1990, p. 243-249.
Copyright
The efficiency of failure prediction methodologies (FPMs) is reviewed with respect to enhancing the reliability of electronic equipment designs. The intended uses of FPM are set forth, which include the reduction of unreliable parts in the critical path, the use of a criterion to select higher quality parts, and the reduction of application stress levels. The potential misuses are enumerated including the inherent prohibition against plastic-encapsulated parts and unfounded concerns regarding electronic engine controls. Various examples are given with comparisons of in-service data against FPM predictions, which in some cases exhibit zero correlation. FPMs predict the failure of boxes based on the failure of parts, which is demonstrated to be typically inaccurate. The notion of constant failure rates accelerated by stress is also shown to be an inaccurate description of current electronic technology. C.C.S.

A91-41155
A METHOD FOR CALCULATING THE CHARACTERISTICS OF A ROTOR WITH ALLOWANCE FOR SHAFT VIBRATIONS [METODIKA RASCHETA KHARAKTERISTIK NESUSHCHEGO VINTA S UCHETOM KOLEBANII VALA]
A. IU. LISS Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1991, p. 6-11. In Russian. refs
Copyright
A method for calculating the characteristics of a rotor with allowance for shaft vibrations is presented which is based on a previously developed theory (Liss, 1972, 1973) for rotors with a fixed shaft. If the matrix of the dynamic response of the fuselage to variable loads is known, then the method can be used to calculate the level of fuselage vibrations with allowance for internal damping. Details of the calculation procedures are given. V.L.

A91-41159
LIMITING THERMAL LOADS IN POROUS STRUCTURES [PREDEL'NYE TEPLOVYE NAGRUZKI V PORISTYKH STRUKTURAKH]
V. M. POLIAEV and A. A. GENBACH Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1991, p. 33-37. In Russian.
Copyright
A model describing the limiting state of a heating surface cooled by porous structures is examined. Based on the thermohydraulic characteristics, expressions are obtained for calculating the ratios of critical heat flows as a function of the operating and design characteristics of the porous elements. The results are in good agreement with experimental data obtained for surfaces of 18N10T and 12Kh18N9T cooled by woven brass and stainless steel mesh structures. V.L.

A91-41168
USING IMPLICIT DISPLACEMENT EXPRESSIONS FOR OBTAINING A SOLUTION IN THE TRANSITION ZONE OF A HYBRID COMPUTATION SCHEME [PRIMENENIE NEIAVNOI FORMY PREDSTAVLENIIA PEREMESHCHENII DLIA FORMIROVANIIA RESHENIIA V PEREKHODNOI ZONE GIBRIDNOI RASCHETNOI SKHEMY]
P. D. LEVASHOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1991, p. 81-83. In Russian.
Copyright
Reference is made to a previous study (Levashov, 1985) in which methods for seeking a solution in the transition zone of hybrid computation schemes have been proposed whereby the displacement vector is in the cross section of interest is represented in the form (q0, Delta-q). With this approach, however, a special algorithm for obtaining (Delta-q) in explict form is required. In the present study, a new approach is proposed whereby the displacements in the transition zone can be represented in implicit form. The method is demonstrated for the problem of determining tangential stresses in the walls of the spars of a five-spar wing. V.L.

A91-41508
THE WEAR MECHANISMS OCCURRING IN ABRADABLE SEALS OF GAS TURBINES
M. O. BOREL, A. R. NICOLL, H. W. SCHLAEPFER, and R. K. SCHMID (Sulzer Plasma Technik, Inc., Corporate Research and Development and Surface Technology Div., Winterthur, Switzerland) IN: Metallurgical coatings 1989; Proceedings of the 16th International Conference, San Diego, CA, Apr. 17-21, 1989. Vol. 1. London and New York, Elsevier Applied Science, 1989, p. 117-126.
Copyright
Metallographic investigations of worn abradable coatings were used to identify and characterize the wear mechanisms occurring in abradable seals of gas turbines. The mechanisms identified included cutting, smearing, adhesive transfer, crushing, melting, and tribooxidaton. It was found that the coating temperature during rub testing depended on the wear mechanism; for instance, the adhesive type of wear induced a small temperature increase, while the cutting wear caused strong heating of the coating. Good correlations were found between the wear-track roughness, the mass variation of the blades, and the occurring wear mechanism. I.S.

A91-41584
POST-CRITICAL BEHAVIOUR OF A UNIFORM CANTILEVER COLUMN SUBJECTED TO A TIP CONCENTRATED SUBTANGENTIAL FOLLOWER FORCE WITH SMALL DAMPING
B. NAGESWARA RAO and G. VENKATESWARA RAO (ISRO, Vikram Sarabhai Space Centre, Trivandrum, India) Forschung im Ingenieurwesen (ISSN 0015-7899), vol. 57, May 1991, p. 81-86. refs
Copyright
The large deflections of a uniform cantilever column under a tip concentrated subtangential follower force have been analyzed employing the dynamic criterion. A simple and reliable iterative numerical scheme is used to solve the problem. The postcritical load, eigencurve, and corresponding coalescence frequency parameter, wherever applicable for different values of the subtangential parameter and the tip angle of the column, are described. It is shown that small damping has a destabilizing effect. R.E.P.

A91-41647#
DESIGN OF THE HIGH RELIABILITY GMA 2100 REDUCTION GEARBOX
J. D. BLACK and E. E. PFAFFENBERGER (General Motors Corp.,

Allison Gas Turbine Div., Indianapolis, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p.
(AIAA PAPER 91-1905) Copyright

Next-generation commercial/military turboprop gearboxes call for greater reliability, power/weight ratios, and power limits, in association with lower user cost and simplifications of maintenance tasks. An account is presently given of the design features and performance capabilities of the GMA 2100 turboprop reduction gearbox, which has achieved such distinctions as: (1) pinion bearing lives 4 times greater than current gearboxes, (2) an isolation of the reduction gearbox from the accessory drivetrain in order to improve reliability and maintainability, and (3) a novel planet bearing whose service life is 6 times greater than that of earlier equipment. O.C.

A91-41648*# Lucas Western, Inc., City of Industry, CA.
ADVANCED ROTORCRAFT TRANSMISSION (ART) PROGRAM STATUS
ROBERT BOSSLER (Lucas Western, Inc., Applied Technology Div., City of Industry, CA) and GREGORY HEATH (McDonnell Douglas Helicopter Co., Mesa, AZ) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. U.S. Army-supported research.
(Contract NAS3-25454)
(AIAA PAPER 91-1906) Copyright

Reported herein is work done on the Advanced Rotorcraft Transmission by McDonnell Douglas Helicopter Company under Army/NASA contract. The novel concept pursued includes the use of face gears for power transmission and a torque splitting arrangement. The design reduces the size and weight of the corner-turning hardware and the next reduction stage. New methods of analyzing face gears have increased confidence in their usefulness. Test gears have been designed and manufactured for power transmission testing on the NASA-Lewis spiral bevel test rig. Transmission design effort has included finite element modeling of the split torque paths to assure equal deflection under load. A finite element model of the Apache main transmission has been completed to substantiate noise prediction methods. A positive engagement overrunning clutch design is described. Test spur gears have been made by near-net-shape forging from five different materials. Three housing materials have been procured for evaluation testing. Author

A91-41650*# Sikorsky Aircraft, Stratford, CT.
ADVANCED ROTORCRAFT TRANSMISSION (ART) PROGRAM STATUS
JULES KISH (Sikorsky Aircraft, Stratford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. U.S. Army-supported research. refs
(Contract NAS3-25423)
(AIAA PAPER 91-1909) Copyright

A weight reduction of 23 percent, noise reduction greater than 10 dB, and almost a fourfold increase in mean time between transmission removals has been demonstrated for a helicopter gearbox having a high output reduction ratio split path gear arrangement. These performance gains have been achieved by application of advanced transmission technology concepts in areas which offer high gain but are outside of normal design practices. New technology is being developed in such areas as split power gear concepts, composites, double helical gears, new gear materials, high speed spring clutches, and ceramic rolling element bearings. The programs, when completed, will provide demonstrated component and drive arrangement technology supported by analytical tools. The work is being accomplished under a CR&D program funded by NASA/Army termed the Advanced Rotorcraft transmission (ART) program. It is expected that the ART technology will be incorporated in future rotorcraft of the 1990s and 2000s. This paper summarizes the work accomplished to date on the program by Sikorsky Aircraft. Author

A91-41651#
COMPOSITE GEARBOXES, DESIGNING FOR THE 90'S
A. G. MEYER (Textron Lycoming, Stratford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-1910) Copyright

Textron Lycoming is studying Organic Matrix Composites to increase power to weight ratio and decrease cost for many of its engine components. These lighter weight, less expensive materials are ideal for gearbox applications and may be supplemented to improve a host of design parameters. Accessory gearbox covers were molded from PMR15 and subsequently machined to develop manufacturing technology. Static pressure and torque testing was conducted on both the composite and standard aluminum covers for comparison and Photostress coat was used to measure strain while indicators recorded deflections at various locations. The experience gained is now being applied to larger covers and entire gearboxes for the 90s. Author

A91-41676#
WAKE INGESTION PROPULSION BENEFIT
LEROY H. SMITH, JR. (GE Aircraft Engines, Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-2007) Copyright

It is well known that the efficiency of propulsion is improved if part or all of the propulsive fluid comes from the wake of the craft being propelled. In this paper this propulsion benefit is quantified in terms of wake parameters and propulsor properties. The formulations apply directly to unducted fans or propellers, but the conclusions are also relevant to ducted propulsors. It is found that the power saving is greatest when the propulsor disk loading is high, when the wake form factor is high (flow near separation), and when the propulsor design is such that the wake profile tends to be flattened as it passes through the propulsor (high wake recovery). Examples are given showing that the benefit can be in the 20 percent range in some cases. Propeller design parameters that lead to high wake recovery are also given. Author

A91-41726#
VISUALIZATION OF AIRBLAST ATOMIZED SPRAY STRUCTURE UNDER VARYING AIR PRESSURE CONDITIONS
A. WYNNE (Rolls-Royce, PLC, Combustion Research Dept., Derby, England) and A. K. JASUJA (Cranfield Institute of Technology, England) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-2199) Copyright

Nonburning spray visualization is investigated for various air pressure conditions of gas turbine fuel injector/combustor head assembly hardware. In simulations of ground-idle through take-off conditions, aviation kerosene is employed to examine four pre-filming-type airblast injectors. High-intensity spark photography and video imaging are employed to record the dynamic and unsteady elements of spray behavior. These visualization techniques are shown to yield important quantitive as well as qualitative data regarding spray characteristics. An inhomogeneous structure with respect to both droplet concentration and ballistics is demonstrated by the sprays. Spray placement and structure are affected significantly by the design of the airblast injector and the operating conditions under which they are utilized. Because fuel sprays are nonuniform and variable, they affect the flame characteristics and increase the production of soot and other pollutant species. C.C.S.

A91-41798#
HEAT MANAGEMENT CONCEPTS FOR HYPERSONIC PROPULSION SYSTEMS
K. RUED, H. MARK, and G. GOETZ (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p.

BMFT-supported research.
(AIAA PAPER 91-2493) Copyright

This paper presents preliminary results on the design of heat management and cooling concepts for turbo-ramjet propulsion systems with flight operation up to Mach 7. The studies were conducted with the aim to define the technologies that have to be matured for the final engine design. The results presented in this paper focus on the assessment of the overall cooling requirements, on the thermal and structural design of both hydrogen and aircooled engine structures and on the evaluation of the most suitable cooler system for generating cooling air. A final heat balance compares the total cooling requirements with the available heat sink capacity of the hydrogen fuel flow. Author

A91-41846
ESTIMATING THE PERIOD LENGTH OF PERIODIC SIGNALS [SCHAETZUNG DER PERIODENDAUER VON PERIODISCHEN SIGNALEN]
DIETER NAGEL (Telefunken Systemtechnik GmbH, Ulm, Federal Republic of Germany) IN: Radar Symposium, 7th, Ulm, Federal Republic of Germany, Oct. 10-12, 1989, Reports. Duesseldorf, Deutsche Gesellschaft fuer Ortung und Navigation, 1989, p. 473-483. In German. refs
Copyright

A numerical technique for determining the rotor-blade frequency of a helicopter from a noise-perturbed Doppler radar signal is developed analytically and demonstrated by means of numerical simulations. A method based on maximum-likelihood analysis yields an optimum estimate in the case of white noise, but requires additional adaptive bandpass filtering for clutter suppression in the case of colored noise (as when the antenna is mounted on an aircraft). An alternative nonlinear processing technique employing parameter approximation is shown to avoid this difficulty, generating the cepstrum without ambiguity. D.G.

A91-41849
INTELLIGENT RADAR DATA PROCESSING [INTELLIGENTE RADAR-DATEN-VERARBEITUNG]
ULRICH D. HOLZBAUR (AEG AG, Frankfurt am Main, Federal Republic of Germany) IN: Radar Symposium, 7th, Ulm, Federal Republic of Germany, Oct. 10-12, 1989, Reports. Duesseldorf, Deutsche Gesellschaft fuer Ortung und Navigation, 1989, p. 515-528. In German. refs
Copyright

The application of artificial intelligence principles to the processing of radar signals is considered theoretically. The main capabilities required are learning and adaptation in a changing environment, processing and modeling information (especially dynamics and uncertainty), and decision-making based on all available information (taking its reliability into account). For the application to combat-aircraft radar systems, the tasks include the combination of data from different types of sensors, reacting to electronic counter-countermeasures, evaluation of how much data should be acquired (energy and radiation management), control of the radar, tracking, and identification. Also discussed are related uses such as monitoring the avionics systems, supporting pilot decisions with respect to the radar system, and general applications in radar-system R&D. D.G.

A91-42241
REDUCTION OF THE RCS OF THE LEADING EDGE OF A CONDUCTING WING-SHAPED STRUCTURE BY MEANS OF LOSSLESS DIELECTRIC MATERIAL
A. J. BOOYSEN, C. W. I. PISTORIUS, and J. A. G. MALHERBE (Pretoria, University, Republic of South Africa) Microwave and Optical Technology Letters (ISSN 0895-2477), vol. 4, June 1991, p. 277-279.
Copyright

The radar cross section of the leading edge of a conducting wing-shaped structure is reduced by replacing part of the structure with a lossless dielectric material. The structure retains its original external shape, thereby ensuring that the aerodynamic properties are not altered by the structural changes needed to reduce the radar cross section. Author

A91-42258#
JET-WAKE THERMAL CHARACTERISTICS OF HEATED TURBULENT JETS IN CROSSFLOW
S. A. SHERIF (Miami, University, Coral Gables) and R. H. PLETCHER (Iowa State University of Science and Technology, Ames) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 5, Apr.-June 1991, p. 181-191. Research supported by Iowa State University of Science and Technology. Previously cited in issue 20, p. 3398, Accession no. A88-48978. refs
(Contract NSF ENG-78-12901; NSF MEA-82-11713)
Copyright

A91-42282#
MODIFICATION OF THE VAN DRIEST DAMPING FUNCTION TO INCLUDE THE EFFECTS OF SURFACE ROUGHNESS
PER-AGE KROGSTAD (Norwegian Institute of Technology, Trondheim, Norway) AIAA Journal (ISSN 0001-1452), vol. 29, June 1991, p. 888-894. refs
Copyright

A prediction method for rough surfaces has been given that is based on a simple extension of the van Driest damping function. The method stimulates the turbulent shear stresses near the wall by manipulating the amount of viscous damping applied. It is demonstrated that the model reproduces the shift in the logarithmic layer found for sand roughness. For very high surface roughness, an intermediate logarithmic layer is found that links the viscous sublayer to the fully developed logarithmic layer. The method has been applied to a series of test cases of varying sublayer to the fully developed logarithmic layer. The method has been applied to a series of test cases of varying complexity and surface roughness, showing that the predictions of flows along rough surfaces can be computed with the same degree of accuracy as for flows over smooth surfaces. Author

A91-42292#
RELIABILITY OF INITIALLY COMPRESSED UNCERTAIN LAMINATED PLATES IN SUPERSONIC FLOW
D. G. LIAW and HENRY T. Y. YANG (Purdue University, West Lafayette, IN) AIAA Journal (ISSN 0001-1452), vol. 29, June 1991, p. 952-960. refs
(Contract NSF ECE-85-16915)
Copyright

The reliability of initially compressed laminated thin plates whose structural characteristics are uncertain due to variabilities incurred during fabrication are considered in light of a stochastic thin-plate finite element to determine buckling and supersonic flutter failure criteria, as well as the interactive effects between the in-plane load and aerodynamic pressure. The 16-DOF quadrilateral laminated thin-plate element is based on classical lamination theory; the stochastic element formulation, accomplished by including the effects of structural uncertainties and random in-plane loads, bases its solution procedure on the mean-centered, second-moment perturbation technique. O.C.

A91-42294#
UNIFIED TREATMENT FOR DEALING WITH AUXILIARY CONDITIONS IN BLADE DYNAMICS
A. ROSEN, R. G. LOEWY, and M. B. MATHEW (Rensselaer Polytechnic Institute, Troy, NY) AIAA Journal (ISSN 0001-1452), vol. 29, June 1991, p. 968-976. refs
(Contract DAAG29-82-K-0093; DAAL03-88-C-0004)
Copyright

Use of Lagrange multipliers is shown here to lead to a convenient method for the numerical analysis of blade dynamics in which a variety of auxiliary conditions may be imposed. General equations are derived that can deal with blades having virtually all of the possible combinations of boundary conditions. The method is combined with a generalized coordinates approach to obtain a unified and efficient formulation that is applicable to both linear and nonlinear situations. The different stages of the solution procedures are explained, and the method is demonstrated by calculating the natural frequencies of rotating and nonrotating blades having various boundary conditions at the root. The results of the present method are shown to agree very well with those from both transfer matrix analysis and exact analytical solution. Computational efficiencies available for design studies in which blade root flap, lag, and pitch springs and/or dampers are varied widely, for example, as used with a particular rotor blade, say, with substantial flap-pitch and flap-lag coupling, are a motivating factor in proposing this method. These aspects are also discussed. Author

A91-42602#
NUMERICAL AND EXPERIMENTAL STUDY OF FOUNTAIN FLOWS PRODUCED BY MULTIJET IMPINGEMENT ON A GROUND PLANE
J. M. M. BARATA (Instituto Superior Tecnico, Lisbon, Portugal) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-1806) Copyright
A numerical and experimental study is made of the characteristics of three-dimensional fountain flows generated by the impingement of two or three axisymmetric turbulent jets on a ground plane through the influence of a low-velocity crossflow. This study provides a basis for understanding more complex flowfields in numerous practical situations, including jet-powered VSTOL aircraft. The simulations are based on the solution of the time-averaged Navier-Stokes equations and the k-epsilon turbulence model. The computed results are compared with LDV measurements and visualization results for the cases of two and three jets impinging on a flat plate located at 5 jet diameters from the jet exit and a velocity ratio between the jet and crossflow of 30. Comparisons between experimental and numerical results show generally good agreement for the mean flowfield quantities. Author

A91-42801#
MODEL FOR AIRBLAST ATOMIZATION
N. K. RIZK and H. C. MONGIA (General Motors Corp., Combustion Dept., Indianapolis, IN) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, May-June 1991, p. 305-311. Previously cited in Issue 20, p. 3150, Accession no. A89-46748. refs
Copyright

A91-43000#
A STUDY OF SUPERSONIC AERODYNAMIC MIXING IN THE SCRAMJET COMBUSTOR
YASUNORI ANDO, MASAFUMI KAWAI, TOSHIRO FUJIMORI, HIDETO IKEDA, YASUNORI OHMORI et al. Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 31, Jan. 1991, p. 1-7. In Japanese, with abstract in English. refs
Two-dimensional and three-dimensional CFD codes are described for predicting the mixing and combustion of hydrogen fuel in the turbulent flowfield of supersonic combustion ramjets, which use a TVD to efficiently capture the discontinuous surfaces. The experimental validation of the codes is performed and the applicability of the codes to simulations of realistic scramjet combustor flowfields is evaluated. I.S.

A91-43310*# Wichita State Univ., KS.
METHODS FOR OBTAINING AND REDUCING EXPERIMENTAL DROPLET IMPINGEMENT DATA ON ARBITRARY BODIES
MICHAEL PAPADAKIS (Wichita State University, KS), R. ELANGOVAN, GEORGE A. FREUND, JR., and MARLIN D. BREER (Boeing Co., Wichita, KS) Journal of Aircraft (ISSN 0021-8669), vol. 28, May 1991, p. 328-336. FAA-supported research. refs
(Contract NAG3-566)
Copyright
Experimental water droplet impingement data are used to validate particle trajectory computer codes used in the analysis and certification of aircraft de-icing/anti-icing systems. Water droplet impingement characteristics of aerodynamic surfaces are usually obtained from wind-tunnel dye tracer experiments. This paper presents a dye tracer method for measuring water droplet impingement characteristics on arbitrary geometries and a new data reduction method, based on laser reflectance measurements, for extracting impingement data. Extraction of impingement data has been a very time-consuming process in the past. The new data reduction method developed is at least an order of magnitude more efficient than the method previously used. The accuracy of the method is discussed and results obtained are presented. Author

A91-43326
WITH US YOU FLY RIGHT - THE INFLUENCE OF MODERN TECHNOLOGY ON THE DEVELOPMENT AND OPERATION OF NEW AIRCRAFT [BEI UNS FLIEGEN SIE RICHTIG - DER EINFLUSS MODERNER TECHNIKEN AUF ENTWICKLUNG UND BETRIEB VON NEUEN FLUGGERAETEN]
BERND GELHAAR (DLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) DLR-Nachrichten (ISSN 0937-0420), May 1991, p. 2-7. In German.
Copyright
The influence of advances in computer technology on the development and operation of new aircraft is examined. Emphasis is given to improvements in handling and improved simulations using computers. The use of parallel computers based on transputer networks is addressed. C.D.

A91-43328
VELOCITY MEASUREMENTS IN TURBINE ENGINES - NEW DEVELOPMENTS USING THE LASER TWO-FOCUS METHOD [GESCHWINDIGKEITSMESSUNG IN TURBOMASCHINEN - NEUE ENTWICKLUNGEN BEIM LASER-2-FOKUS-VERFAHREN]
RICHARD SCHODL and WOLFGANG FOERSTER (DLR, Institut fuer Antriebstechnik, Cologne, Federal Republic of Germany) DLR-Nachrichten (ISSN 0937-0420), May 1991, p. 12-18. In German.
Copyright
Progress made in the use of the laser two-focus method to make velocity measurements in turbine engines is discussed. The abbreviation of the measurement time is examined along with the use of stepped ray spacing and three-dimensional procedures. Difficulties with the laser two-focus approach are addressed. C.D.

A91-43334
STRUCTURAL MECHANICS RESEARCH IN THE DLR [STRUKTURMECHANISCHE FORSCHUNG IN DER DLR]
JOACHIM BLOCK DLR-Nachrichten (Sonderbeilage) (ISSN 0937-0420), May 1991, p. 3-11. In German.
Copyright
Structural mechanics and its role in air and space flight are discussed. Damage mechanisms, thermal mechanisms, and the stability and optimization of light structures are addressed. Methods for testing damage, stress, and deformation in structural mechanics of air and space flight structures are considered. The significance of some special materials in the mechanics of these structures is briefly examined. C.D.

A91-43446*# Lockheed Engineering and Sciences Co., Hampton, VA.
AN ANALYTICAL COMPARISON OF CONVECTIVE HEAT TRANSFER CORRELATIONS IN SUPERCRITICAL HYDROGEN
WILLIAM M. DZIEDZIC, STUART C. JONES (Lockheed Engineering and Sciences Co., Hampton, VA), DANA C. GOULD, and DENNIS H. PETLEY (NASA, Langley Research Center, Hampton, VA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 15 p. refs
(AIAA PAPER 91-1382) Copyright
Four correlations that cover the ranges of liquid to gas for turbulent flow convection of hydrogen are compared with CFD analysis over a range of expected design conditions for active cooling of hypersonic aircraft. Analysis of hydrogen cooling in a typical cooling panel shows how predicted design performance

varies with the correlation utilized. The CFD heat transfer coefficient results for a heat spike differed significantly from all four correlations. An acceptable heat transfer coefficient can be calculated at the heat spike location by overlooking the coefficient at the spike and averaging the coefficient before and after the spike. R.E.P.

A91-43447#
THERMAL MODELING AND ANALYSIS OF A CRYOGENIC TANK DESIGN EXPOSED TO EXTREME HEATING PROFILES
CRAIG A. STEPHENS (PRC, Inc., Edwards, CA) and GREGORY J. HANNA (Hanna Technology Resources, Boulder, CO) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 19 p. refs
(AIAA PAPER 91-1383) Copyright

A cryogenic test article, the Generic Research Cryogenic Tank, was designed to qualitatively simulate the thermal response of transatmospheric vehicle fuel tanks exposed to the environment of hypersonic flight. One-dimensional and two-dimensional finite-difference thermal models were developed to simulate the thermal response and assist in the design of the Generic Research Cryogenic Tank. The one-dimensional thermal analysis determined the required insulation thickness to meet the thermal design criteria and located the purge jacket to eliminate the liquefaction of air. The two-dimensional thermal analysis predicted the temperature gradients developed within the pressure-vessel wall, estimated the cryogen boiloff, and showed the effects the ullage condition has on pressure-vessel temperatures. The degree of ullage mixing, location of the applied high-temperature profile, and the purge gas influence on insulation thermal conductivity had significant effects on the thermal behavior of the Generic Research Cryogenic Tank. In addition to analysis results, a description of the Generic Research Cryogenic Tank and the role it will play in future thermal structures and transatmospheric vehicle research at the NASA Dryden Flight Research Facility is presented. Author

A91-43477#
SUPERSONIC FILM COOLING EFFECTIVENESS USING AIR AND HELIUM FOR A RANGE OF INJECTANT TEMPERATURES AND MACH NUMBERS
M. L. HUNT, K. A. JUHANY, and J. M. SIVO (California Institute of Technology, Pasadena) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 8 p. Research supported by California Institute of Technology, Aerojet, General Motors Corp., and TRW, Inc. refs
(AIAA PAPER 91-1416) Copyright

The current work experimentally investigates the dependence film cooling effectiveness on the injection Mach number, velocity and mass flux. The free stream Mach number is 2.4 and the injection Mach numbers range from 1.2 to 1.9 for both air and helium injection. The injection velocity and mass flux are varied by changing the total temperature and Mach number while maintaining matched pressure conditions between the injected flow and that of the free stream. The total temperature of the free stream is 295 K, and that for the injection ranges from 215-345 K. The results indicate an increase in film cooling effectiveness as the injection rate is increased. With larger injection Mach numbers, there is slight increase in the effective cooling length per mass injection rate. The results for helium injection indicate an increase in effectiveness as compared to that for air injection. The experimental results are also compared with earlier studies in the literature. Author

A91-43528#
COMBUSTION-DRIVEN BLOWDOWN FACILITIES FOR CHEMICAL LASER RESEARCH
WALTER R. WARREN, JR., LEO E. SCHNEIDER, and JAMES N. RODRIGUEZ (Pacific Applied Research, Rancho Palos Verdes, CA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 22 p. Research sponsored by SDIO and U.S. Army. refs
(AIAA PAPER 91-1455) Copyright

The importance of fluid dynamic phenomena in the development of high-energy/high-power lasers (HELs) is outlined, and the value of blowdown test facility (BDF) concepts in short wavelength chemical laser studies is shown, with emphasis on the NF(a)/BiF(A-X) transfer laser mechanism. The general characteristics and advantages of the BDF approach applied to HEL studies are shown, and the simple operating principles of the BDF concept are illustrated. Simplified parametric calculations are made for the BDF for its application to the investigation of short wavelength all-chemically pumped electronic transition HELs (SWCL) mechanisms. The procedure used for a nonequilibrium combustor operation is described, and an original alternate combustor charging procedure is shown. Results are reported from a brief series of HF fundamental transitional lasing experiments. P.D.

A91-43593*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INSTANTANEOUS PLANAR VISUALIZATION OF REACTING SUPERSONIC FLOWS USING SILANE SEEDING
MICHAEL W. SMITH and G. B. NORTHAM (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-1690) Copyright

A new visualization technique for reacting flows has been developed. This technique, which is suitable for supersonic combustion flows, has been demonstrated on a scramjet combustor model. In this application, gaseous silane (SiH_4) was added to the primary hydrogen fuel. When the fuel reacted, so did the (SiH_4), producing silica (SiO_2) particles in situ. The particles were illuminated with a laser sheet formed from a frequency-doubled Nd:YAG laser (532 nm) beam and the Mie scattering signal was imaged. These planar images of the silica Mie scattering provided instantaneous 'maps' of combustion progress within the turbulent reacting flowfield. Author

A91-43613#
OBSERVATIONS OF SUPERSONIC TRANSVERSE JETS
DIMITRI PAPAMOSCHOU, DENNIS G. HUBBARD (California, University, Irvine), and MIKE LIN AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs
(Contract F33615-88-C-2889)
(AIAA PAPER 91-1723) Copyright

This paper describes preliminary experimental results on penetration of round supersonic jets normal to a supersonic cross flow. The experiments have been conducted in a variable Mach number/gas supersonic tunnel, with schlieren photography the primary diagnostic. The study examines the effects of jet-to-freestream momentum ratio, jet and freestream Mach numbers, and pressure and density ratios at the jet exit. It is found that penetration is strongly dependent on momentum ratio, weakly dependent on Mach numbers and pressure ratio, and independent of density ratio. For fixed momentum ratio, increasing freestream Mach number produced a small increase in penetration, while changing the jet Mach number produced no apparent effect. Values of pressure ratio that appear to maximize penetration are suggested in the paper. Flow visualization reveals large-scale turbulent structure in the jet and significant unsteadiness of the bow shock in front of the jet. Author

A91-43706
A NEW METHOD FOR THE VIBRATION OF THIN-WALLED BEAMS
ZONGFEN ZHANG and SUHUAN CHEN (Jilin University of Technology, Changchun, People's Republic of China) Computers and Structures (ISSN 0045-7949), vol. 39, no. 6, 1991, p. 597-601. refs
Copyright

This paper presents a new method for thin-walled beams with constrained torsional vibration. Based on the differential equation for torsional vibration, which includes the effect of cross-sectional warping, the shape functions are determined and, in turn, the

frequency-dependent mass and stiffness matrices are derived. As an application of the new method, the dynamic finite element method, a numerical example is presented. The results show that this method gives more accurate results in the high-frequency range than those obtained by the static finite-element method.
Author

A91-44047#
PARAMETRIC INVESTIGATION INTO THE COMBINED EFFECTS OF PRESSURE AND TEMPERATURE DISTORTION ON COMPRESSION SYSTEM STABILITY
M. W. DAVIS, JR. (Sverdrup Technology, Inc., Arnold AFB, TN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-1895)
Presented are results of an analytical parametric investigation of the combined effects of transient and steady-state pressure and temperature distortion on compression system operability. The investigation was conducted using a stage-by-stage parallel compression system numerical simulation configured for two circumferential segments. Temporal and spatial effects on two 180-deg segments, in phase (concurrent) and out of phase (opposing), are presented with respect to their combined effects on the system stability limit. Inlet temperature ramps in combination with steady-state pressure distortion were also investigated both concurrently and in opposition.
Author

A91-44054#
SIMPLE LEAKAGE FLOW MODEL FOR BRUSH SEALS
RAYMOND E. CHUPP (Teledyne CAE, Toledo, OH), CONSTANCE A. DOWLER (USAF, Wright Laboratory, Wright-Patterson AFB, OH), and GLENN F. HOLLE AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. Research supported by USAF and Teledyne CAE. refs
(AIAA PAPER 91-1913)
Brush seals are potential replacements for some or most of the air-to-air labyrinth seals in gas turbine engines. A simple flow model is presented to generalize brush seal leakage performance throughout the range of test and application environments. The model uses a single parameter, effective brush thickness, to correlate flow through the seal. This effective brush thickness is a measure of the compactness of the bristle bed. Initial model results have been obtained using leakage flow data from two investigators. The results indicate that this simple single parameter model gives insight into the active nature of a brush seal and approximately accounts for the effect of fluid temperature, especially at the higher pressure ratios, where brush seals are commonly applied.
Author

A91-44057*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NAVIER-STOKES SIMULATION OF THE SUPERSONIC COMBUSTION FLOWFIELD IN A RAM ACCELERATOR
SHAYE YUNGSTER (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 17 p. Previously announced in STAR as N91-24541. refs
(AIAA PAPER 91-1916) Copyright
A computational study of the ram accelerator, a ramjet-in-tube device for accelerating projectiles to ultrahigh velocities, is presented. The analysis is performed using a fully implicit TVD scheme that efficiently solves the Reynolds-averaged Navier-Stokes equations and the species continuity equations associated with a finite rate combustion model. The present results indicate that viscous effects are of primary importance in all the cases studied, shock-induced combustion always started in the boundary layer. The effects of Mach number, mixture composition, pressure and tubulence are investigated for various configurations. Two types of combustion processes, one stable and the other unstable, were observed depending on the inflow conditions. The possibility of stabilizing the detonation wave by means of a backward facing step is also investigated. Two numerical techniques were tested: vector extrapolation, to accelerate convergence, and a diagonal formulation that eliminates the expense of inverting large block matrices which arise in chemically reacting flows.
Author

A91-44078#
CFD ANALYSIS OF BAFFLE FLAME STABILIZATION
YEN-SEN CHEN and RICHARD C. FARMER (SECA, Inc., Huntsville, AL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-1967) Copyright
A computational fluid dynamics analysis of ignition and combustion in baffle flame stabilized combustors was developed in order to increase the understanding of combustion efficiency and stability. The objectives of this investigation were to develop and verify a computational model of the ignition and combustion of typical augmenter configurations and to generalize the model for application to the combustion occurring in a generic gas turbine engine with augmenters, upstream vitiation, and a downstream chocked nozzle. Triangular bar and cone stabilized flames were simulated. Quasi-global propane and methane kinetics models were employed in the computation. A more detailed methane-air kinetics model was also used. An ignition procedure was devised by initially providing a 1200 K hot spot near the base to start the flame. The recirculation zone lengths of cold and hot flows were well predicted. Time averaged flow quantities were used for data comparisons since the predicted recirculating zones of the reacting flows were unsteady.
Author

A91-44099#
AN EXPERIMENTAL INVESTIGATION INTO THE EFFECTS TURBULATOR PROFILE AND SPACING HAVE ON HEAT TRANSFER COEFFICIENTS AND FRICTION FACTORS IN SMALL COOLED TURBINE AIRFOILS
M. E. TASLIM (Northeastern University, Boston, MA) and S. D. SPRING (GE Aircraft Engines, Lynn, MA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-2033) Copyright
An experimental investigation is conducted using liquid crystals to study the effects of turbulator profile and spacing on heat transfer coefficient. Friction factors are also measured and both friction factor and heat transfer results for fifteen turbulator geometries are compared. All test configurations position the turbulators on two opposite walls of a rectangular test section in a staggered arrangement with an angle of attack to the mainstream flow of 90 degrees. It is concluded that while turbulators with aspect ratios greater than unity produce higher heat transfer coefficients at the expense of higher pressure losses, 'jersey-barrier' shaped turbulators, properly spaced, are very effective in heat removal with moderate pressure losses.
R.E.P.

A91-44116#
COMPUTATIONS OF THREE-DIMENSIONAL GAS TURBINE COMBUSTOR FLOWS
A. MOSTAFA, J. MENDILLO, and N. MARCHIONNA (Textron Lycoming, Stratford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-2076) Copyright
Combusting and isothermal 3D turbulent flows in a sector of a swirl-stabilized can combustor with multiple dilution jets are studied numerically. Equilibrium algebraic stress models (ASMs) and a k-epsilon turbulence model are examined to demonstrate their influences on predicted results. Comparison was also made between the predictions of fast and finite-rate chemistry models to determine the more suited model for turbulent reacting flows. Predictions are compared with experimental data. Results indicate that there is a fair agreement with data at axial stations downstream of the primary region. However, neither the ASM nor the k-epsilon models are capable of predicting the flow field in the recirculation region.
Author

A91-44159*# Aerojet-General Corp., Sacramento, CA.
LIGHTWEIGHT CERAMIC COMPONENTS FOR PROPULSION APPLICATIONS
J. E. FRANKLIN (Aerojet, Propulsion Div., Sacramento, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 7 p.
(Contract NAS3-25416)
(AIAA PAPER 91-2217) Copyright

It is demonstrated that two ceramic engine components of reduced weight can be efficiently produced and employed at higher combustion gas temperatures. The engine components, containing internal cooling and hydraulic passages, are fabricated in a process involving platelet technology, tape casting, and multilayer ceramic packaging techniques. Traditional metal platelet design techniques are used to fabricate components from ceramic tape which are then laminated and processed to densities of close to 100 percent. A methane cooled regenerator for an air turbo ramjet engine and a rocket engine bipropellant injector are fabricated from silicon nitride. The two components are tested under conditions similar to the pressurization, thrusts, and temperatures encountered in a combustion gas environment. The survivability and leak-free nature of the components demonstrate that more complex ceramic engine components can be fabricated using these techniques. C.C.S.

A91-44166#
AERODYNAMIC AND HEAT TRANSFER ANALYSIS OF THE LOW ASPECT RATIO TURBINE USING A 3D NAVIER-STOKES CODE
D. CHOI and C. J. KNIGHT (Textron Defense Systems, Everett, MA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. Research supported by Textron Lycoming. refs
(AIAA PAPER 91-2240) Copyright

The single-stage, high-pressure ratio Garrett Low Aspect Ratio Turbine (LART) test data obtained in a shock tunnel are employed as a basis for evaluating a new three-dimensional Navier Stokes code based on the O-H grid system. It uses Coakley's two-equation turbulence modeling with viscous sublayer resolution. For the nozzle guide vanes, calculations were made based on two grid zones: an O-grid zone wrapping around airfoil and an H-grid zone outside of the O-grid zone, including the regions upstream of the leadig edge and downstream of the trailing edge. For the rotor blade row, a third O-grid zone was added for the tip-gap region leakage flow. The computational results compare well with experiment. These comparisons include heat transfer distributions on the airfoils and end-walls. The leakage flow through the tip-gap clearance is well resolved. Author

A91-44167*# Kansas Univ. Center for Research, Inc., Lawrence.
THREE-DIMENSIONAL NAVIER-STOKES ANALYSIS OF TURBINE PASSAGE HEAT TRANSFER
ALI A. AMERI (University of Kansas Center for Research, Inc., Lawrence) and ANDREA ARNONE (Firenze, Universita, Florence, Italy) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 14 p. refs
(Contract NAG3-1194)
(AIAA PAPER 91-2241) Copyright

The three-dimensional Reynolds-averaged Navier-Stokes equations are numerically solved to obtain the pressure distribution and heat transfer rates on the endwalls and the blades of two linear turbine cascades. The TRAF3D code which has recently been developed in a joint project between researchers from the University of Florence and NASA Lewis Research Center is used. The effect of turbulence is taken into account by using the eddy viscosity hypothesis and the two-layer mixing length model of Baldwin and Lomax. Predictions of surface heat transfer are made for Langston's cascade and compared with the data obtained for that cascade by Graziani. The comparison was found to be favorable. The code is also applied to a linear transonic rotor cascade to predict the pressure distributions and heat transfer rates. Author

A91-44171*# Science Applications International Corp., Fort Washington, PA.
PREDICTION OF JET MEAN FLOW STRUCTURE IN SUPPORT OF HSCT NOISE SUPPRESSION CONCEPTS
N. SINHA, S. M. DASH, B. J. YORK, and R. A. LEE (Science Applications International Corp., Fort Washington, PA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 33 p. NASA-supported research. refs
(AIAA PAPER 91-2253) Copyright

The paper describes the application of techniques based on computational fluid dynamics to the simulation of jet flowfields. A solution code for the Reynolds-averaged Navier-Stokes equations is supplemented by conventional two-equation turbulence models based on the Boussinesq approximation. The axisymmetric SCIPVIS code is enhanced with the PARCH and CRAFT codes to examine plug-jet flowfields and imperfectly expanded axisymmetric free round jets. The sensitivity of shock/boundary layer interactions is observed in simulations of the plug case, and the adaptive gridding in the disk region and turbulence levels generated at the triple point are identified as areas in the Mach case that require improvement. Jet-wave structure in the region beyond the first several shock cells can be predicted, and turbulence modeling can be undertaken with respect to improving compressibility, length scale, vorticity, and energy budget. The mean flow structure of imperfectly expanded jets can be studied to develop related noise suppression concepts for the High-Speed Civilian Transport (HSCT). C.C.S.

A91-44180*# Missouri Univ., Rolla.
ANALYSIS OF LOSSES IN SUPERSONIC MIXING AND REACTING FLOWS
D. W. RIGGINS (Missouri-Rolla, University, Rolla) and C. R. MCCLINTON (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 21 p. refs
(AIAA PAPER 91-2266) Copyright

A method for analyzing flow losses and thrust potential in supersonic combustors is presented. This method relies on a complete and consistent one-dimensional representation of a three-dimensional flow-field. Numerical results for flush wall fuel injection into a Mach 3 flow are examined and comparisons are made with experimental measurements of fuel concentration. Mixing results for a swept injection ramp, a straight (unswept) injection ramp, and a thirty degree downstream-directed flush wall jet in the same combustor duct are analyzed. The flow loss/thrust potential of the flush wall jet and the swept ramp are investigated (based on reacting solutions) using computed combustor effectiveness. The wall jet displays slightly higher thrust potential than the swept ramp at the end of the combustor. Author

A91-44255#
FLOWFIELD ANALYSIS OF A BACKSWEPT CENTRIFUGAL IMPELLER
JON S. MOUNTS, DANIEL J. DORNEY (United Technologies Research Center, East Hartford, CT), and JOOST J. BRASZ (Carrier Corp., Syracuse, NY) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-2470) Copyright

A time-dependent, three-dimensional Navier-Stokes algorithm has been applied to analyze the complex flowfield within a backswept centrifugal impeller. Issues studied include parametric analyses into the effect of secondary flow structures, due to tip leakage flow, on the development of the flowfield within the impeller passage, and off-design, or part load, analyses at conditions below (60 and 80 percent) the reference volumetric flow rate. Excellent agreement with available experimental data verifies the numerical rig as a viable technique, and suggests its ability to assist in the design process of impeller geometries. Author

A91-44258#
A NUMERICAL METHOD FOR 3D BOUNDARY LAYERS WITH A SMALL CROSSFLOW
J. LEE, G. C. PAYNTER, and T. A. REYHNER (Boeing Commercial Airplane Group, Seattle, WA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 8 p. refs
(AIAA PAPER 91-2473) Copyright
A numerical method for the computation of three-dimensional compressible, turbulent, boundary layers with a small crossflow, as encountered downstream of glancing shock/boundary layer interactions on the sideplates of two-dimensional supersonic inlets was developed and evaluated. The numerical method is based on the solution of the three-dimensional turbulent boundary layer equations with a small crossflow assumption. This decouples the solution for the crossflow from the streamwise boundary layer development. The method was evaluated through comparisons with experimental data for the turbulent boundary layer cases: a flow over a swept wing and a swirling flow around circular cylinder. The results to date are encouraging. Author

A91-44295*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CFD CODE VALIDATION FOR NOZZLE FLOWFIELDS
THOMAS N. JENTINK (NASA, Langley Research Center; Analytical Services and Materials, Inc., Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 17 p. refs
(AIAA PAPER 91-2565) Copyright
Renewed interest in hypersonic airbreathing flight has resulted in heavy reliance on computational fluid dynamics for all aspects of aerodynamic and scramjet component modeling. Credible numerical performance predictions require calibration to unit type flowfields. This paper presents results of one such calibration to nonreacting simulated scramjet nozzle flowfields. The experimental test program was performed on a static thrust stand. Computed results are in excellent agreement with measured wall pressure, pitot pressure profiles, and thrust. Agreement with thrust is shown to be within the reported accuracy of the experimental measurements. Author

A91-44319*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LOCALIZATION OF AEROELASTIC MODES IN MISTUNED HIGH-ENERGY TURBINES
CHRISTOPHE PIERRE (NASA, Lewis Research Center, Cleveland, OH; Michigan, University, Ann Arbor), TODD E. SMITH (NASA, Lewis Research Center, Cleveland; Sverdrup Technology, Inc., Brook Park, OH), and DURBHA V. MURTHY (Toledo, University, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 36 p. Previously announced in STAR as N91-24659. refs
(Contract NAG3-1163; NAG3-742; NAS3-25266)
(AIAA PAPER 91-3379) Copyright
The effects of blades mistuning on the aeroelastic vibration characteristics of high energy turbines are investigated, using the first stage of the oxidizer turbopump in the Space Shuttle Main Engine as an example. A model aeroelastic analysis procedure is used in concert with a linearized unsteady aerodynamic theory that accounts for the effects of blade thickness, camber, and steady loading. Extreme sensitivity of the dynamic characteristics of mistuned rotors is demonstrated. In particular, the aeroelastic modes become localized to a few blades, possibly leading to rogue blade failure, and the locus of the aeroelastic eigenvalues loses its structure when small mistunings (of the order present in actual rotors) are introduced. Perturbation analyses that yield physical insights into these phenomena are presented. A powerful but easily calculated stochastic sensitivity measure that allows the global prediction of mistuning effects is developed. Author

A91-44321#
UNSTEADY HOT STREAK SIMULATION THROUGH A 1-1/2 STAGE TURBINE ENGINE
R. K. TAKAHASHI and R. H. NI (Pratt and Whitney Group, East Hartford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 13 p. refs
(AIAA PAPER 91-3382) Copyright
The temperature redistribution process in a 1-1/2 stage turbine (consisting of a first stator, first rotor, and second stator) was analyzed using an unsteady 3D Euler flow solver. The study concentrated on tracking a hot streak from the inlet of the first stator to the exit of the second stator. The redistribution of the hot streak in the second stator passage was very different from that in the rotor passage, with no signs of temperature segregation in the second stator passage, and with rotor-generated vortices which persist through the second stator passage and partake in redistributing the remains of the hot streak. The unsteady code predicts different time-averaged temperatures and secondary flow in the second stator passage than in the steady multistage code, although the steady code may be sufficient for predicting time-averaged pressure loadings on both rotor and second stator airfoils, and time-averaged secondary flow vortices in the rotor passage. Author

A91-44342#
CREATING A SCENE
IAN FINLAYSON (Link-Miles, Ltd., Lansing, England) Aerospace America (ISSN 0740-722X), vol. 29, July 1991, p. 30-32.
Copyright
An overview is presented of the evolution and development of out-of-the-window visual displays used in commercial and military simulators. Early display systems projecting real images onto screens were superseded by window systems employing wide-angle collimating optics to trick the eye into believing the scene was at a distance, and, in recent years, by wide-angle visual systems that give pilots a cross-cockpit view. Color texture augments the polygon capacity of today's systems to furnish an equivalent several thousand polygons per channel and phototexture can be added for even more convincing realism. Comprehensive visibility and weather simulation is included, and cloud masses that correlate realistically with the simulated weather radar. R.E.P.

N91-25302# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
AGARD HANDBOOK ON ADVANCED CASTING
DIETMAR MIETRACH, ed. (Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen, Germany, F.R.) Mar. 1991 192 p
(AGARD-AG-299; ISBN-92-835-0455-0) Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
The need to improve aircraft performance and, simultaneously, to reduce costs has led to a re-examination of the use of casting processes in aircraft manufacture. The Structures and Materials Panel of AGARD has provided practical information about design, mechanical values, applications, quality assurance and damage tolerance. By providing the data in this form it is hoped that the designer will be encouraged to exploit the many recent advances in casting to optimum effect. Author

N91-25336# Johns Hopkins Univ., Columbia, MD. Chemical Propulsion Information Agency.
COMPUTATIONAL FLUID DYNAMICS CODE VALIDATION/CALIBRATION. JANNAF AIRBREATHING PROPULSION SUBCOMMITTEE WORKSHOP: HIGH-SPEED INLET FOREBODY INTERACTIONS
CAMILLE T. HUDSON, ed. Jan. 1991 103 p Workshop held in Reno, NV, 10-11 Jan. 1991
(Contract N00014-91-C-0001)
(CPIA-PUBL-551) Avail: NTIS HC/MF A06
A summary, viewgraphs, and a transcript of discussions of a workshop on computational fluid dynamics code validation/calibration are presented. The workshop focused on inlet/forebody interactions in high-speed ramjets.

N91-25338*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TESTS IN HELIUM ILLUSTRATE HIGH MACH NUMBER INLET-FOREBODY INTERACTIONS
JOHN WEIDNER and CARL TREXLER *In* JHU, Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Internactions p 31-48 Jan. 1991
Avail: NTIS HC/MF A06

High Mach helium tests are described in the form of the view-graphs. The following topics are included: high-speed inlet-forebody interaction tests; helium tunnel; boundary layer approaching inlet; ramp surface pressure distribution; static pressure on ramp; and pressure variation across wedge and ramp. Author

N91-25339# Sverdrup Technology, Inc., Arnold AFS, TN.
CFD CALIBRATION AND APPLICATION TO THE DESIGN OF FLOW TAILORING DEVICES FOR SIMULATING FOREBODY INFLUENCES ON FIGHTER AIRCRAFT INLET FLOWS
D. K. BEALE, J. C. ADAMS, and M. S. COLLIER (Arnold Engineering Development Center, Arnold Air Force Station, TN.) *In* JHU, Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions p 49-69 Jan. 1991
Avail: NTIS HC/MF A06

CFD calibration and application to the design of flow tailoring devices for simulating forebody influences on fighter aircraft inlet flows is presented in the form of the view-graphs. The following subject areas are covered: free-jet test concept; free-jet test cell C-2 supersonic installation; role of CFD design of forebody simulators; CFD requirements from experimentalist perspective; forebody simulator design technology development plan; CFD calibration program; validation/calibration experiments; CFD model of free-jet configuration; and free-jet CFD calibration results. Author

N91-25345*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SENSITIVITY OF INLET PERFORMANCE PREDICTIONS TO CFD NUMERICAL AND PHYSICAL MODELING
T. A. EDWARDS and S. L. LAWRENCE *In* JHU, Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactios p 179-195 Jan. 1991
Avail: NTIS HC/MF A06 CSCL 20/4

An overview is given of compressible Navier Stokes codes and up-wind solvers. Code validation efforts, inlet analysis requirements, and computational fluid dynamics modeling uncertainties are covered. Information is given in viewgraph form. Author

N91-25347# Grumman Aerospace Corp., Bethpage, NY.
COMPUTATIONAL SIMULATIONS FOR FIGHTER AND HYPERSONIC VEHICLE INLET-FOREBODY INTERACTIONS
CHARLES W. BOPPE *In* JHU, Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions p 215-241 Jan. 1991
Avail: NTIS HC/MF A06

Euler method characteristics, an F-14 fuselage geometry model and shock wave pattern predicted by Euler analysis, prediction of F-14 inlet pressure recovery levels, a fuselage induced inlet flow field comparison, avionic integration, and hypersonic vehicle inlet integration are among the topics covered. Information is given in viewgraph form. Author

N91-25348# McDonnell-Douglas Corp., Saint Louis, MO.
HIGH-SPEED FOREBODY-INLET CODE VALIDATION EXPERIENCE AT MCAIR
R. R. COSNER *In* JHU, Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions p 251-269 Jan. 1991
Avail: NTIS HC/MF A06

The objectives of the validation were to establish the capabilities of the analysis code, define the requirements to attain the best results within the capabilities, and to evaluate the analysis code for specified engineering applications. Topics covered include products of the computational fluid dynamics (CFD) validation, levels of validation, key elements of the validation study, a 2-D inlet model, 2-D inlet model flow field features, the grid density effect on pitot pressure profiles, cowl pressure time histories, inlet surface pressure, inlet surface heating rate, and inlet CFD validation testing approaches. Information is given in viewgraph form. Author

N91-25352*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AEROACOUSTIC AND AERODYNAMIC APPLICATIONS OF THE THEORY OF NONEQUILIBRIUM THERMODYNAMICS
W. CLIFTON HORNE, CHARLES A. SMITH, and KRISHNAMURTY KARAMCHETI (Florida Agricultural and Mechanical Univ., Tallahassee.) Washington Jun. 1991 26 p
(NASA-TP-3118; A-90084; NAS 1.60:3118) Avail: NTIS HC/MF A03 CSCL 20/4

Recent developments in the field of nonequilibrium thermodynamics associated with viscous flows are examined and related to developments to the understanding of specific phenomena in aerodynamics and aeroacoustics. A key element of the nonequilibrium theory is the principle of minimum entropy production rate for steady dissipative processes near equilibrium, and variational calculus is used to apply this principle to several examples of viscous flow. A review of nonequilibrium thermodynamics and its role in fluid motion are presented. Several formulations are presented of the local entropy production rate and the local energy dissipation rate, two quantities that are of central importance to the theory. These expressions and the principle of minimum entropy production rate for steady viscous flows are used to identify parallel-wall channel flow and irrotational flow as having minimally dissipative velocity distributions. Features of irrotational, steady, viscous flow near an airfoil, such as the effect of trailing-edge radius on circulation, are also found to be compatible with the minimum principle. Finally, the minimum principle is used to interpret the stability of infinitesimal and finite amplitude disturbances in an initially laminar, parallel shear flow, with results that are consistent with experiment and linearized hydrodynamic stability theory. These results suggest that a thermodynamic approach may be useful in unifying the understanding of many diverse phenomena in aerodynamics and aeroacoustics. Author

N91-25355 Old Dominion Univ., Norfolk, VA.
AN EXTENSION OF ESSENTIALLY NONOSCILLATORY SHOCK-CAPTURING SCHEMES TO MULTIDIMENSIONAL SYSTEMS OF CONSERVATION LAWS Ph.D. Thesis
JAY CASPER 1990 175 p
Avail: Univ. Microfilms Order No. DA9110250

In recent years, a class of numerical schemes for solving hyperbolic partial differential equations has been developed which generalizes the first-order method of Godunov to arbitrary order of accuracy. High-order accuracy is obtained, wherever the solution is smooth, by an essentially non-oscillatory (ENO) piecewise polynomial reconstruction procedure, which yields high-order pointwise information from the cell averages of the solution at a given point in time. When applied to piece-wise smooth initial data, this reconstruction enables a flux computation that provides a time update of the solution which is of high-order accuracy, wherever the function is smooth, and avoids a Gibbs phenomenon at discontinuities. The promising results of Harten et al., in the use of ENO schemes in solving the one-dimensional Euler equations of gas dynamics, have aroused considerable interest in the aerodynamic community. However, the application of these schemes to areas of scientific and industrial interest,' such as aircraft configuration, obviously requires compressible flow solutions in more than one spatial dimension. This extension of ENO schemes to multi-dimensional applications is presented. In particular, a two-dimensional extensional extension is proposed for the Euler equations of gas dynamics. Among the issues to be considered in this extension are the achievement of formal high-order two-dimensional spatial accuracy, the implementation of boundary conditions, and applications to general curvilinear coordinates. Dissert. Abstr.

N91-25359 Kansas Univ., Lawrence.
INCOMPRESSIBLE BOUNDARY LAYER TRANSITION FLIGHT EXPERIMENTS OVER A NONAXISYMMETRIC FUSELAGE FOREBODY AND COMPARISONS WITH LAMINAR BOUNDARY LAYER STABILITY THEORY Ph.D. Thesis
PAUL M. H. W. VIJGEN 1990 395 p
Avail: Univ. Microfilms Order No. DA9110931

Analyses of previous boundary-layer transition experiments over axisymmetric bodies indicates a potential for achieving substantial amounts of laminar flow over such shapes. Achievement of natural laminar flow over portions of nonlifting aircraft geometries, such as fuselage to forebodies, tip tanks or engine nacelles, could significantly contribute to the reduction of total aircraft viscous drag. A modern surface-panel method, a streamwise boundary-layer analysis method, and streamwise linear stability theory (E(sup n)-method) are used to correlate several previous transition measurements along axisymmetric geometries to study the transition characteristics of a nonaxisymmetric body geometry, a flight investigation was conducted to measure the transition location and analyze the mode of transition over the nonaxisymmetric forebody of an existing light twin-engine propeller-driven airplane. A summary of the inviscid flow field over the forebody of the aircraft at various body angles is presented, indicating the relatively small magnitude of inviscid crossflow along the forebody at typical cruising attitudes. The transition instrumentation installed in the airplane fuselage is described, together with relative surface-waviness measurements along the forebody. The macroscopic location of the transitional front, obtained from arrayed hot-film sensors, is presented for a matrix of flight conditions with various unit-Reynolds numbers, angles of attack and sideslip, and engine power settings. Dissert. Abstr.

N91-25362 Old Dominion Univ., Norfolk, VA.
NAVIER-STOKES SIMULATIONS OF FLOWS ABOUT COMPLEX CONFIGURATIONS USING DOMAIN DECOMPOSITION TECHNIQUES Ph.D. Thesis
KAMRAN FOULADI-SEMNANI 1990 154 p
Avail: Univ. Microfilms Order No. DA9110255

An algorithm is developed to obtain numerical simulations of flows about complex configurations composed of multiple and nonsimilar components with arbitrary geometries. The algorithm uses a hybridization of the domain decomposition techniques for grid generation and to reduce the computer memory requirement. Three dimensional, Reynolds-averaged, unsteady, compressible, and complete Navier-Stokes equations are solved on each of the subdomains by a fully-vectorized, finite-volume, upwind-biased, approximately factored, and multigrid method. The effect of Reynolds stresses is incorporated through an algebraic turbulence model with several modifications for interference flows. The present algorithm combines the advantages of an efficient, geometrically conservative, minimally and automatically dissipative algorithm with advantages and flexibility of domain decomposition techniques. The algorithm is used to simulate supersonic flows over two-dimensional profiles and a body of revolution at high angles of attack. The suitability of the baseline solution algorithm is examined to gain a better understanding of this class of flows. The grid overlapping is tested by obtaining the solution of a supersonic flow over a blunt-nose-cylinder at high angles of attack using a composite of overlapped grids. To accomplish one of the main objectives, the algorithm is then applied to simulate the supersonic flow over an ogive-nose-cylinder near and inside a cavity. The cylinder is attached to an offset L-shaped sting when placed above the cavity opening. Dissert. Abstr.

N91-25366# National Aerospace Lab., Tokyo (Japan).
OBSERVATION OF LAMINAR BOUNDARY LAYER TRANSITION ON LIGHT MONOPLANE WING SURFACE
TAKESHI OHNUKI, YUSHI TERUI, YUKIO KAMATA, and NOBUHIKO KAMIYA Sep. 1990 15 p In JAPANESE; ENGLISH summary
(NAL-TR-1077; ISSN-0389-4010) Avail: NTIS HC/MF A03

A series of flight tests were carried out to visualize the boundary layer transition on a wing of the FUJI FA-200X. The transition location was marked out by use of sublimating chemicals. The agreement between theoretical and experimental results was very good. The transition Reynolds number was about 1.3 million. The experimental procedure and the theoretical approaches are presented. Author

N91-25375# Sandia National Labs., Albuquerque, NM.
EFFECT OF THE GRID SYSTEM ON HEAT TRANSFER COMPUTATIONS FOR HIGH SPEED FLOWS
K. A. HOFFMANN, M. S. SIDDIQUI (Texas Univ., Austin.), and W. H. RUTLEDGE 1991 10 p
(Contract DE-AC04-76DP-00789)
(DE91-010874; SAND-91-0884C) Avail: NTIS HC/MF A02

Difficulties in the accurate heat transfer computation of high speed, blunt body flows have been encountered by numerous researchers. The primary reason for these difficulties has been shown to be the grid dependency of the wall flux quantities. Obviously, the accuracy of the computed heat fluxes will, to a certain extent, depend on the particular numerical scheme employed. The flux vector splitting technique is studied. An attempt was made to develop procedures which will provide guidelines for selecting appropriate grid systems and, in particular, the grid line distribution near the surface for accurate heat transfer computations. The results have clearly shown the dependency of the heat flux quantities on the grid system. In addition, it is shown that changes in flow Mach number and/or Reynolds number may require further refinement of the grid system. DOE

N91-25408# Argonne National Lab., IL.
THE POTENTIAL ROLE OF MAGLEV IN SHORT-HAUL AIRLINE OPERATIONS
L. R. JOHNSON 1991 6 p Presented at the Electro International Conference and Exhibition, New York, 16-18 Apr. 1991
(Contract W-31-109-ENG-38)
(DE91-010813; ANL/CP-72295; CONF-9104211-1) Avail: NTIS HC/MF A02

Intercity travel is predominately by commercial air transport. However, airports are becoming increasingly congested at a time when there is often substantial local opposition to the expansion of airport infrastructure because of the environmental impacts. This paper explores the potential for integrating high-speed maglev systems into the airport infrastructure, but more importantly into airline operations. DOE

N91-25411*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ACOUSTICAL ANALYSIS OF GEAR HOUSING VIBRATION
A. F. SEYBERT, T. W. WU, X. F. WU (Kentucky Univ., Lexington.), and FRED B. OSWALD Apr. 1991 10 p Presented at the American Helicopter Society Technical Specialists Meeting, Philadelphia, PA, 15-16 Oct. 1991 Original contains color illustrations
(Contract DA PROJ. 1L1-62209-A-47A)
(NASA-TM-103691; E-5910; NAS 1.15:103691; AVSCOM-TR-90-C-002) Avail: NTIS HC/MF A02; 1 functional color page CSCL 13/9

The modal and acoustical analysis of the NASA gear-noise rig is described. Experimental modal analysis techniques were used to determine the modes of vibration of the transmission housing. The resulting modal data were then used in a boundary element method (BEM) analysis to calculate the sound pressure and sound intensity on the surface of the housing as well as the radiation efficiency of each mode. The radiation efficiencies of the transmission housing modes are compared with theoretical results for finite, baffled plates. A method that uses the measured mode shapes and the BEM to predict the effect of simple structural changes on the sound radiation efficiency of the modes of vibration is also described. Author

N91-25412*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED ROTORCRAFT TRANSMISSION (ART) PROGRAM-BOEING HELICOPTERS STATUS REPORT
JOSEPH W. LENSKI, JR. (Boeing Helicopter Co., Philadelphia, PA.) and MARK J. VALCO 1991 26 p Presented at the 27th Joint Propulsion Conference, Sacramento, CA, 24-27 Jun. 1991; sponsored by AIAA, SAE, ASME, and the American Society for Electrical Engineers
(Contract DA PROJ. 1L1-62099-AH-76)
(NASA-TM-104474; E-6321; NAS 1.15:104474; AVSCOM-TR-91-C-032) Avail: NTIS HC/MF A03 CSCL 13/9

The Advanced Rotorcraft Transmission (ART) program is structured to incorporate key emerging material and component technologies into an advanced rotorcraft transmission with the intention of making significant improvements in the state of the art (SOA). Specific objectives of ART are: (1) Reduce transmission weight by 25 pct.; (2) Reduce transmission noise by 10 dB; and (3) Improve transmission life and reliability, while extending Mean Time Between Removal to 5000 hr. Boeing selected a transmission sized for the Tactical Tilt Rotor (TTR) aircraft which meets the Future Air Attack Vehicle (FAVV) requirements. Component development testing will be conducted to evaluate the high risk concepts prior to finalizing the advanced transmission configuration. The results of tradeoff studies and development test which were completed are summarized. Author

N91-25413*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MAGNETIC BEARINGS-STATE OF THE ART
DAVID P. FLEMING Jul. 1991 27 p Submitted for publication
(NASA-TM-104465; E-6309; NAS 1.15:104465) Avail: NTIS HC/MF A03 CSCL 13/11

Magnetic bearings have existed for many years, at least in theory. Earnshaw's theorem, formulated in 1842, concerns stability of magnetic suspensions, and states that not all axes of a bearing can be stable without some means of active control. In Beam's widely referenced experiments, a tiny (1/64 in diameter) rotor was rotated to the astonishing speed of 800,000 rps while it was suspended in a magnetic field. Despite a long history, magnetic bearings have only begun to see practical application since about 1980. The development that finally made magnetic bearings practical was solid state electronics, enabling power supplies and controls to be reduced in size to where they are now comparable in volume to the bearings themselves. An attempt is made to document the current (1991) state of the art of magnetic bearings. The referenced papers are large drawn from two conferences publications published in 1988 and 1990 respectively. Author

N91-25422*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
COMBINED COMPRESSIVE AND SHEAR BUCKLING ANALYSIS OF HYPERSONIC AIRCRAFT STRUCTURAL SANDWICH PANELS
WILLIAM L. KO and RAYMOND H. JACKSON Washington May 1991 38 p
(NASA-TM-4290; H-1694; NAS 1.15:4290) Avail: NTIS HC/MF A03 CSCL 20/11

The combined-load (compression and shear) buckling equations were established for orthotropic sandwich panels by using the Rayleigh-Ritz method to minimize the panel total potential energy. The resulting combined-load buckling equations were used to generate buckling interaction curves for super-plastically-formed/diffusion-bonded titanium truss-core sandwich panels and titanium honeycomb-core sandwich panels having the same specific weight. The relative combined-load buckling strengths of these two types of sandwich panels are compared with consideration of their sandwich orientations. For square and nearly square panels of both types, the combined load always induces symmetric buckling. As the panel aspect ratios increase, antisymmetric buckling will show up when the loading is shear-dominated combined loading. The square panel (either type) has the highest combined buckling strength, but the combined load buckling strength drops sharply as the panel aspect ratio increases. For square panels, the truss-core sandwich panel has higher compression-dominated combined load buckling strength. However, for shear dominated loading, the square honeycomb-core sandwich panel has higher shear-dominated combined load buckling strength. Author

N91-26412# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
OPPORTUNITIES FOR ADVANCED SPEECH PROCESSING IN MILITARY COMPUTER-BASED SYSTEMS
C. J. WEINSTEIN 11 Feb. 1991 51 p
(Contract F19628-90-C-0002)
(AD-A233724; TR-904; ESD-TR-90-133) Avail: NTIS HC/MF A04 CSCL 25/4

This report presents a study of military applications of advanced speech processing technology which includes three major elements: (1) review and assessment of current efforts in military applications of speech technology; (2) identification of opportunities for future military applications of advanced speech technology; and (3) identifications of problem areas where research in speed processing is needed to meet application requirements and of current research thrusts which appear promising. The relationship of this study to previous assessments of military applications of speech technology is discussed, and substantial recent progress is noted. Current efforts in military applications of speech technology which are highlighted include: (1) narrowband (2400 b/s) and very-low-rate (50-1200 b/s) secure voice communication; (2) voice/data integration in computer networks; (3) speech recognition in fighter aircraft, military helicopters, battle management, and air traffic control training systems; and (4) noise and interference removal for human listeners. Opportunities for advanced applications are identified by means of descriptions of several generic systems which would be possible with advances in speech technology and in system integration. GRA

N91-26431# RAND Corp., Santa Monica, CA.
THE WILD WEASEL DEVELOPMENT PROGRAMS, ONE RUN, ONE HIT, ONE ERROR
GERALD J. STILES Jul. 1990 51 p
(RAND-P-7661-RGS) Avail: NTIS HC/MF A04

Traced here are the development and upgrade programs for a specialized program, the F-4G Wild Weasel. Potential reasons why the initial development program for the aircraft succeeded, whereas the follow-on program failed, are examined. Author

N91-26432# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
DIGITAL SIGNAL CONDITIONING FOR FLIGHT TEST, VOLUME 19
G. A. BEVER (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.) Jun. 1991 92 p
(AGARD-AG-160-VOL-19; ISBN-92-835-0621-9) Copyright Avail: NTIS HC/MF A05; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Flight test instrumentation engineers are provided with an introduction to digital processes on aircraft. Flight test instrumentation systems are rapidly evolving from analog intensive to digital intensive systems, including the use of onboard digital computers. Topics include: measurements that are digital in origin, sampling, encoding, transmitting, and storing of data. Particular emphasis is placed on modern avionic data bus architectures and what to be aware of when extracting data from them. Some example data extractions are given. Tradeoffs between digital logic families, trends in digital development, and design testing techniques are discussed. An introduction to digital filtering is also covered. Author

N91-26433# Mitre Corp., McLean, VA. Civil Systems Div.
FUNCTIONAL BASELINE SPECIFICATION FOR ATC DATA LINK SERVICE IMPLEMENTATION IN THE HOST COMPUTER SYSTEM Final Report
F. BUCK, P. CRATCH, H. GABRIELI, and D. SWEENEY Jun. 1991 134 p
(Contract DTFA01-89-C-00001)
(DOT/FAA/CT-91/12; MTR-90W00164) Avail: NTIS HC/MF A07

This specification defines the requirements for implementing the initial air traffic control (ATC) data link services in the host computer system. In addition to describing how each of the initial services operate in the context of current host processing, the new controller data entries and display features associated with each of the initial data link services are defined. System supervisory and support functions are also specified. Author

N91-26466# Aeronautical Research Inst. of Sweden, Stockholm.
METHODS TO ENHANCE THE ACCURACY OF FINITE VOLUME SCHEMES 2
THILO SCHOENFELD (Centre Europeen Recherche et de Formation Advance en Calcul Scientific, Toulouse, France) and PETER WILDE 1991 32 p Sponsored in part by Swedish National Board for Technical Development, and by Defence Materiel Administration of Sweden
(FFA-147) Avail: NTIS HC/MF A03

Several compact higher order schemes to solve the three dimensional Euler equations are constructed. The methods are based on the finite volume technique with a cell-vertex space discretization. Different explicit time integration schemes of Runge-Kutte type are compared in connection with the higher order schemes. The stability behavior of the methods is analyzed and their usefulness is demonstrated by results obtained for the transonic flow around a delta wing at incidence. Author

N91-26477# Colorado Univ., Boulder.
THEORETICAL STUDIES OF THE KINEMATICS, DYNAMICS, STABILITY, AND CONTROL OF UNSTEADY/VORTICAL FLOWS Final Report, 1 Aug. 1988 - 31 Dec. 1990
CHUEN-YEN CHOW Feb. 1991 4 p
(Contract F49620-88-C-0098)
(AD-A235190; REPT-1-5-36452; AFOSR-91-0235TR) Avail: NTIS HC/MF A01 CSCL 20/4

Several unsteady vortical flows have been computed with success. A free vortex might be trapped by an oscillating airfoil for lift augmentation. Numerical simulations of streaklines have shown some pitfalls that might be encountered when interpreting photographs of unsteady vortical flows. Traveling acoustic waves are found to have the effect of either re-orienting a cluster of vortices or destabilizing the otherwise stable Karman vortex street. The onset of instability of boundary layers along semi-infinite circular cylinders is analyzed, including the effects of transverse curvature and spin motion of the cylinders. Some important mechanisms that are responsible for vorticity generation and flow separation on bodies in unsteady motion have been identified. GRA

N91-26482 Tel-Aviv Univ. (Israel). Dept. of Fluid Mechanics and Heat Transfer.
THE DELAY OF TURBULENT BOUNDARY LAYER SEPARATION BY OSCILLATORY ACTIVE CONTROL M.S. Thesis
BOAZ NISHRI Dec. 1989 110 p In HEBREW; ENGLISH summary
(ITN-91-85104) Copyright Avail: Tel-Aviv Univ., Exact Sciences Library, Ramat Aviv 69978, Israel

The aims were to develop an active method to control turbulent boundary layer separation, to study its efficiency, and to study the flow regime after its activation. In a subsonic open-ended wind tunnel, a sharp angle in a flat plate created a local discontinuity and a strong downstream positive pressure gradient, causing boundary layer separation from the plate. A vibrating flap at the discontinuity constituted the active means of separation control. A hot-wire probe was used to measure the velocity field along the length of the plate. The data were processed to obtain information on the fluid behavior, averaged over frequency and time. The similarity of the velocity profile of the upper part of the separated flow to the average velocity profile in a 2-dimensional mixing layer in which a vibrating flap increased the mixing among different velocities, led to the suggestion that, in the present case of a separated boundary layer, a vibrating flap would enhance the mixing of the energy-rich upper part of the flow with the energy-poor lower part, leading to reattachment of the flow. Reattachment occurred, characterized by 3 regions: a small region of large 2-dimensional vortices; a region in which the vortices decayed, whose location depended on vibration frequency, and in which the boundary layer was characteristic of a vibrating fluid moving against a positive pressure gradient; and a region where the decaying large vortices no longer affected the flow near the plate surface, and with a classic turbulent boundary layer. The principle conclusion was that a vibrating flap provides an effective active control means for a turbulent boundary layer, and can prevent flow separation. ISA

N91-26490*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
APPLIED HIGH-SPEED IMAGING FOR THE ICING RESEARCH PROGRAM AT NASA LEWIS RESEARCH CENTER
HOWARD SLATER, JAY OWENS (Cortez 3 Services Corp., Brook Park, OH.), and JAIWON SHIN 1991 18 p Presented at the 1991 International Symposium on Optical Applied Science and Engineering, San Diego, CA, 21-26 Jul. 1991; sponsored by the Society of Photo-Optical Instrumentation Engineers
(Contract NAS3-24816)
(NASA-TM-104415; E-6246; NAS 1.15:104415) Avail: NTIS HC/MF A03 CSCL 14/2

The Icing Research Tunnel at NASA Lewis Research Center provides scientists a scaled, controlled environment to simulate natural icing events. The closed-loop, low speed, refrigerated wind tunnel offers the experimental capability to test for icing certification requirements, analytical model validation and calibration techniques, cloud physics instrumentation refinement, advanced ice protection systems, and rotorcraft icing methodology development. The test procedures for these objectives all require a high degree of visual documentation, both in real-time data acquisition and post-test image processing. Information is provided to scientific, technical, and industrial imaging specialists as well as to research personnel about the high-speed and conventional imaging systems will be on the recent ice protection technology program. Various imaging examples for some of the tests are presented. Additional imaging examples are available from the NASA Lewis Research Center's Photographic and Printing Branch. Author

13

GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A91-42224
COMPARISON OF AIRCRAFT SYNTHETIC APERTURE RADAR AND BUOY SPECTRA DURING THE NORWEGIAN CONTINENTAL SHELF EXPERIMENT OF 1988
C. L. RUFENACH, R. A. SHUCHMAN, C. A. RUSSEL (Michigan, Environmental Research Institute, Ann Arbor), and R. B. OLSEN (MacLaren Plansearch, Ltd., Halifax, Canada) Journal of Geophysical Research (ISSN 0148-0227), vol. 96, June 15, 1991, p. 10,423-10,441. refs
(Contract N00014-81-C-0692)
Copyright

Aircraft SAR measurements from seven flight paths at two different altitudes were acquired over a trimodal ocean wave system off the coast of Norway on March 11, 1988. These three wave systems traveling in different directions were also measured by a directional buoy with the buoy spectra rotated into the radar coordinates for comparison with SAR spectra. Fifteen subspectra were averaged to obtain the measured SAR spectra, and sixteen spectral bands were averaged to obtain the measured buoy spectra. The seven flight paths in conjunction with the three wave systems resulted in a nearly uniform distribution of azimuth peak directions varying from 0 to 83 deg and R/V varying from 28 to 110. The comparison of the SAR- and buoy-derived peak wavelength and direction shows some scatter. Scanning distortion is shown to cause significant bias in the SAR and buoy comparison for slow-flying aircraft imaging ocean wave swell. Correction of the SAR spectra for this special radar-ocean condition gives significant improvement in the SAR-buoy comparison. Author

N91-25482*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
C-130 AUTOMATED DIGITAL DATA SYSTEM (CADDS)
C. P. SCOFIELD and CHIEN NGUYEN *In* NASA, Washington, 4th Airborne Geoscience Workshop p 243-244 1991
Avail: NTIS HC/MF A13 CSCL 05/2
Real time airborne data acquisition, archiving and distribution on the NASA/Ames Research Center (ARC) C-130 has been improved over the past three years due to the implementation of the C-130 Automated Digital Data System (CADDS). CADDS is a real time, multitasking, multiprocessing ROM-based system. CADDS acquires data from both avionics and environmental sensors inflight for all C-130 data lines. The system also displays the data on video monitors throughout the aircraft. Author

N91-25553*# FWG Associates, Inc., Tullahoma, TN.
GUIDE TO MEASUREMENT OF WINDS WITH INSTRUMENTED AIRCRAFT Final Report
WALTER FROST, TERRY S. PAIGE, and ANDREW E. NELIUS 25 Mar. 1991 89 p
(Contract NAS8-37893)
(NASA-CR-188601; NAS 1.26:188601) Avail: NTIS HC/MF A05 CSCL 04/2
Aircraft measurement techniques are reviewed. Review of past and present applications of instrument aircraft to atmospheric observations is presented. Questions to be answered relative to measuring mean wind profiles as contrasted to turbulence measurements are then addressed. Requirements of instrumentation and accuracy, data reduction, data acquisition, and theoretical and certainty analysis are considered. Author

N91-26151*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MEASUREMENT OF ATMOSPHERIC TURBULENCE
HAROLD N. MURROW *In* AGARD, Manual on the Flight of Flexible Aircraft in Turbulence p 1-30 May 1991
Copyright Avail: NTIS HC/MF A08; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 04/1
The material contained is primarily a compilation of information that has already been published. The attached reference list should be adequate for clarifying points to any detail desired. The purpose is to provide a description of the methodology required for measuring atmospheric turbulence in the form of true gust velocity. The content will include instrumentation requirements and selections used, flight assessments of the measurement system, some data reduction considerations, and finally some typical data obtained. Author

15

MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A91-41163
AN INTEGRATED AUTOMATIC RAMJET ENGINE CONTROL SYSTEM TOLERANT TO FAILURES OF THE FUNCTIONAL COMPONENTS [INTEGRIROVANNAIA SISTEMA AVTOMATICHESKOGO UPRAVLENIIA PVRD, USTOICHIVAIA K OTKAZAM FUNKTSIONAL'NYKH ELEMENTOV]
IU. M. GUSEV, S. A. EVDOKIMOV, and V. N. EFANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1991, p. 61-65. In Russian.
Copyright
A method is proposed for the synthesis of an automatic control system for ramjet engines that is tolerant to failures of the controllers of the hot flow-path components. The method is based on the use of functionally redundant elements in the control system, ensuring the functioning of the system under normal conditions and in the case of component failures. As an example, the method proposed here is used to synthesize a controller for a hypothetical control plant described by a transfer function matrix. V.L.

A91-41805#
EXPERT SYSTEMS FOR TRAINING PURPOSES
G. TORELLA (Accademia Aeronautica, Pozzuoli, Italy) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-2508) Copyright
An evaluation has been made of the feasibility of developing expert systems to conduct such functions as diagnostics, fault simulation, and trouble shooting for gas turbine and reciprocating engines. Attention is given to the importance of engine simulations for the construction of reliable and complete knowledge-bases, using matrices-of-influence, and to the application of such expert systems to the training of aircraft engine maintenance personnel. It is judged that substantial development efforts must be mounted before this technology reaches the level of sophistication in gas turbine diagnostics applications which is already in evidence in medical diagnostics expert systems. O.C.

A91-42703 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL TECHNOLOGY FOR FLIGHT VEHICLES; PROCEEDINGS OF THE SYMPOSIUM ON COMPUTATIONAL TECHNOLOGY ON FLIGHT VEHICLES, WASHINGTON, DC, NOV. 5-7, 1990
AHMED K. NOOR, ED. (NASA, Langley Research Center; Virginia, University, Hampton) and SAMUEL L. VENNERI, ED. (NASA, Materials and Structures Div., Washington, DC) Symposium sponsored by George Washington University, University of Virginia, and NASA. Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, 476 p. For individual items see A91-42704 to A91-42740.
Copyright
The present conference on computational methods for aeronautics applications discusses topics in the fields of parallel computing, multidisciplinary computational methods, grid generation, visualization methods for CFD, probabilistic modeling, numerical simulations and methodologies for different flow regimes, computational strategies and adaptive methods in CFD, and computational strategies and dynamics and control. Attention is given to the MACH system-software kernel, a multidisciplinary approach to aeroelastic analysis, interactive grid generation with control points, interactive flow visualization using stream surfaces,

numerical simulations of dynamic/aerodynamic interactions, implicit mathods for the Navier-Stokes equations, and the automatic phase-space analysis of dynamical systems. O.C.

A91-42709
A MULTIDISCIPLINARY APPROACH TO AEROELASTIC ANALYSIS
C. J. BORLAND (Boeing Commercial Airplanes, Seattle, WA) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 197-209. refs
Copyright
Possible approaches to the problem of aeroelastic analysis and design of aircaft are described. The relative advantages and disadvantages of integrated and interfaced systems are discussed. A multidisciplinary approach, in which various portions of an analysis are performed by specialists from various disciplines, is discussed. Recent experience in development of an Advanced Aeroelastic System employing nonlinear methods of CFD and finite element structural analysis is described. Author

A91-43079#
INTEGRATED COMPUTER SYSTEMS IN AIRCRAFT DESIGN AND MANUFACTURE DIFFICULTIES AND IMPLICATIONS
W. W. BRAITHWAITE (Boeing Commercial Airplanes, Seattle, WA) IN: Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Collection of Papers. Haifa, Israel, Technion - Israel Institute of Technology, 1990, p. 18-26.
The incorporation of computers in the design-build process of commercial aircraft is discussed. Particular attention is given to the interfacing of heterogeneous systems and the homogeneous environment. The application of a digital mockup on the 737-500 derivative program is described in detail. K.K.

A91-43926* Bell Telephone Labs., Inc., Middletown, NJ.
SYSTEMATIC METHODS FOR KNOWLEDGE ACQUISITION AND EXPERT SYSTEM DEVELOPMENT
BRENDA L. BELKIN (AT&T Bell Laboratories, Middletown, NJ) and ROBERT F. STENGEL (Princeton University, NJ) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 6, June 1991, p. 3-11. Research sponsored by U.S. Navy and FAA. refs
(Contract DAAG29-84-K-0048; NGL-31-001-252)
Copyright
Nine cooperating rule-based systems, collectively called AUTOCREW which were designed to automate functions and decisions associated with a combat aircraft's subsystems, are discussed. The organization of tasks within each system is described; performance metrics were developed to evaluate the workload of each rule base and to assess the cooperation between the rule bases. Simulation and comparative workload results for two mission scenarios are given. The scenarios are inbound surface-to-air-missile attack on the aircraft and pilot incapacitation. The methodology used to develop the AUTOCREW knowledge bases is summarized. Issues involved in designing the navigation sensor selection expert in AUTOCREW's NAVIGATOR knowledge base are discussed in detail. The performance of seven navigation systems aiding a medium-accuracy INS was investigated using Kalman filter covariance analyses. A navigation sensor management (NSM) expert system was formulated from covariance simulation data using the analysis of variance (ANOVA) method and the ID3 algorithm. ANOVA results show that statistically different position accuracies are obtained when different navaids are used, the number of navaids aiding the INS is varied, the aircraft's trajectory is varied, and the performance history is varied. The ID3 algorithm determines the NSM expert's classification rules in the form of decision trees. The performance of these decision trees was assessed on two arbitrary trajectories, and the results demonstrate that the NSM expert adapts to new situations and provides reasonable estimates of the expected hybrid performance. I.E.

A91-44266*# Tennessee Univ., Tullahoma.
NEURAL NETWORK BASED EXPERT SYSTEM FOR COMPRESSOR STALL MONITORING
CHING F. LO and G. Z. SHI (Tennessee, University, Tullahoma) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. USAF-supported research.
(Contract NAG2-596)
(AIAA PAPER 91-2500) Copyright
This research is designed to apply a new information processing technology, artificial neural networks, to monitoring compressor stall. The outputs of neural networks support the dynamic knowledge data base of an expert system. This is the open-loop mode to avoid compressor stall. The integration of a control system with neural networks is the closed-loop mode in stall avoidance. The feasibility of the concept has been demonstrated for the compressor of 16-foot transonic/supersonic propulsion wind tunnels. The construction of a prototpye expert system has been initiated. Author

N91-25122# Lockheed Aeronautical Systems Co., Thousand Oaks, CA.
THE PILOT'S ASSOCIATE: EXPLOITING THE INTELLIGENT ADVANTAGE
DOUGLAS I. HOLMES and JOHN P. RETELLE, JR. (Lockheed Missiles and Space Co., Calabasas, CA.) *In* AGARD, Knowledge Based System Applications for Guidance and Control 8 p Apr. 1991
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
The Pilot's Associate program has provided a series of technology demonstrations of the potential of integrating intelligent systems and artificial intelligence technology into modern avionics systems. The Defense Advanced Research Projects Agency and the United State Air Force have provided funding and program management to determine the potential increases in mission effectiveness from such a system. The Pilot's Associate effort pursued by Lockheed and its partners has produced not only prototypes for advanced systems, but also new insights into the nature of the systems themselves as well as new approaches for quickly producing software for these systems. The rapid prototyping methods that have been utilized have also provided the ultimate consumers (the pilots) with significant awareness of the operation of the Pilot's Associate, and with many opportunities to improve the requirements for such a system. The evolution of Lockheed's Pilot's Associate System approach leading to the current system configuration is described. Also described are some lessons learned from managing a large software development team assembled to produce an unprecedented system. Author

N91-25133# Vanderbilt Univ., Nashville, TN.
A NEURAL NETWORK FOR THE ANALYSIS OF AIRCRAFT TEST DATA
J. B. GOLDEN and B. A. WHITEHEAD (Tennessee Univ. Space Inst., Tullahoma.) *In* AGARD, Knowledge Based System Applications for Guidance and Control 13 p Apr. 1991
Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
With the advent of the USAF's Advanced Tactical Fighter and NASA's National Aerospace Plane, demands for concise test data reduction and interpretation will increase beyond the capabilities of current methodologies. As mission complexity increases it becomes apparent that real time data analysis for flight safety, mission control and test conduct becomes a necessary tool. A neural network is a biologically inspired mathematical model, which can be represented by a directed graph, that has the ability to learn through training. They are excellent for parameter estimation and pattern recognition in signal data. A prototype system is discussed which was designed and implemented to discover patterns in test data from an engine test cell in order to determine

if any part of the system is in failure. The results show that a neural net can be used for fault diagnosis in an engine test cell when the problem of fault monitoring and diagnosis is seen as one of pattern recognition. A two layer semilinear feedforward neural net is able to separate simulated sensor data into normal and abnormal classes and the addition of a hidden layer makes the network more resistant to noise and improves its network classifying ability. Author

N91-25458*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

NASA/AMES RESEARCH CENTER DC-8 DATA SYSTEM

S. C. CHERNISS (Sterling Software, Moffett Field, CA.) and C. P. SCOFIELD *In* NASA, Washington, 4th Airborne Geoscience Workshop p 127-130 1991

Avail: NTIS HC/MF A13 CSCL 09/2

In-flight facility data acquisition, distribution, and recording on the NASA Ames Research Center (ARC) DC-8 are performed by the Data Acquisition and Distribution System (DADS). Navigational and environmental data collected by the DADS are converted to engineering units and distributed real-time to investigator stations once per second. Selected engineering units data are printed and displayed on closed circuit television monitors throughout flights. An in-flight graphical display of the DC-8 flight track (with barbs indicating wind direction and magnitude) has recently been added to the DADS capabilities. Logging of data run starts/stops and commentary from the mission director are also provided. All data are recorded to hard disk in-flight and archived to tape medium post-flight. Post-flight, hard copies of the track map and mission director's log are created by the DADS. The DADS is a distributed system consisting of a data subsystem, an Avionic Serial Data-to-VMEbus (ASD2VME) subsystem, and a host subsystem. Each subsystem has a dedicated central processing unit (CPU) and is capable of stand-alone operation. All three subsystems are housed in a single 20-slot VME chassis and communicate with each other over the VMEbus. The data and host subsystems are briefly discussed, and the DC-8 DADS internal configuration and system block diagram are presented. Author

N91-25623*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

INTRODUCTION TO THE LARC CENTRAL SCIENTIFIC COMPUTING COMPLEX

JOHN N. SHOOSMITH Apr. 1991 49 p

(NASA-TM-104092; NAS 1.15:104092) Avail: NTIS HC/MF A03 CSCL 09/2

The computers and associated equipment that make up the Central Scientific Computing Complex of the Langley Research Center are briefly described. The electronic networks that provide access to the various components of the complex and a number of areas that can be used by Langley and contractors staff for special applications (scientific visualization, image processing, software engineering, and grid generation) are also described. Flight simulation facilities that use the central computers are described. Management of the complex, procedures for its use, and available services and resources are discussed. Author

N91-25642 Stanford Univ., CA.

AN IDENTIFICATION ALGORITHM BASED ON SMOOTHING Ph.D. Thesis

MOSHE IDAN 1990 128 p

Avail: Univ. Microfilms Order No. DA9108844

An identification algorithm that is based on smoothing is presented. This is an off-line time domain identification procedure that can be classified as a maximum likelihood type algorithm in the presence of process and measurement noise. Parameter identification is a nonlinear programming problem. The suggested algorithm solves this problem by dividing it into two parts, each of which has an easier solution than the general one. The experimental data are smoothed with different sets of system parameters. The smoothed data include the smoothed estimates of the states, the process noise and the Language multipliers. These data are used to compute the gradients of the identification performance measure with respect to the system parameters. The system parameters are then updated using a quasi-Newton algorithm together with a numerical rank-two procedure for estimating the inverse of the Hessian matrix. The smoothing and parameter updates are repeated until the parameters have converged and the performance measure is minimized. This identification approach was previously presented for discrete linear time invariant systems. Identification algorithms for linear and nonlinear hybrid systems, that consists of continuous state space models and discrete measurement equations, are derived and tested with real flight test data. These algorithms are also extended to identify one set of parameters from several test runs. The multi-maneuver algorithm was used to extract the stability and control derivatives of the rigid body model of the DLR BO-105 research helicopter from flight test data. Both nonlinear and linear identification algorithms were used for data consistency checks of the Black Hawk UH-60 research helicopter flight test data, using nonlinear and linearized kinematics models. Author

N91-25643 Kansas Univ., Lawrence.

AN OPTIMAL POLE PLACEMENT GAIN SCHEDULING ALGORITHM USING OUTPUT FEEDBACK Ph.D. Thesis

REINER SUIKAT 1990 177 p

Avail: Univ. Microfilms Order No. DA9110923

The development of an optimal gain scheduling method for pole placement using output feedback and the application of the method to an advanced flight control system are discussed. Conventionally a gain schedule is computed from gain matrices obtained at a number of design points using some curve fitting method. A curve fit is however unable to take the controller performance into account and hence may fail to produce acceptable results. The gain scheduling method developed in the current research solves this problem by minimizing a cost function which directly relates to the difference between the design eigenvalues and the actually achieved eigenvalues of the closed-loop system at all design points. This enables the method to place the eigenvalues more accurately than a gain schedule obtained from a curve fitting technique. Weights can be placed on all eigenvalues to improve the placement of particular poles. This output feedback pole placement gain schedule is then applied to a flight control system for an advanced research aircraft. The state vector is augmented by integrator and filter states to enhance the performance characteristics of the flight control system. Special consideration is given to the selection of design eigenvalues and eigenvectors for the additional states. Dissert. Abstr.

N91-25694 Virginia Polytechnic Inst. and State Univ., Blacksburg.

OPTIMAL CONTROL PROBLEMS WITH SWITCHING POINTS Ph.D. Thesis

HANS SEYWALD 1990 243 p

Avail: Univ. Microfilms Order No. DA9109418

An overview of the problems and difficulties that arise in solving optimal control problems with switching points is presented. A brief discussion of existing optimality conditions and a numerical approach for solving the multipoint boundary value problems associated with the first-order necessary conditions of optimal control are also presented. Two real-life aerospace optimization problems are treated explicitly. These are attitude maximization for a sounding rocket (Goddard problem) in presence of a dynamic pressure limit, and range maximization of a supersonic aircraft flying in the vertical plane, also in presence of a dynamic pressure limit. In the second problem, singular control appears along arcs with active dynamic pressure limit, which, in the context of optimal control, represents a first-order state inequality constraint. An extension of the generalized Legendre-Clebsch condition to the case of singular control along state/control constrained arcs is presented and is applied to the aircraft range maximization problem stated above. A contribution to the field of Jacobi necessary conditions is made by giving a new proof for the non-optimality of conjugate paths in the accessory minimum problem. Because of its simple and explicit character the new proof may provide the basis for an extension of Jacobi's necessary condition to the case

of trajectories with interior point constraints. Finally, the result that touch points cannot occur for first-order state inequality constraints is extended to the case of vector valued control functions.
Dissert. Abstr.

N91-25750# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Avionics and Aerospace Medical Panel.
MISSION PLANNING SYSTEMS FOR TACTICAL AIRCRAFT (PRE-FLIGHT AND IN-FLIGHT)
May 1991 51 p Original contains color illustrations
(AGARD-AR-296; ISBN-92-835-0615-4) Copyright Avail: NTIS HC/MF A04; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The concept of planning a mission for a military aircraft is probably as old and well established as that of the military aircraft itself, but until recently the methodology and technology associated with mission planning had received only limited attention from scientists and engineers. The last few years have, however, seen a marked increase in the attention given to mission planning both by the users, who are demanding improved facilities, and by the suppliers, who are able to provide increasingly more capable systems. As a result, the air forces of many of the NATO countries are procuring new and advanced mission planning systems that have capabilities far in advance of those previously available.
Author

N91-25937*# Kansas Coll. of Technology, Salina. Dept. of Computer Science.
DETECTION AND AVOIDANCE OF ERRORS IN COMPUTER SOFTWARE
LES KINSLER *In* Maryland Univ., The 1989 NASA-ASEE Summer Faculty Fellowship Program in Aeronautics and Research p 35 Sep. 1989
Avail: NTIS HC/MF A04 CSCL 09/2

The acceptance test errors of a computer software project to determine if the errors could be detected or avoided in earlier phases of development. GROAGSS (Gamma Ray Observatory Attitude Ground Support System) was selected as the software project to be examined. The development of the software followed the standard Flight Dynamics Software Development methods. GROAGSS was developed between August 1985 and April 1989. The project is approximately 250,000 lines of code of which approximately 43,000 lines are reused from previous projects. GROAGSS had a total of 1715 Change Report Forms (CRFs) submitted during the entire development and testing. These changes contained 936 errors. Of these 936 errors, 374 were found during the acceptance testing. These acceptance test errors were first categorized into methods of avoidance including: more clearly written requirements; detail review; code reading; structural unit testing; and functional system integration testing. The errors were later broken down in terms of effort to detect and correct, class of error, and probability that the prescribed detection method would be successful. These determinations were based on Software Engineering Laboratory (SEL) documents and interviews with the project programmers. A summary of the results of the categorizations is presented. The number of programming errors at the beginning of acceptance testing can be significantly reduced. The results of the existing development methodology are examined for ways of improvements. A basis is provided for the definition is a new development/testing paradigm. Monitoring of the new scheme will objectively determine its effectiveness on avoiding and detecting errors.
Author

N91-26797*# Boeing Military Airplane Development, Seattle, WA.
STRUCTURED REPRESENTATION FOR REQUIREMENTS AND SPECIFICATIONS
GERALD C. COHEN, GENE FISHER, DEBORAH FRINCKE, and DAVE WOLBER (California Univ., Davis.) 18 Jul. 1991 93 p
(Contract NAS1-18586)
(NASA-CR-187522; NAS 1.26:187522) Avail: NTIS HC/MF A05 CSCL 09/2

This document was generated in support of NASA contract NAS1-18586, Design and Validation of Digital Flight Control Systems suitable for Fly-By-Wire Applications, Task Assignment 2. Task 2 is associated with a formal representation of requirements and specifications. In particular, this document contains results associated with the development of a Wide-Spectrum Requirements Specification Language (WSRSL) that can be used to express system requirements and specifications in both stylized and formal forms. Included with this development are prototype tools to support the specification language. In addition a preliminary requirements specification methodology based on the WSRSL has been developed. Lastly, the methodology has been applied to an Advanced Subsonic Civil Transport Flight Control System.
Author

16

PHYSICS

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

A91-41540
THE DESIGN AND COMMISSIONING OF AN ACOUSTIC LINER FOR PROPELLER NOISE TESTING IN THE ARA TRANSONIC WIND TUNNEL
M. E. WOOD (Aircraft Research Association, Ltd., Bedford, England) and D. A. NEWMAN (Rolls-Royce, PLC, Derby, England) Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100), vol. 204, no. G2, 1990, p. 135-145. Research supported by Department of Trade and Industry of England, British Aerospace, PLC, and Dowty Aerospace. refs
Copyright

An acoustic liner has been designed and manufactured for use in the ARA transonic wind tunnel to provide an acoustically acceptable environment for propeller noise testing up to high subsonic Mach number. Details of the aerodynamic design and development are presented and calibration of the liner with propeller model support systems is included. It is shown how the design of the acoustic treatment was aided by the use of a theoretical model for the tunnel reverberant field. An acoustic development program was undertaken involving horn tests to improve the quality of the liner. The success of this is demonstrated by propeller noise results. These results also provided the basis for definition of the practical acoustic test regime of the ARA lined tunnel suitable for the accurate measurement of propeller noise.
Author

A91-41708#
RE-ENGINING - THE SOUND CASE FOR AIRCRAFT NOISE REDUCTION
K. GODDARD (Rolls-Royce, PLC., Derby, England) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 8 p.
(AIAA PAPER 91-2144) Copyright

The paper reviews the history of legislation to reduce jet-powered aircraft noise, particularly in the U.S.A. Recently introduced legislation is discussed and the paper goes on to explain the fundamental advantage of re-engining as a means of reducing aircraft noise. Th Rolls-Royce Tay engine is introduced and the two re-engine programs already launched are described. The expected large reductions in noise level which result from re-engining are illustrated. The paper concludes with a discussion on new programs, on the current airline business scene and on some aspects of the economics of re-engining.
Author

A91-42999#
ON THE ACOUSTICAL PERFORMANCES OF NOISE SUPPRESSORS WITH DEPRESSIVE NETWORKS FOR JET ENGINES TEST RIGS AND SUPERSONIC WIND TUNNEL FACILITIES
C. TEODORESCU-TINTEA Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 35, Sept.-Dec. 1990, p. 439-507. refs
The main features of noise suppressors with Teodorescu-Coanda networks designed for jet-engine test rings and supersonic wind tunnels are described. The high efficiency of these noise suppressors within the whole audible-spectrum range has been demonstrated on the basis of a large volume of acoustic measurements. L.M.

A91-43169
NONLINEAR OSCILLATIONS OF A HEAVY AXISYMMETRIC BODY IN A RESISTANT MEDIUM WITH DRAG [NELINEINYE KOLEBANIIA TIAZHELOGO OSESIMMETRICHNOGO TELA V SOPROTIVLIAIUSHCHEISIA SREDE]
M. I. LOSITSKAIA Moskovskii Universitet, Vestnik, Seriia 1 - Matematika, Mekhanika (ISSN 0579-9368), Mar.-Apr. 1991, p. 46-49. In Russian. refs
Copyright
An analysis is made of the free motion of a heavy axisymmetric body experiencing the quasi-static effect of the medium. The stability of vertical descent with a vertically oriented axis of symmetry is investigated in the case when the parameter values are equal to or almost equal to the critical ones. The results are of interest in connection with the study of parachute descent. L.M.

A91-43503#
PREDICTION OF HELICOPTER ROTOR ROTATIONAL NOISE
GUOHUA XU and ZHENG GAO (Nanjing Aeronautical Institute, People's Republic of China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956), vol. 23, June 1991, p. 20-26. In Chinese, with abstract in English. refs
Based on Farassat (1981) formulation 1A for subsonic time domain, a method is developed for predicting the rotor rotational noise, which is valid for arbitrary observer positions and all linear flight conditions. Without considering the elasticity of the blade, the retarded time equation and all of the integrands in the formulation 1A are derived and expressed as the proper form for numerical calculation. As examples, the noise calculation of the helicopter Z-8 rotor and 1/4 scale UH-1 rotor in hover are carried out. Discussions are presented on the influence of rotor parameters, such as the tip Mach number, the disk loading, and the blade airfoil. Author

A91-43514
ON THE ESTIMATION OF SOUND PRODUCED BY COMPLEX FLUID-STRUCTURE INTERACTIONS, WITH APPLICATION TO A VORTEX INTERACTING WITH A SHROUDED ROTOR
M. S. HOWE (BBN Laboratories, Inc., Cambridge, MA) Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0080-4630), vol. 433, no. 1889, June 8, 1991, p. 573-598. refs
(Contract N00167-87-C-0021)
Copyright
An analytical method is presented which allows the estimation of the sound produced by certain fluid-structure interactions in flows with small Mach numbers. Dipoles characterized by strengths that are dependent on unsteady surface forces are the primary acoustic sources, and fluid velocity, vorticity, and harmonic functions based on surface shapes are employed to describe the dipoles. The surface forces are considered to be important sources of sound even when their interaction with the structure is indirect. A model illustrates the interaction of a shrouded rotor in a duct with a vortex, in which high-frequency sound is created when the vortex is pulled into the rotor disk and affected by the blades. Indirect blade-vortex interactions are found to introduce relatively low-frequency sound. C.C.S.

A91-43560*# Grumman Aerospace Corp., Bethpage, NY.
CFD PREDICTION OF THE NEAR-FIELD SONIC BOOM ENVIRONMENT FOR TWO LOW BOOM HSCT CONFIGURATIONS
M. J. SICLARI (Grumman Corporate Research Center, Bethpage, NY) and C. M. DARDEN (NASA, Langley Research Center, Hampton, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 19 p. refs
(AIAA PAPER 91-1631) Copyright
Current efforts to reduce the sonic boom of a future High Speed Civil Transport (HSCT) by careful shaping have led to the need for more accurate predictions of the near-field flow conditions of the configuration. A fully three-dimensional Euler finite volume code is used to predict sonic boom pressure signatures for two low boom concepts - one designed to cruise at Mach 2 and the other at Mach 3. Calculations were carried out using a grid topology that has been modified to reduce the inaccuracies caused by grid spreading often suffered with CFD methods when calculations several body lengths downstream become necessary. Comparisons of CFD results and experimental wind tunnel signatures are shown. Ground signatures are predicted by extrapolating the pressures predicted by the Euler code with an extrapolation method based on the Whitham theory. Author

A91-44174# AeroChem Research Labs., Inc., Princeton, NJ.
THREE-DIMENSIONAL JET NOISE COMPUTATIONS
C. BERMAN, G. GORDON (AeroChem Research Laboratories, Inc., Princeton, NJ), G. KARNIADAKIS, and S. ORSZAG (Princeton University, NJ) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 17 p. refs
(Contract NAS3-25829; NAS1-18849)
(AIAA PAPER 91-2256) Copyright
Jet exhaust turbulence noise is computed using a time-dependent solution of the three-dimensional Navier-Stokes equations to supply the source terms for an acoustic computation based on the Phillips equation. The goal of applying these techniques to designing complex three-dimensional noise suppression nozzles of interest for the high speed civil transport may be impractical due to excessive computation time. For this reason a time-averaged flow and frequency domain acoustic analysis is discussed since it would greatly decrease the time required to obtain results. Author

N91-25815# National Aerospace Lab., Tokyo (Japan).
THE REDUCTION OF CAVITY NOISE AT SUBSONIC SPEEDS
KATSUMI TAKEDA, HIDEO NISHIWAKI, and SHOUICHI FUJII Sep. 1990 11 p In JAPANESE; ENGLISH summary
(NAL-TR-1081) Avail: NTIS HC/MF A03
It is generally recognized that airframe noise becomes a significant contributor to overall aircraft noise under landing conditions. Airframe noise is considered to be the sound radiated aerodynamically as a result of complex interplay between local flows and configurations that intrude or are recessed or deployed over the lifting surfaces and fuselage. The scale model acoustic testing of landing gears revealed that the cavity noise was predominant in sound sources of landing device. A study performed to determine the sound generation mechanism and to reduce the sound level of the cavity noise is presented. It is observed that an array of fins attached on the leading edge of the cavity offered a reduction of 7 to 8 dB in the sound pressure levels. Author

N91-26878# Florida State Univ., Tallahassee. Dept. of Mathematics.
COMPUTATION OF BROADBAND MIXING NOISE FROM TURBOMACHINERY Semiannual Progress Report, 1 Sep. 1990 - 28 Feb. 1991
CHRISTOPHER TAM 28 Feb. 1991 3 p
(Contract N00014-89-J-1836)
(AD-A233991) Avail: NTIS HC/MF A01 CSCL 20/1
This work focuses on the phenomena of dispersion and spurious

acoustic radiation in calculating propeller noise using the finite difference method. The same phenomena will also affect computational solutions of turbomachinery noise problems. GRA

N91-26889*# Duke Univ., Durham, NC. Dept. of Mechanical Engineering and Materials Science.
AIRCRAFT INTERIOR NOISE REDUCTION BY ALTERNATE RESONANCE TUNING Final Progress Report, period ending Dec. 1990
JAMES A. GOTTWALD and DONALD B. BLISS Dec. 1990 215 p
(Contract NAG1-722)
(NASA-CR-185453; NAS 1.26:185453) Avail: NTIS HC/MF A10 CSCL 20/1

The focus is on a noise control method which considers aircraft fuselages lined with panels alternately tuned to frequencies above and below the frequency that must be attenuated. An interior noise reduction called alternate resonance tuning (ART) is described both theoretically and experimentally. Problems dealing with tuning single paneled wall structures for optimum noise reduction using the ART methodology are presented, and three theoretical problems are analyzed. The first analysis is a three dimensional, full acoustic solution for tuning a panel wall composed of repeating sections with four different panel tunings within that section, where the panels are modeled as idealized spring-mass-damper systems. The second analysis is a two dimensional, full acoustic solution for a panel geometry influenced by the effect of a propagating external pressure field such as that which might be associated with propeller passage by a fuselage. To reduce the analysis complexity, idealized spring-mass-damper panels are again employed. The final theoretical analysis presents the general four panel problem with real panel sections, where the effect of higher structural modes is discussed. Results from an experimental program highlight real applications of the ART concept and show the effectiveness of the tuning on real structures. Author

17

SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A91-41548
REFLECTIONS ON THE SPACEPLANE
PIERRE BETIN (SEP, Suresnes, France) Space Policy (ISSN 0265-9646), vol. 7, May 1991, p. 137-145. Translation.
Copyright

The possible military and economic uses of a partially hypersonic spaceplane are examined and the technical challenges involved are discussed. Current efforts in various countries are described, and it is argued both that research into hypersonic flight is vital for the future and that France is not yet doing enough. Consideration is given to the spaceplane - a vehicle that would be free from the determinism of the quasi-ballistic trajectories of present-day rockets, and therefore capable of being independent of launch windows and equatorial launch sites. The history of hypersonics is traced, and the technology that must be mastered to make the spaceplane a reality is described. Specific efforts by countries in this field are examined, with emphasis on the U.S. and France. P.D.

N91-26995# Aeronautical Systems Div., Wright-Patterson AFB, OH.
RESULTS OF THE AERONAUTICAL SYSTEMS DIVISION CRITICAL PROCESS TEAM ON INTEGRATED PRODUCT DEVELOPMENT Final Report
LAVERN J. MENKER Nov. 1990 49 p
(AD-A235419; ASD-TR-90-5014) Avail: NTIS HC/MF A03 CSCL 12/6

This report provides a vision of the Integrated Product Development (IPD) Process as it could be implemented within the Aeronautical Systems Division (ASD). It captures the results of the ASD Critical Process Team on IPD and recent efforts to refine guidance for its implementation. The primary purpose of this document is to provide a conceptual framework to provoke dialogue that will lead to incremental improvements in the acquisition process. IPD is an efficient process of bringing a product from user's needs to field operation. The basic principle is to iterate and integrate the design of a product and the design of its manufacturing, operation, support and training processes with specific focus on achieving low-cost development, production, operations and support within the shortest schedule while achieving robust quality of products and services. GRA

N91-27046# Committee on Science, Space and Technology (U.S. House).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION MULTIYEAR AUTHORIZATION ACT OF 1991
GEORGE E. BROWN, JR., RALPH M. HALL, TOM LEWIS, F. JAMES SENSENBRENNER, JR., and TIM VALENTINE Washington GPO 23 Apr. 1991 22 p A bill on H.R. 1988 referred to the Committee on Science, Space and Technology, 102d Congress, 1st Session, 23 Apr. 1991
Avail: Document Room, House of Representatives, Washington, DC 20515 HC free

Presented here is the text for a bill to authorize appropriations to the National Aeronautics and Space Administration (NASA) for research and development, space flight, control, data communications, construction of facilities, research and program management, and the Inspector General, as well as for other purposes. Author

19

GENERAL

A91-41541
THE ORIGINS AND EVOLUTION OF DESIGN REQUIREMENTS FOR BRITISH MILITARY AIRCRAFT
K. J. MEEKCOMS (Ministry of Defence, London, England) Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100), vol. 204, no. G2, 1990, p. 147-155.
Copyright

This paper traces the origins and evolution of design requirements for British military aircraft over a period of 80 years, recording significant developments, changes and some personalities during that time. The publication of this paper also marks the fiftieth anniversary of the UK military Joint Airworthiness Committee. Author

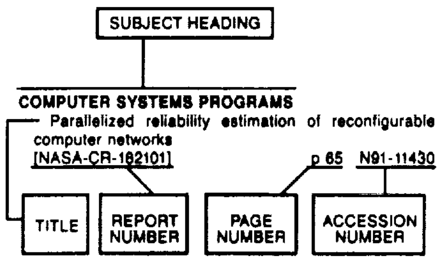
A91-43076
ISRAEL ANNUAL CONFERENCE ON AVIATION AND ASTRONAUTICS, 31ST, TEL AVIV, ISRAEL, FEB. 21, 22, 1990, COLLECTION OF PAPERS AND SUPPLEMENT
Conference supported by Technion - Israel Institute of Technology, Tel Aviv University, Ministry of Defence of Israel, et al. Haifa, Israel, Technion - Israel Institute of Technology, 1990, p. Collection of Papers, 237 p.; Supplement, 34 p. For individual items see A91-43077 to A91-43097, A91-43099 to A91-43104.

The conference presents papers on the automatic design of transonic airfoils to reduce the shock induced pressure drag, a simulation model of a single rotor helicopter, singularity avoidance for SCARA-type robots, and FCS skewed sensors array. Other topics include the study of a spherical spinning combustion chamber for orbit insertion, the effect of inlet geometry on the flow and combustion processes in a solid fuel ramjet, and the design and testing of an optimal beam composed of unimodal elements. Consideration is also given to the use of high lift-to-drag hypersonic vehicles for aero-assisted orbit maneuvering. K.K.

N91-26112*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LANGLEY AEROSPACE TEST HIGHLIGHTS, 1990
May 1991 184 p
(NASA-TM-104090; NAS 1.15:104090) Avail: NTIS HC/MF A09
CSCL 05/2

The role of NASA-Langley is to perform basic and applied research necessary for the advancement of aeronautics and spaceflight, to generate new and advanced concepts for the accomplishment of related national goals, and to provide research advice, technological support, and assistance to other NASA installations, other government agencies, and industry. Some of the significant tests are highlighted which were performed during 1990 in the NASA-Langley test facilities, a number of which are unique in the world. Both the broad range of the research and technology activities at NASA-Langley and the contributions of this work toward maintaining U.S. leadership in aeronautics and space research are illustrated. Other highlights of Langley research and technology for 1990 are described in Research and Technology 1990 Langley Research Center. Author

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of document content, a title extension is added, separated from the title by three hyphens. The accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence.

A

ABLATION
Size dependence of gaseous cluster reactivity and evaporation dynamics as a mechanistic probe
[AD-A233811] p 766 N91-26249
ACTIVE CONTROL
Improved reduction of gust loads data for gust intensity p 758 N91-26153
The delay of turbulent boundary layer separation by oscillatory active control
[ITN-91-85104] p 779 N91-26482
ACTUATORS
Design optimization of an electronic fuel control unit featuring two digital actuators
[AIAA PAPER 91-2003] p 745 A91-41672
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
ADAPTIVE CONTROL
Development of an adaptive failure detection and identification system for detecting aircraft control element failures
[NASA-TP-3051] p 758 N91-25151
ADVECTION
Upwind implicit residual smoothing method for multi-stage schemes
[AIAA PAPER 91-1533] p 696 A91-40708
AEROACOUSTICS
The design and commissioning of an acoustic liner for propeller noise testing in the ARA transonic wind tunnel p 783 A91-41540
A study of aeroacoustic performance of a contra-rotating axial flow compressor stage p 706 A91-42248
Three-dimensional jet noise computations
[AIAA PAPER 91-2256] p 784 A91-44174
Aeroacoustic and aerodynamic applications of the theory of nonequilibrium thermodynamics
[NASA-TP-3118] p 776 N91-25352
AEROBRAKING
Trim angle measurements in free-flight facilities
[AIAA PAPER 91-1632] p 719 A91-43561
AERODYNAMIC CHARACTERISTICS
The effect of artificial vorticity on the discrete solution of Euler equations
[AIAA PAPER 91-1553] p 698 A91-40727
An investigation of a hovering rotor in ground effect p 704 A91-41462
Aerodynamic losses due to pressure side coolant ejection in a transonic turbine cascade
[AIAA PAPER 91-2032] p 745 A91-41684
Reduction of the RCS of the leading edge of a conducting wing-shaped structure by means of lossless dielectric material p 770 A91-42241
Super/hypersonic aerodynamic characteristics for a transatmospheric vehicle concept having a minimum drag forebody
[AIAA PAPER 91-1694] p 709 A91-42558
Some characteristics of and dynamic scaling behavior in strong vortex flows
[AIAA PAPER 91-1821] p 713 A91-42609
Enhancements to the high speed convective heating and viscous drag prediction techniques of the Aerodynamic Preliminary Analysis System (APAS)
[AIAA PAPER 91-1435] p 717 A91-43494
An approach to aerodynamic characteristics of low radar cross-section fuselages p 718 A91-43501
An approximate computation method to compute low-speed aerodynamic characteristics of wing with separation p 718 A91-43510
Aerodynamic characteristics of Mach-3 air-intake tested in supersonic wind tunnel
[AIAA PAPER 91-2011] p 727 A91-44091
Low-speed, powered ground effects of a generic, hypersonic configuration
[NASA-TP-3092] p 730 N91-25103
Dynamic analysis of advanced tip rotors including three-dimensional aerodynamics p 731 N91-25111
A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116
Aeroacoustic and aerodynamic applications of the theory of nonequilibrium thermodynamics
[NASA-TP-3118] p 776 N91-25352
Performance optimization of helicopter rotor blades
[NASA-TM-104054] p 741 N91-26137
Size dependence of gaseous cluster reactivity and evaporation dynamics as a mechanistic probe
[AD-A233811] p 766 N91-26249
An experimental investigation of structure, mixing, and combustion in compressible turbulent shear layers
[AD-A235278] p 766 N91-26281
AERODYNAMIC COEFFICIENTS
Trim angle measurements in free-flight facilities
[AIAA PAPER 91-1632] p 719 A91-43561
A drag analysis of the early stages of large-scale high-altitude free balloon ascents p 731 N91-25108
AERODYNAMIC CONFIGURATIONS
Aerodynamic shape optimization using sensitivity analysis on third-order Euler equations
[AIAA PAPER 91-1577] p 699 A91-40751
Computer-aided block-structuring through the use of optimization and expert system techniques
[AIAA PAPER 91-1585] p 700 A91-40759
A three-dimensional Navier-Stokes/full-potential coupled analysis for viscous transonic flow
[AIAA PAPER 91-1595] p 701 A91-40769
Pareto-optimal shapes of axisymmetric bodies moving at high supersonic velocities p 707 A91-42330
Transonic flutter analysis of aerodynamic surfaces in the presence of structural nonlinearities p 713 A91-42710
Computational aerodynamics methodology for the Aerospace Plane p 714 A91-42728
A general method for practical conformal mapping of aerodynamic shapes p 715 A91-42902
Euler solver for arbitrary configurations - Further applications p 716 A91-43100
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies p 771 A91-43310
Enhancements to the high speed convective heating and viscous drag prediction techniques of the Aerodynamic Preliminary Analysis System (APAS)
[AIAA PAPER 91-1435] p 717 A91-43494
Block-structured computation of three-dimensional transonic Euler equations
[AIAA PAPER 91-1679] p 721 A91-43588
A comparison of the analytical and experimental performance of the solid version of a cooled radial rotor
[AIAA PAPER 91-2133] p 752 A91-44133
Wind tunnel results of counter rotation prop-fans designed with lifting line and Euler code methods
[AIAA PAPER 91-2499] p 755 A91-44265
The impact of LO-configured forebodies on inlet approach flowfields
[AIAA PAPER 91-2599] p 730 A91-44304
AERODYNAMIC DRAG
Super/hypersonic aerodynamic characteristics for a transatmospheric vehicle concept having a minimum drag forebody
[AIAA PAPER 91-1694] p 709 A91-42558
Enhancements to the high speed convective heating and viscous drag prediction techniques of the Aerodynamic Preliminary Analysis System (APAS)
[AIAA PAPER 91-1435] p 717 A91-43494
A drag analysis of the early stages of large-scale high-altitude free balloon ascents p 731 N91-25108
Incompressible boundary layer transition flight experiments over a nonaxisymmetric fuselage forebody and comparisons with laminar boundary layer stability theory p 777 N91-25359
Viscous flow simulations of internal store carriage and separation
[NASA-CR-185343] p 732 N91-26123
AERODYNAMIC FORCES
Areas for future CFD development as illustrated by transport aircraft applications
[AIAA PAPER 91-1527] p 696 A91-40703
Stabilization of the sling load of a helicopter p 756 A91-41169
Post-critical behaviour of a uniform cantilever column subjected to a tip concentrated subtangential follower force with small damping p 768 A91-41584
Viscous flow simulations of internal store carriage and separation
[NASA-CR-185343] p 732 N91-26123
AERODYNAMIC HEAT TRANSFER
Limiting thermal loads in porous structures p 768 A91-41159
Pareto-optimal shapes of axisymmetric bodies moving at high supersonic velocities p 707 A91-42330
Numerical performance estimates for a generic hypersonic forebody
[AIAA PAPER 91-1695] p 722 A91-43595
AERODYNAMIC HEATING
Surface heat transfer change induced by unsteady shock reflections and numerical simulations on shock reflection p 695 A91-40647
Supersonic film cooling effectiveness using air and helium for a range of injectant temperatures and Mach numbers
[AIAA PAPER 91-1416] p 772 A91-43477
Effect of the grid system on heat transfer computations for high speed flows
[DE91-010874] p 777 N91-25375
AERODYNAMIC INTERFERENCE
Asymptotic methods for the prediction of transonic wind tunnel wall interference
[AIAA PAPER 91-1712] p 762 A91-44334
Navier-Stokes simulations of flows about complex configurations using domain decomposition techniques p 777 N91-25362
Viscous flow simulations of internal store carriage and separation
[NASA-CR-185343] p 732 N91-26123

AERODYNAMIC LOADS
Areas for future CFD development as illustrated by transport aircraft applications
[AIAA PAPER 91-1527] p 696 A91-40703
The level of self-oscillations of aerodynamic control surfaces under nonseparating transonic gas flow
p 703 A91-41218
Flutter control of incompressible flow turbomachine blade rows by splitter blades
[AIAA PAPER 91-1900] p 704 A91-41645
Periodic blade loads of a high speed propeller at small angle of attack
[AIAA PAPER 91-2250] p 705 A91-41735
Prediction of unsteady aerodynamic loads in cascades using the linearized Euler equations on deforming grids
[AIAA PAPER 91-3378] p 730 A91-44318
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
Manual on the flight of flexible aircraft in turbulence
[AGARD-AG-317] p 758 N91-26150

AERODYNAMIC NOISE
On the estimation of sound produced by complex fluid-structure interactions, with application to a vortex interacting with a shrouded rotor p 784 A91-43514
The reduction of cavity noise at subsonic speeds
[NAL-TR-1081] p 784 N91-25815

AERODYNAMIC STABILITY
Stabilization of the sling load of a helicopter
p 756 A91-41169
Dynamics of elastic bending and torsion of hingeless rotors with dynamic stall
[AD-A234775] p 741 N91-26134

AERODYNAMIC STALLING
Dynamic stall experiments on a swept three-dimensional wing in compressible flow
[AIAA PAPER 91-1795] p 712 A91-42595
Laser velocimetry measurements of oscillating airfoil dynamic stall flow field
[AIAA PAPER 91-1799] p 725 A91-43648
Dynamics of elastic bending and torsion of hingeless rotors with dynamic stall
[AD-A234775] p 741 N91-26134

AERODYNAMICS
A comparison of implicit multigrid Euler solvers implemented on a multiprocessor computer
[AIAA PAPER 91-1580] p 700 A91-40754
Adaptive EAGLE - Solution-adaptive and quality-enhancing multi-block grids for arbitrary domains
[AIAA PAPER 91-1593] p 701 A91-40767
Development of a new flux splitting scheme
p 768 A91-40793
Measured thrust losses associated with secondary air injection through nozzle walls
[AIAA PAPER 91-2244] p 705 A91-41734
Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990 p 780 A91-42703
Recent advances in hypersonic technology
p 716 A91-43103
A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114
Technical evaluation report on the flight mechanics panel symposium on progress in military airlift
[AGARD-AR-300] p 733 N91-25119
Handling qualities of unstable highly augmented aircraft
[AGARD-AR-279] p 740 N91-25146
Detection and avoidance of errors in computer software p 783 N91-25937
Calculated aerodynamics of wings in severe maneuver
[AD-A235241] p 732 N91-26120
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124

AEROELASTICITY
Determination of the stress-strain state of a soft lifting system --- Single-Shell Parachute Airfoil
p 704 A91-41320
Conclusions from high-speed rotorcraft studies
[AIAA PAPER 91-2149] p 693 A91-41711
An expert system for predicting flutter in turbomachines
[AIAA PAPER 91-2527] p 748 A91-41808
A multidisciplinary approach to aeroelastic analysis
p 781 A91-42709
Static aeroelastic analysis of a three-dimensional oblique wing p 714 A91-42711
Influence of thickness and camber on the aeroelastic stability of supersonic throughflow fans
p 715 A91-42814
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319
Estimation of the aeroelastic characteristics from flight test data of the STOL research aircraft ASKA
[NAL-TR-1083] p 740 N91-25145
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113
State space models for aeroelastic and viscoelastic systems
[AD-A234730] p 732 N91-26117

AERONAUTICAL ENGINEERING
Results of the aeronautical systems division critical process team on integrated product development
[AD-A235419] p 785 N91-26995

AERONAUTICS
Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Collection of Papers and Supplement p 785 A91-43076
Langley aerospace test highlights, 1990
[NASA-TM-104090] p 786 N91-26112

AEROSPACE INDUSTRY
Structural mechanics research in the DLR
p 771 A91-43334

AEROSPACE PLANES
Reflections on the spaceplane p 785 A91-41548
Computational aerodynamics methodology for the Aerospace Plane p 714 A91-42728
Rapid methodology for design and performance prediction of integrated supersonic combustion ramjet engine p 739 A91-42818
Numerical simulation of hypersonic viscous flow for the design of H-II orbiting plane (HOPE). II
[AIAA PAPER 91-1390] p 717 A91-43453

AEROSPACE SYSTEMS
State space models for aeroelastic and viscoelastic systems
[AD-A234730] p 732 N91-26117
Results of the aeronautical systems division critical process team on integrated product development
[AD-A235419] p 785 N91-26995

AEROSPACE VEHICLES
Surface reconstruction from scattered data through pruning of unstructured grids
[AIAA PAPER 91-1584] p 700 A91-40758
Structured and unstructured remeshing method for high-speed flows p 713 A91-42630

AEROTHERMOCHEMISTRY
Recent advances in hypersonic technology
p 716 A91-43103

AEROTHERMODYNAMICS
Mach 6 turbulent boundary layer characteristics on smooth and rough surfaces
[AIAA PAPER 91-1762] p 711 A91-42580
Thermostructural concepts for hypervelocity vehicles
p 764 A91-43311
Viscous equilibrium computations using program LAURA
[AIAA PAPER 91-1389] p 717 A91-43452
Aerothermal test methodology for the development of structural components for hypersonic vehicles
[AIAA PAPER 91-1441] p 764 A91-43498

AFTERBODIES
Computational and experimental aftbody flow fields for hypersonic, airbreathing configurations with scramjet exhaust flow simulation
[AIAA PAPER 91-1709] p 709 A91-42561
Turbulent flow predictions for afterbody/nozzle geometries including base effects p 715 A91-42813
A study on the stiffness simulation calculation method of flutter models of after body and horizontal tail of a new type aeroplane p 739 A91-43511

AIR
Refurbishing AV-8 on-board oxygen generation system beds
[AD-A235083] p 741 N91-26136

AIR BREATHING ENGINES
HOTOL space transport for the twenty-first century
p 763 A91-41537
Feedback linearization for control of air breathing engines
[AIAA PAPER 91-2000] p 745 A91-41671
Development of a vitiated air heater for engine test facilities
[AIAA PAPER 91-2501] p 761 A91-41802
Supersonic inlet flow computations using fortified Navier-Stokes approach
[AIAA PAPER 91-1730] p 710 A91-42567
Experimental investigation of a unique airbreathing pulsed laser propulsion concept
[AIAA PAPER 91-1922] p 751 A91-44059
Aerodynamic characteristics of Mach-3 air-intake tested in supersonic wind tunnel
[AIAA PAPER 91-2011] p 727 A91-44091
Supersonic air-intake study aiming at future airbreathing engine
[AIAA PAPER 91-2012] p 751 A91-44092

AIR DATA SYSTEMS
In-flight measurement of static pressures and boundary-layer state with integrated sensors
p 742 A91-43306

AIR DEFENSE
Integrated control and avionics for air superiority: A knowledge-based decision aiding system
p 743 N91-25138

AIR INTAKES
Improved methods of characterizing ejector pumping performance p 749 A91-42815
Aerodynamic characteristics of Mach-3 air-intake tested in supersonic wind tunnel
[AIAA PAPER 91-2011] p 727 A91-44091
Supersonic air-intake study aiming at future airbreathing engine
[AIAA PAPER 91-2012] p 751 A91-44092

AIR NAVIGATION
Computer-drawn charts for EROPS flights
p 735 A91-41446
Combined satellite navigation systems could lead to more reliable and more precise air navigation
p 736 A91-42780
Autonomous aircraft initiative study
[NASA-CR-186013] p 742 N91-26140

AIR POLLUTION
Release of benz(a)pyrene with the exhaust gases of gas turbine engines burning natural gas
p 764 A91-41173
IAE V2500 - Technology for the environment
p 749 A91-43118

AIR TRAFFIC
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126
Format and basic geometry of a perspective display of air traffic for the cockpit
[NASA-TM-86680] p 743 N91-26142

AIR TRAFFIC CONTROL
The European ATC system - Constraints and traffic management p 734 A91-41439
The progressive improvement of European flow-management p 734 A91-41440
The airline's perception of air traffic management
p 734 A91-41441
Alternative strategies for traffic flow-management in Europe p 734 A91-41442
A new threat detection criterion for airborne collision avoidance systems p 735 A91-41447
ACAS in Europe - A U.K. view p 733 A91-41448
A radar-data communication network for ATC in the Benelux nations and northern Germany
p 736 A91-41853
ATC simulators do not have to replicate operational systems physically p 761 A91-42789
Visual systems for ATC training p 761 A91-42792
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100
Functional baseline specification for ATC data link service implementation in the host computer system
[DOT/FAA/CT-91/12] p 779 N91-26433

AIR TRAFFIC CONTROLLERS (PERSONNEL)
The airline's perception of air traffic management
p 734 A91-41441
ATC simulators do not have to replicate operational systems physically p 761 A91-42789
Visual systems for ATC training p 761 A91-42792

AIR TRANSPORTATION
Aging fleet - Maintaining airworthiness
p 693 A91-43077
With us you fly right - The influence of modern technology on the development and operation of new aircraft
p 771 A91-43326
Technical evaluation report on the flight mechanics panel symposium on progress in military airlift
[AGARD-AR-300] p 733 N91-25119
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126

AIRBORNE EQUIPMENT
Accurate airborne surface temperature measurements with chopper-stabilized radiometers p 742 A91-42142
GPS and airborne gravimetry - Recent progress and future plans p 742 A91-43315
Guide to measurement of winds with instrumented aircraft
[NASA-CR-188601] p 780 N91-25553

AIRBORNE/SPACEBORNE COMPUTERS
C-130 Automated Digital Data System (CADDS)
p 780 N91-25482

AIRCRAFT ACCIDENTS
Seeking crashworthy seats p 740 A91-44345

AIRCRAFT ANTENNAS
Low profile Satcom aircraft antenna development p 736 A91-42781

AIRCRAFT BRAKES
A look at digital nose wheel steering
[AD-A233944] p 741 N91-26131

AIRCRAFT COMMUNICATION
The airline's perception of air traffic management p 734 A91-41441

AIRCRAFT COMPARTMENTS
Aircraft interior noise reduction by alternate resonance tuning
[NASA-CR-185453] p 785 N91-26889

AIRCRAFT CONFIGURATIONS
MACGS - A zonal grid generation system for complex aero-propulsion configurations
[AIAA PAPER 91-2156] p 738 A91-41714
Analysis of pressure distribution on hypersonic vehicles with power effects
[AIAA PAPER 91-2491] p 738 A91-41796
CFD prediction of the near-field sonic boom environment for two low boom HSCT configurations --- High Speed Civil Transport
[AIAA PAPER 91-1631] p 784 A91-43560
Interactive design of hypersonic waverider geometries
[AIAA PAPER 91-1697] p 740 A91-43597
A powered lift experiment for CFD validation
[AIAA PAPER 91-1731] p 723 A91-43619
An extension of essentially nonoscillatory shock-capturing schemes to multidimensional systems of conservation laws p 776 N91-25355
Technology needs for high-speed rotorcraft, volume 1
[NASA-CR-177585] p 742 N91-26139

AIRCRAFT CONSTRUCTION MATERIALS
Trends in aircraft engine materials
[AIAA PAPER 91-1890] p 693 A91-41643
Composite gearboxes, designing for the 90's
[AIAA PAPER 91-1910] p 769 A91-41651
Forming of aluminum-lithium sheet for fighter aircraft applications p 765 A91-43913
Properties of commercially available Al-Li alloys' possible use on civil aircraft p 766 A91-43920

AIRCRAFT CONTROL
A Western engine for an Eastern aircraft - Re-engining of CSFR LET 610 turboprop transport with the GE CT7-9
[AIAA PAPER 91-1911] p 744 A91-41652
A preliminary investigation of the use of throttles for emergency flight control
[AIAA PAPER 91-2222] p 756 A91-41731
Fuzzy logic for control of roll and moment for a flexible wing aircraft p 757 A91-43932
Knowledge Based System Applications for Guidance and Control
[AGARD-CP-474] p 736 N91-25121
Handling qualities of unstable highly augmented aircraft
[AGARD-AR-279] p 740 N91-25146
Development of an adaptive failure detection and identification system for detecting aircraft control element failures
[NASA-TP-3051] p 758 N91-25151
Flight control law synthesis using neural network theory
[AD-A234990] p 758 N91-26149

AIRCRAFT DESIGN
The origins and evolution of design requirements for British military aircraft p 785 A91-41541
A parametric experimental study of isolated rectangular nozzles
[AIAA PAPER 91-2136] p 738 A91-41706
High-speed rotorcraft propulsion
[AIAA PAPER 91-2147] p 746 A91-41709
Conclusions from high-speed rotorcraft studies
[AIAA PAPER 91-2149] p 693 A91-41711
A multidisciplinary approach to aeroelastic analysis p 781 A91-42709
Integrated computer systems in aircraft design and manufacture difficulties and implications p 781 A91-43079
Piaggio P180 Avanti - Efficiency using three levels of aerodynamic lift p 739 A91-43119
Sub-contractors play new strategic roles p 694 A91-43273
Thermostructural concepts for hypervelocity vehicles p 764 A91-43311
Calculating time-correlated gust loads using matched filter and random process theories p 739 A91-43312
Computational fluid dynamics in the design of the YF-23 ATF prototype
[AIAA PAPER 91-1627] p 719 A91-43558
Optimized scramjet integration on a waverider
[AIAA PAPER 91-1693] p 739 A91-43594
Aeropropulsion analysis of tactical aircraft - Status and plans
[AIAA PAPER 91-1528] p 740 A91-43673
Technical evaluation report on the flight mechanics panel symposium on progress in military airlift
[AGARD-AR-300] p 733 N91-25119
Development of a system of interactive computer programs for airplane conceptual design and advanced airplane analysis p 740 N91-25144
Manual on the flight of flexible aircraft in turbulence
[AGARD-AG-317] p 758 N91-26150
Measurement of atmospheric turbulence p 780 N91-26151
Certification procedures and requirements p 759 N91-26154

AIRCRAFT DETECTION
A knowledge-based tracker for aircraft formations --- using radar systems p 736 A91-41851

AIRCRAFT ENGINES
Design of a language processor for aviation engine testing p 760 A91-41164
Thermodynamic analysis of gas turbine engines and plants at high air pressure levels p 743 A91-41171
Characteristics of the working cycle of a low-pressure pneumatic nozzle with a sector structure of the fuel jet p 744 A91-41174
Investigation of coatings at high temperature for use in turbomachinery p 744 A91-41507
The effects of bearing misalignment on the non-linear vibration of aero-engine rotor-damper assemblies p 744 A91-41536
Twenty-first century aero-engine design - The environmental factor p 744 A91-41539
Trends in aircraft engine materials
[AIAA PAPER 91-1890] p 693 A91-41643
APU exhaust plume effects in underbody installations
[AIAA PAPER 91-1904] p 744 A91-41646
Aircraft gas turbine performance for the year 2000
[AIAA PAPER 91-2233] p 746 A91-41733
Measured thrust losses associated with secondary air injection through nozzle walls
[AIAA PAPER 91-2244] p 705 A91-41734
An approach to modeling continuous turbine engine operation from startup to shutdown
[AIAA PAPER 91-2373] p 747 A91-41764
Testing a modern turboprop propulsion system
[AIAA PAPER 91-2480] p 747 A91-41791
New capabilities for aeromechanical testing and evaluation of aircraft turbine engines
[AIAA PAPER 91-2498] p 747 A91-41801
A theoretical study on the vibration damping of aircraft gearbox gears
[AIAA PAPER 91-2558] p 738 A91-41813
Experimental and computational investigation of isothermal swirling flow in an axisymmetric dump combustor p 749 A91-42806
Three-dimensional analysis of gas turbine combustors p 749 A91-42819
IAE V2500 - Technology for the environment p 749 A91-43118
Ceramic composites for aircraft gas turbine engines
[AIAA PAPER 91-1892] p 750 A91-44045
Advanced technology engine casing designs
[AIAA PAPER 91-1893] p 750 A91-44046
Transient performance of fan engine with water ingestion
[AIAA PAPER 91-1897] p 750 A91-44049
Computer modelling of implanted component faults in a gas turbine engine
[AIAA PAPER 91-1912] p 750 A91-44053
Prediffuser-combustor model studies under conditions of water ingestion in engines
[AIAA PAPER 91-1965] p 751 A91-44077
Propulsion systems for upgrades of current fighter aircraft
[AIAA PAPER 91-2026] p 752 A91-44095
Advanced high work turbine technology
[AIAA PAPER 91-2028] p 752 A91-44096
Concepts for reduction of turbine rotor inertia
[AIAA PAPER 91-2031] p 752 A91-44098
Combined cycle aircraft engines
[AIAA PAPER 91-2377] p 754 A91-44217
Hot-surface ignition and fire-suppression tests in an aircraft engine bay
[AIAA PAPER 91-2382] p 754 A91-44219
Fuel-rich, catalytic reaction experimental results --- fuel development for high-speed civil transport aircraft
[AIAA PAPER 91-2463] p 754 A91-44250
A new concept on compressor and turbine for aerospace propulsion
[AIAA PAPER 91-2591] p 755 A91-44303
The PC as a generic developmental fuel control for expendable turbojet engines
[AIAA PAPER 91-3399] p 755 A91-44329
Survey of current aircraft engine conditions
[AD-A235143] p 756 N91-26144
Titanium alloy integrated centrifugal impeller 5 coordinate computer assisted manufacturing technology
[AD-A234797] p 766 N91-26300

AIRCRAFT EQUIPMENT
Accurate airborne surface temperature measurements with chopper-stabilized radiometers p 742 A91-42142
Estimation of aircraft attitude by angular rate measurements p 757 A91-43095

AIRCRAFT GUIDANCE
Ground-based 4-D guidance of flights in strong winds p 734 A91-41438
Knowledge Based System Applications for Guidance and Control
[AGARD-CP-474] p 736 N91-25121

AIRCRAFT ICING
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies p 771 A91-43310

AIRCRAFT INSTRUMENTS
Experimental X-band synthetic aperture radar in aircraft p 735 A91-41825
Concept and results of the Azimuth Quick-Look Processor for aircraft SAR of the DLR p 735 A91-41828
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153

AIRCRAFT LANDING
Ground-based 4-D guidance of flights in strong winds p 734 A91-41438

AIRCRAFT MAINTENANCE
Condition monitoring of aircraft high lift systems p 738 A91-41535
Ground support equipment maintenance data analysis p 760 A91-41538
The importance of maintainability and reliability in the design process - An airline perspective
[AIAA PAPER 91-2374] p 693 A91-41765
Repair of F-104 aircraft nosedome by composite patching p 693 A91-43009
Aging fleet - Maintaining airworthiness p 693 A91-43077

AIRCRAFT MANEUVERS
Handling qualities of unstable highly augmented aircraft
[AGARD-AR-279] p 740 N91-25146
Calculated aerodynamics of wings in severe maneuver
[AD-A235241] p 732 N91-26120

AIRCRAFT MODELS
MBB Bo 108 - Serial construction begins p 739 A91-43117
Low-speed, powered ground effects of a generic, hypersonic configuration
[NASA-TP-3092] p 730 N91-25103

AIRCRAFT NOISE
Prediction of jet mean flow structure in support of HSCT noise suppression concepts --- High Speed Civilian Transport
[AIAA PAPER 91-2253] p 774 A91-44171
The reduction of cavity noise at subsonic speeds
[NAL-TR-1081] p 784 N91-25815
Aircraft interior noise reduction by alternate resonance tuning
[NASA-CR-185453] p 785 N91-26889

AIRCRAFT PARTS
Sub-contractors play new strategic roles p 694 A91-43273
Aerothermal test methodology for the development of structural components for hypersonic vehicles
[AIAA PAPER 91-1441] p 764 A91-43498

AIRCRAFT PERFORMANCE
Conclusions from high-speed rotorcraft studies
[AIAA PAPER 91-2149] p 693 A91-41711
Computer aiding for low-altitude helicopter flight
[NASA-TM-103861] p 737 N91-25142
AGARD handbook on advanced casting
[AGARD-AG-299] p 775 N91-25302
Acquisition of statistical gust load data by commercial airplanes p 758 N91-26152

AIRCRAFT PILOTS
Pivoting seat for fighter aircraft
[AD-D014822] p 733 N91-25120

AIRCRAFT RELIABILITY
The origins and evolution of design requirements for British military aircraft p 785 A91-41541
The importance of maintainability and reliability in the design process - An airline perspective
[AIAA PAPER 91-2374] p 693 A91-41765
Aging fleet - Maintaining airworthiness p 693 A91-43077
Gust design procedures p 759 N91-26155

AIRCRAFT STABILITY
A chart of unstable aircraft motions due to cross constraints of various origins p 756 A91-41156

AIRCRAFT STRUCTURES
Limiting thermal loads in porous structures p 768 A91-41159

Analysis of structural damping of titanium alloy shell structures as compared with that of aluminium alloy structures p 765 A91-41606
Calculating time-correlated gust loads using matched filter and random process theories p 739 A91-43312
A comparison of large AA8090, AA8091 and AA7010 die forgings for helicopter structural applications p 765 A91-43912
AGARD handbook on advanced casting
[AGARD-AG-299] p 775 N91-25302
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422
Analysis by the statistical discrete gust method p 759 N91-26156

AIRCRAFT WAKES
Wake ingestion propulsion benefit
[AIAA PAPER 91-2007] p 769 A91-41676

AIRFOIL OSCILLATIONS
Effect of thickness on the unsteady aerodynamics of closely coupled oscillating airfoils p 716 A91-43308
A quantitative study of unsteady compressible flow on an oscillating airfoil
[AIAA PAPER 91-1683] p 722 A91-43590
Laser velocimetry measurements of oscillating airfoil dynamic stall flow field
[AIAA PAPER 91-1799] p 725 A91-43648
Theoretical studies of the kinematics, dynamics, stability, and control of unsteady/vortical flows
[AD-A235190] p 779 N91-26477

AIRFOIL PROFILES
Navier-Stokes solution for high-lift multielement airfoil system with flap separation
[AIAA PAPER 91-1623] p 707 A91-42535
Multiblock mesh generation for multiple element airfoils with Euler solutions p 714 A91-42719
Automatic design of transonic airfoils to reduce the shock induced pressure drag p 716 A91-43078
New airfoil design concept p 716 A91-43307
Effect of thickness on the unsteady aerodynamics of closely coupled oscillating airfoils p 716 A91-43308
Airfoils admitting non-unique solutions of the Euler equations
[AIAA PAPER 91-1625] p 719 A91-43557
Transition predictions using Reynolds-averaged Navier-Stokes and linear stability analysis methods
[AIAA PAPER 91-1641] p 720 A91-43567
Opportunities for applications of natural laminar flow technology at high-subsonic speeds
[AIAA PAPER 91-1773] p 724 A91-43638
Time dependent calculations using multigrid, with applications to unsteady flows past airfoils and wings
[AIAA PAPER 91-1596] p 727 A91-43675

AIRFOILS
Implicit solvers for unstructured meshes
[AIAA PAPER 91-1537] p 696 A91-40712
A vertex-centroid scheme for improved finite-volume solution of the Navier-Stokes equations
[AIAA PAPER 91-1540] p 697 A91-40715
Hodograph solution for compressible flow past a corner and comparison with Euler numerical predictions
[AIAA PAPER 91-1547] p 697 A91-40722
Viscous airfoil computations using Richardson extrapolation
[AIAA PAPER 91-1559] p 698 A91-40733
Low-dimensional description of the dynamics in separated flow past thick airfoils
[AIAA PAPER 91-1622] p 707 A91-42534
Effect of model cooling on periodic transonic flow
[AIAA PAPER 91-1714] p 709 A91-42562
Drag and lift in nonadiabatic transonic flow
[AIAA PAPER 91-1716] p 710 A91-42564
Steady and unsteady solutions of the Navier-Stokes equations for flows about airfoils at low speeds
[AIAA PAPER 91-1733] p 710 A91-42568
Hopf bifurcation in viscous flows about airfoils at low speeds
[AIAA PAPER 91-1807] p 712 A91-42603
Influence of thickness and camber on the aeroelastic stability of supersonic throughflow fans p 715 A91-42814
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116

AIRFRAME MATERIALS
The fatigue response of the aluminium-lithium alloy, 8090 p 765 A91-43857
Application of aluminum-lithium alloys to fighter aircraft p 766 A91-43916

AIRFRAMES
Survey of current aircraft engine conditions
[AD-A235143] p 756 N91-26144

AIRLINE OPERATIONS
The importance of maintainability and reliability in the design process - An airline perspective
[AIAA PAPER 91-2374] p 693 A91-41765
Airport capacity and delay analyses
[DOT/FAA/CT-TN91/18] p 762 N91-25152
The potential role of maglev in short-haul airline operations
[DE91-010813] p 777 N91-25408
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126

AIRPORT PLANNING
Guidelines for design, construction, and evaluation of airport pavement drainage
[DOT/FAA/RD-90/31] p 763 N91-26161

AIRPORTS
Airport capacity and delay analyses
[DOT/FAA/CT-TN91/18] p 762 N91-25152
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153
Unified methodology for airport pavement analysis and design. Volume 1: State of the art
[DOT/FAA/RD-91/15-VOL-1] p 762 N91-25154
Guidelines for design, construction, and evaluation of airport pavement drainage
[DOT/FAA/RD-90/31] p 763 N91-26161

AIRSPEED
Effect of shock waves upon seat mounted sensors in escape systems p 738 A91-41543
Conclusions from high-speed rotorcraft studies
[AIAA PAPER 91-2149] p 693 A91-41711

ALGORITHMS
Higher order accuracy for upwind methods by using the compatibility equations
[AIAA PAPER 91-1543] p 697 A91-40718
Constraint management requirements for on-line aircraft route planning p 737 N91-25126
An identification algorithm based on smoothing p 782 N91-25642

ALLOYING
Aluminium-lithium weldable alloy 1420 - Alloying system Al-Li-Mg-Zr p 765 A91-43891

ALTERNATING DIRECTION IMPLICIT METHODS
Numerical investigation of the effect of leading edge geometry on dynamic stall of airfoils
[AIAA PAPER 91-1798] p 712 A91-42597

ALTIMETERS
Evaluation of the C/EC/KC-135 Ground Collision Avoidance System (GCAS), study 1
[AD-A235301] p 737 N91-26130

ALUMINUM ALLOYS
Analysis of structural damping of titanium alloy shell structures as compared with that of aluminium alloy structures p 765 A91-41606
The fatigue response of the aluminium-lithium alloy, 8090 p 765 A91-43857
Aluminium-lithium weldable alloy 1420 - Alloying system Al-Li-Mg-Zr p 765 A91-43891
A comparison of large AA8090, AA8091 and AA7010 die forgings for helicopter structural applications p 765 A91-43912
Forming of aluminum-lithium sheet for fighter aircraft applications p 765 A91-43913
Application of aluminum-lithium alloys to fighter aircraft p 766 A91-43916
Properties of commercially available Al-Li alloys' possible use on civil aircraft p 766 A91-43920

ANGLE OF ATTACK
A chart of unstable aircraft motions due to cross constraints of various origins p 756 A91-41156
Control of vortex structure on a delta wing by small amplitude perturbations of angle-of-attack p 706 A91-42094
Numerical study of the X-31 high angle-of-attack flow characteristics
[AIAA PAPER 91-1630] p 708 A91-42538
Navier-Stokes computations of hypersonic flow past a blunt edge delta wing at several angles of attack
[AIAA PAPER 91-1698] p 709 A91-42559
Navier-Stokes correlation of a swept helicopter rotor tip at high alpha
[AIAA PAPER 91-1752] p 711 A91-42574
Sources of high alpha vortex asymmetry at zero sideslip
[AIAA PAPER 91-1810] p 713 A91-42604
Chine forebody vortex manipulation by mechanical and pneumatic techniques on a delta wing configuration
[AIAA PAPER 91-1812] p 713 A91-42605
An approach to aerodynamic characteristics of low radar cross-section fuselages p 718 A91-43501
Trim angle measurements in free-flight facilities
[AIAA PAPER 91-1632] p 719 A91-43561
Mach 3.5 boundary-layer transition on a cone at angle of attack
[AIAA PAPER 91-1804] p 725 A91-43650
Numerical investigation of the effects of blowing on high angle of attack flow over delta wings
[AIAA PAPER 91-1809] p 726 A91-43652
High angle of attack aerodynamics of a glide vehicle
[AIAA PAPER 91-1813] p 726 A91-43654
Inlet/fan cowl design for increased angle-of-attack requirements of transport aircraft - Methodology and test results
[AIAA PAPER 91-2481] p 730 A91-44263

ANTENNA ARRAYS
Low profile Satcom aircraft antenna development p 736 A91-42781
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153

ANTENNA DESIGN
Low profile Satcom aircraft antenna development p 736 A91-42781

APPLICATIONS PROGRAMS (COMPUTERS)
3-D Navier-Stokes analysis of crossing, glancing shocks/turbulent boundary layer interactions
[AIAA PAPER 91-1758] p 723 A91-43631
The design/analysis of flows through turbomachinery: A viscous/inviscid approach
[NASA-TM-104447] p 755 N91-25148

APPROACH
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153

APPROPRIATIONS
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046

ARMED FORCES (UNITED STATES)
What fuels our future?
[AD-A233674] p 767 N91-26387

ARTIFICIAL INTELLIGENCE
Intelligent radar data processing p 770 A91-41849
Knowledge Based System Applications for Guidance and Control
[AGARD-CP-474] p 736 N91-25121
The pilot's associate: Exploiting the intelligent advantage p 781 N91-25122
Knowledge-based cockpit assistant for IFR operations p 736 N91-25125
Intelligent real-time knowledge based inflight mission management p 737 N91-25128
Autonomous aircraft initiative study
[NASA-CR-186013] p 742 N91-26140

ASCENT
A drag analysis of the early stages of large-scale high-altitude free balloon ascents p 731 N91-25108

ASPECT RATIO
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422

ASTRONAUTICS
Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Collection of Papers and Supplement p 785 A91-43076

ASYMPTOTIC METHODS
Asymptotic methods for the prediction of transonic wind tunnel wall interference
[AIAA PAPER 91-1712] p 762 A91-44334

ATMOSPHERIC CIRCULATION
Science requirements and feasibility/design studies of a very-high-altitude aircraft for atmospheric research p 740 N91-25481

ATMOSPHERIC MODELS
Certification procedures and requirements p 759 N91-26154

ATMOSPHERIC TURBULENCE
Development of an adaptive failure detection and identification system for detecting aircraft control element failures
[NASA-TP-3051] p 758 N91-25151
Manual on the flight of flexible aircraft in turbulence
[AGARD-AG-317] p 758 N91-26150
Measurement of atmospheric turbulence p 780 N91-26151
Certification procedures and requirements p 759 N91-26154
Analysis by the statistical discrete gust method p 759 N91-26156

ATOMIZING
Model for airblast atomization p 771 A91-42801
Effects of nozzle lip geometry on spray atomization and emissions advanced gas turbine combustors
[AIAA PAPER 91-2201] p 753 A91-44153
Fuel-rich, catalytic reaction experimental results — fuel development for high-speed civil transport aircraft
[AIAA PAPER 91-2463] p 754 A91-44250

ATTITUDE CONTROL
Estimation of aircraft attitude by angular rate measurements p 757 A91-43095
Detection and avoidance of errors in computer software p 783 N91-25937
AUTOMATIC CONTROL
An integrated automatic ramjet engine control system tolerant to failures of the functional components p 780 A91-41163
Pivoting seat for fighter aircraft [AD-D014822] p 733 N91-25120
AUTOMATIC FLIGHT CONTROL
Synchronization device of digital flight controlling computer and the algorithm for system scheduling p 742 A91-43508
Application of transformational ideas to automatic flight control design [AD-A234758] p 758 N91-26148
AUTONOMY
Autonomous aircraft initiative study [NASA-CR-186013] p 742 N91-26140
AUTOREGRESSIVE PROCESSES
Estimation of the aeroelastic characteristics from flight test data of the STOL research aircraft ASKA [NAL-TR-1083] p 740 N91-25145
AUXILIARY POWER SOURCES
APU exhaust plume effects in underbody installations [AIAA PAPER 91-1904] p 744 A91-41646
AVIONICS
Failure detection of liquid cooled electronics in sealed packages --- in airborne information management system [AIAA PAPER 91-1423] p 742 A91-43482
The pilot's associate: Exploiting the intelligent advantage p 781 N91-25122
Intelligent real-time knowledge based inflight mission management p 737 N91-25128
Integrated control and avionics for air superiority: A knowledge-based decision aiding system p 743 N91-25138
C-130 Automated Digital Data System (CADDS) p 780 N91-25482
Evaluation of the C/EC/KC-135 Ground Collision Avoidance System (GCAS), study 1 [AD-A235301] p 737 N91-26130
VHSIC electronics and the cost of Air Force avionics in the 1990s [RAND-R-3843-AF] p 743 N91-26143
Digital signal conditioning for flight test, volume 19 [AGARD-AG-160-VOL-19] p 778 N91-26432
AXIAL FLOW
Two-dimensional thrust vector control nozzle [AIAA PAPER 91-2101] p 745 A91-41696
AXIAL FLOW TURBINES
Transient performance of fan engine with water ingestion [AIAA PAPER 91-1897] p 750 A91-44049
Advanced high work turbine technology [AIAA PAPER 91-2028] p 752 A91-44096
AXISYMMETRIC BODIES
Navier-Stokes solution of complete turbulent flow past finite axisymmetric bodies p 707 A91-42298
Pareto-optimal shapes of axisymmetric bodies moving at high supersonic velocities p 707 A91-42330
Nonlinear oscillations of a heavy axisymmetric body in a resistant medium with drag p 784 A91-43169
Supersonic viscous flow calculations for axisymmetric, two and three-dimensional configurations [AIAA PAPER 91-1802] p 725 A91-43649
Self-propelled slender axisymmetric body flows: Errors in the Poisson equation field calculation p 731 N91-25110
AXISYMMETRIC FLOW
The design/analysis of flows through turbomachinery: A viscous/inviscid approach [NASA-TM-104447] p 755 N91-25148
AZIMUTH
Concept and results of the Azimuth Quick-Look Processor for aircraft SAR of the DLR p 735 A91-41828

B

BACKWARD FACING STEPS
Mixing enhancement in compressible mixing layers - An experimental study [AIAA PAPER 91-1721] p 723 A91-43612
Theoretical study of supersonic flow separation over a rearward facing step [AIAA PAPER 91-2161] p 753 A91-44139
BAFFLES
CFD analysis of baffle flame stabilization [AIAA PAPER 91-1967] p 773 A91-44078
BASE FLOW
A numerical investigation of turbulent baseflow p 703 A91-40799
Secondary instability of high-speed flows and the influence of wall cooling and suction [AIAA PAPER 91-1647] p 720 A91-43572
C.F.D. of the base flow on a plane body between a subsonic flow on one side and a supersonic flow on the other [AIAA PAPER 91-2372] p 729 A91-44215
BAYS (STRUCTURAL UNITS)
Hot-surface ignition and fire-suppression tests in an aircraft engine bay [AIAA PAPER 91-2382] p 754 A91-44219
BEAMS (SUPPORTS)
A new method for the vibration of thin-walled beams p 772 A91-43706
BEARINGS
The effects of bearing misalignment on the non-linear vibration of aero-engine rotor-damper assemblies p 744 A91-41536
Advanced Rotorcraft Transmission (ART) program-Boeing helicopters status report [NASA-TM-104474] p 778 N91-25412
BEDS (PROCESS ENGINEERING)
Refurbishing AV-8 on-board oxygen generation system beds [AD-A235083] p 741 N91-26136
BEND TESTS
Failure analysis and damage initiation in carbon-carbon composite materials under three-point bending p 764 A91-41569
BIBLIOGRAPHIES
Magnetic bearings-state of the art [NASA-TM-104465] p 778 N91-25413
BIRD-AIRCRAFT COLLISIONS
Turbofan engine bird ingestion testing [AIAA PAPER 91-2380] p 754 A91-44218
BLADE TIPS
A numerical analysis of the flow passing through a cascade with tip clearance - Subsonic flow through a linear cascade composed of flat plates p 695 A91-40575
The effect of square trailing edges on turbine blade performance [AIAA PAPER 91-2130] p 704 A91-41704
Unified treatment for dealing with auxiliary conditions in blade dynamics p 770 A91-42294
Investigation of the tip shape influence on the flowfield around hovering rotor blades [AIAA PAPER 91-1754] p 711 A91-42576
Computer modelling of implanted component faults in a gas turbine engine [AIAA PAPER 91-1912] p 750 A91-44053
BLADE-VORTEX INTERACTION
On the estimation of sound produced by complex fluid-structure interactions, with application to a vortex interacting with a shrouded rotor p 784 A91-43514
The vortex interaction in a propeller/stator flow field [AIAA PAPER 91-1818] p 726 A91-43657
BLOWDOWN WIND TUNNELS
Combustion-driven blowdown facilities for chemical laser research [AIAA PAPER 91-1455] p 772 A91-43528
BLOWING
Numerical investigation of the effects of blowing on high angle of attack flow over delta wings [AIAA PAPER 91-1809] p 726 A91-43652
BLUNT BODIES
Laminar heat transfer to spherically blunted cones in high enthalpy hyper velocity flows p 695 A91-40646
Wave processes occurring in supersonic motion of blunted body through dust layer p 695 A91-40656
Dissipation additions to flux-difference splitting [AIAA PAPER 91-1544] p 697 A91-40719
Pressure-based flux vector splitting for blunt geometries p 703 A91-40797
Effect of nose bluntness on flowfield over slender bodies in hypersonic flows p 707 A91-42256
Navier-Stokes computations of hypersonic flow past a blunt edge delta wing at several angles of attack [AIAA PAPER 91-1698] p 709 A91-42559
An approximate viscous shock layer approach to calculating hypersonic flows about blunt-nosed bodies [AIAA PAPER 91-1348] p 717 A91-43417
BODIES OF REVOLUTION
Sources of high alpha vortex asymmetry at zero sideslip [AIAA PAPER 91-1810] p 713 A91-42604
BODY-WING CONFIGURATIONS
Navier-Stokes calculations for attached and separated flows using different turbulence models [AIAA PAPER 91-1791] p 712 A91-42594
BOEING AIRCRAFT
Upgraded T55 engine for Special Forces MH-47E aircraft [AIAA PAPER 91-2024] p 752 A91-44094
BORON
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets p 748 A91-42805
BOUNDARY CONDITIONS
Quasi-3-D non-reflecting boundary conditions for Euler equations calculations [AIAA PAPER 91-1603] p 702 A91-40775
Numerical study of the X-31 high angle-of-attack flow characteristics [AIAA PAPER 91-1630] p 708 A91-42538
An extension of essentially nonoscillatory shock-capturing schemes to multidimensional systems of conservation laws p 776 N91-25355
BOUNDARY ELEMENT METHOD
Acoustical analysis of gear housing vibration [NASA-TM-103691] p 777 N91-25411
BOUNDARY LAYER COMBUSTION
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets p 748 A91-42805
BOUNDARY LAYER CONTROL
Numerical evaluation of vortex flow control devices [AIAA PAPER 91-1825] p 713 A91-42612
A parametric study of the leading edge attachment line for the F-16XL [AIAA PAPER 91-1621] p 718 A91-43555
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78 [NAL-TR-1076] p 732 N91-25116
The delay of turbulent boundary layer separation by oscillatory active control [ITN-91-85104] p 779 N91-26482
BOUNDARY LAYER EQUATIONS
A primary study of Reynolds number effect in transonic flow p 718 A91-43502
BOUNDARY LAYER FLOW
Modification of the van Driest damping function to include the effects of surface roughness p 770 A91-42282
Hypersonic rarefied flow about a compression corner - DSMC simulation and experiment [AIAA PAPER 91-1313] p 716 A91-43385
Effects of streamwise pressure gradient on the suction surface boundary layer of a turbine airfoil [AIAA PAPER 91-2030] p 727 A91-44097
Intakes and boundary layer crossflows for hypersonic vehicles [AIAA PAPER 91-2160] p 728 A91-44138
BOUNDARY LAYER SEPARATION
The peak surface pressure in fin-generated shock-wave boundary-layer interactions p 696 A91-40672
Effect of a multi-dimensional flux function on the monotonicity of Euler and Navier-Stokes computations [AIAA PAPER 91-1530] p 696 A91-40705
Comment on 'Critique of turbulence models for shock-induced flow separation' p 707 A91-42307
Application of indicial theory to the prediction of unsteady separation [AIAA PAPER 91-1742] p 710 A91-42572
A study of flow separation on an aspect ratio three flap at Mach number 2.4 [AIAA PAPER 91-1620] p 718 A91-43554
The delay of turbulent boundary layer separation by oscillatory active control [ITN-91-85104] p 779 N91-26482
BOUNDARY LAYER STABILITY
Compressible boundary layer stability analyzed with the PSE equations [AIAA PAPER 91-1637] p 708 A91-42539
Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis [AIAA PAPER 91-1635] p 719 A91-43563
Compressible stability of growing boundary layers using parabolized stability equations [AIAA PAPER 91-1636] p 720 A91-43564
Assessment of meanflow solutions for instability analysis of transitioning flows [AIAA PAPER 91-1638] p 720 A91-43565
Secondary instability of high-speed flows and the influence of wall cooling and suction [AIAA PAPER 91-1647] p 720 A91-43572
Incompressible boundary layer transition flight experiments over a nonaxisymmetric fuselage forebody and comparisons with laminar boundary layer stability theory p 777 N91-25359
Theoretical studies of the kinematics, dynamics, stability, and control of unsteady/vortical flows [AD-A235190] p 779 N91-26477
BOUNDARY LAYER TRANSITION
Direct numerical simulation of transition and turbulence in a spatially evolving boundary layer [AIAA PAPER 91-1607] p 702 A91-40779

Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis
[AIAA PAPER 91-1635] p 719 A91-43563
Compressible stability of growing boundary layers using parabolized stability equations
[AIAA PAPER 91-1636] p 720 A91-43564
Mach 3.5 boundary-layer transition on a cone at angle of attack
[AIAA PAPER 91-1804] p 725 A91-43650
A quiet flow Ludwieg tube for study of transition in compressible boundary layers: Design and feasibility
[NASA-CR-188499] p 731 N91-25107
Incompressible boundary layer transition flight experiments over a nonaxisymmetric fuselage forebody and comparisons with laminar boundary layer stability theory p 777 N91-25359
Observation of laminar boundary layer transition on light monoplane wing surface
[NAL-TR-1077] p 777 N91-25366

BOUNDARY LAYERS
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124

BOUNDARY VALUE PROBLEMS
Optimal control problems with switching points
p 782 N91-25694

BRANCHING (MATHEMATICS)
Hopf bifurcation in viscous flows about airfoils at low speeds
[AIAA PAPER 91-1807] p 712 A91-42603

BROADBAND
Computation of broadband mixing noise from turbomachinery
[AD-A233991] p 784 N91-26878

BUCKLING
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422

BURNING RATE
Burning and flameholding characteristics of a miniature solid fuel ramjet combustor p 749 A91-42807

C

C-130 AIRCRAFT
C-130 Automated Digital Data System (CADDS)
p 780 N91-25482

C-135 AIRCRAFT
KC-135 ground collision avoidance system questionnaire
[AD-A234385] p 733 N91-26125
Evaluation of the C/EC/KC-135 Ground Collision Avoidance System (GCAS), study 1
[AD-A235301] p 737 N91-26130

CALCULUS OF VARIATIONS
Combined energy management and calculus of variations approach for optimizing hypersonic vehicle trajectories p 739 A91-42738

CALIBRATING
Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions
[CPIA-PUBL-551] p 775 N91-25336
CFD calibration and application to the design of flow tailoring devices for simulating forebody influences on fighter aircraft inlet flows p 776 N91-25339
Applied high-speed imaging for the icing research program at NASA Lewis Research Center
[NASA-TM-104415] p 779 N91-26490

CAMBER
Influence of thickness and camber on the aeroelastic stability of supersonic throughflow fans
p 715 A91-42814

CANARD CONFIGURATIONS
Static and dynamic water tunnel flow visualization studies of a canard-configured X-31A-like fighter aircraft model
[AIAA PAPER 91-1629] p 708 A91-42537

CANTILEVER MEMBERS
Post-critical behaviour of a uniform cantilever column subjected to a tip concentrated subtangential follower force with small damping p 768 A91-41584

CARBON-CARBON COMPOSITES
Failure analysis and damage initiation in carbon-carbon composite materials under three-point bending
p 764 A91-41569

CARRIAGES
Viscous flow simulations of internal store carriage and separation
[NASA-CR-185343] p 732 N91-26123

CARTESIAN COORDINATES
An adaptively-refined Cartesian mesh solver for the Euler equations
[AIAA PAPER 91-1542] p 697 A91-40717

CASCADE FLOW
An application of topological method to analysing the three-dimensional flow in cascades. II - Topological analysis on the vector field patterns of skin-frictions and section streamlines p 694 A91-40569
A numerical analysis of the flow passing through a cascade with tip clearance - Subsonic flow through a linear cascade composed of flat plates p 695 A91-40575
Multi-cascade compression - Effective means to obtain high temperature dense gas in piston gas dynamic units (PGU) p 760 A91-40641
Application of shock tunnel at pressure and heat transfer experiments on turbine blade p 760 A91-40649
Inlet turbulence distortion and viscous flow development in a controlled-diffusion compressor cascade at very high incidence
[AIAA PAPER 91-2004] p 704 A91-41673
A row-by-row off-design performance calculation method for turbines
[AIAA PAPER 91-2132] p 745 A91-41705
Viscous/inviscid method for preliminary design of transonic cascades
[AIAA PAPER 91-2364] p 706 A91-41760
Influence of thickness and camber on the aeroelastic stability of supersonic throughflow fans
p 715 A91-42814
Computations of three-dimensional viscous flows in turbomachinery cascades
[AIAA PAPER 91-2237] p 728 A91-44164
Improved turbulence modeling for gas turbine application
[AIAA PAPER 91-2239] p 728 A91-44165

CASTING
AGARD handbook on advanced casting
[AGARD-AG-299] p 775 N91-25302

CATALYSTS
Fuel-rich, catalytic reaction experimental results --- fuel development for high-speed civil transport aircraft
[AIAA PAPER 91-2463] p 754 A91-44250

CAUCHY PROBLEM
State space models for aeroelastic and viscoelastic systems
[AD-A234730] p 732 N91-26117

CAUCHY-RIEMANN EQUATIONS
An explicit, rotated upwind algorithm for solution of the Euler/Navier-Stokes equations
[AIAA PAPER 91-1531] p 696 A91-40706

CAVITIES
The reduction of cavity noise at subsonic speeds
[NAL-TR-1081] p 784 N91-25815

CENTRIFUGAL COMPRESSORS
Active unsteady aerodynamic suppression of rotating stall in an incompressible flow centrifugal compressor with vaned diffuser
[AIAA PAPER 91-1898] p 704 A91-41644
Flowfield analysis of a backswept centrifugal impeller
[AIAA PAPER 91-2470] p 774 A91-44255
Titanium alloy integrated centrifugal impeller 5 coordinate computer assisted manufacturing technology
[AD-A234797] p 766 N91-26300

CERAMIC COATINGS
Flight service evalulation of thermal barrier coatings by physical vapor deposition at 5200 h p 764 A91-41511
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150

CERAMIC MATRIX COMPOSITES
Ceramic composites for aircraft gas turbine engines
[AIAA PAPER 91-1892] p 750 A91-44045

CERAMICS
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799
Lightweight ceramic components for propulsion applications
[AIAA PAPER 91-2217] p 774 A91-44159
Ceramic technology for advanced heat engines project
[DE91-010451] p 766 N91-26384

CERTIFICATION
Certification procedures and requirements
p 759 N91-26154

CHARTS
Computer-drawn charts for EROPS flights
p 735 A91-41446

CHEMICAL LASERS
Combustion-driven blowdown facilities for chemical laser research
[AIAA PAPER 91-1455] p 772 A91-43528

CHEMICAL REACTIONS
Computational aspects of chemically reacting flows
[AIAA PAPER 91-1574] p 699 A91-40748
Size dependence of gaseous cluster reactivity and evaporation dynamics as a mechanistic probe
[AD-A233811] p 766 N91-26249

CHIPS (ELECTRONICS)
VHSIC electronics and the cost of Air Force avionics in the 1990s
[RAND-R-3843-AF] p 743 N91-26143

CIRCULAR CYLINDERS
Theoretical studies of the kinematics, dynamics, stability, and control of unsteady/vortical flows
[AD-A235190] p 779 N91-26477

CIRCULATION CONTROL AIRFOILS
Grid restructuring for moving boundaries
[AIAA PAPER 91-1589] p 700 A91-40763

CIVIL AVIATION
A new threat detection criterion for airborne collision avoidance systems p 735 A91-41447
CFD prediction of the near-field sonic boom environment for two low boom HSCT configurations --- High Speed Civil Transport
[AIAA PAPER 91-1631] p 784 A91-43560
Airport capacity and delay analyses
[DOT/FAA/CT-TN91/18] p 762 N91-25152

COCKPITS
Technical evaluation report on the flight mechanics panel symposium on progress in military airlift
[AGARD-AR-300] p 733 N91-25119
Knowledge-based cockpit assistant for IFR operations
p 736 N91-25125
Format and basic geometry of a perspective display of air traffic for the cockpit
[NASA-TM-86680] p 743 N91-26142

COLD FLOW TESTS
Scale model test results of several STOVL ventral nozzle concepts
[AIAA PAPER 91-2134] p 752 A91-44134

COLLISION AVOIDANCE
A new threat detection criterion for airborne collision avoidance systems p 735 A91-41447
ACAS in Europe - A U.K. view p 733 A91-41448
KC-135 ground collision avoidance system questionnaire
[AD-A234385] p 733 N91-26125
Evaluation of the C/EC/KC-135 Ground Collision Avoidance System (GCAS), study 1
[AD-A235301] p 737 N91-26130

COLUMNS (SUPPORTS)
Post-critical behaviour of a uniform cantilever column subjected to a tip concentrated subtangential follower force with small damping p 768 A91-41584

COMBAT
SEAN: A navigation aid expert system for combat aircraft p 737 N91-25137

COMBINED CYCLE POWER GENERATION
Combined cycle aircraft engines
[AIAA PAPER 91-2377] p 754 A91-44217

COMBINED STRESS
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422

COMBUSTIBLE FLOW
Analysis of external burning on inclined surfaces in supersonic flow
[AIAA PAPER 91-2390] p 747 A91-41767
Combusting flow simulations of detonation and shock-induced combustion waves for ram accelerator configurations with viscous effect
[AIAA PAPER 91-1674] p 721 A91-43584
Application of a Reynolds Stress turbulence model to a supersonic hydrogen-air diffusion flame
[AIAA PAPER 91-1786] p 725 A91-43643
Intakes and boundary layer crossflows for hypersonic vehicles
[AIAA PAPER 91-2180] p 728 A91-44138
An experimental investigation of structure, mixing, and combustion in compressible turbulent shear layers
[AD-A235278] p 766 N91-26281

COMBUSTION
Fuel-rich, catalytic reaction experimental results --- fuel development for high-speed civil transport aircraft
[AIAA PAPER 91-2463] p 754 A91-44250
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150

COMBUSTION CHAMBERS
Characteristics of the working cycle of a low-pressure pneumatic nozzle with a sector structure of the fuel jet
p 744 A91-41174
Performance implications of gas-turbine pressure-gain combustors
[AIAA PAPER 91-1879] p 744 A91-41641
Dynamics of discrete phase in a gas turbine co-axial, counter-swirling, combustor dome swirl cup
[AIAA PAPER 91-2353] p 746 A91-41758
Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41768

A CFD study of jet mixing in reduced flow areas for lower combustor emissions
[AIAA PAPER 91-2460] p 747 A91-41788
Burning and flameholding characteristics of a miniature solid fuel ramjet combustor p 749 A91-42807
Combined tangential-normal injection into a supersonic flow p 715 A91-42816
Three-dimensional analysis of gas turbine combustors p 749 A91-42819
A study of supersonic aerodynamic mixing in the scramjet combustor p 771 A91-43000
Low NOx rich-lean combustion concept application
[AIAA PAPER 91-1962] p 751 A91-44075
Prediffuser-combustor model studies under conditions of water ingestion in engines
[AIAA PAPER 91-1965] p 751 A91-44077
Computations of three-dimensional gas turbine combustor flows
[AIAA PAPER 91-2076] p 773 A91-44116
Performance evaluation of semi-freejet tests of the Generic High Speed Engine
[AIAA PAPER 91-2163] p 753 A91-44141
Effects of nozzle lip geometry on spray atomization and emissions advanced gas turbine combustors
[AIAA PAPER 91-2201] p 753 A91-44153
Analysis of losses in supersonic mixing and reacting flows
[AIAA PAPER 91-2266] p 774 A91-44180
A demonstration of mode transition in a scramjet combustor
[AIAA PAPER 91-2395] p 754 A91-44225
CFD analysis of jet mixing in low NOx flametube combustors
[NASA-TM-104466] p 756 N91-26146

COMBUSTION EFFICIENCY
A CFD study of jet mixing in reduced flow areas for lower combustor emissions
[AIAA PAPER 91-2460] p 747 A91-41788
Fuel-rich, catalytic reaction experimental results -- fuel development for high-speed civil transport aircraft
[AIAA PAPER 91-2463] p 754 A91-44250

COMBUSTION PHYSICS
Navier-Stokes simulation of the supersonic combustion flowfield in a ram accelerator
[AIAA PAPER 91-1916] p 773 A91-44057

COMBUSTION PRODUCTS
Release of benz(a)pyrene with the exhaust gases of gas turbine engines burning natural gas p 764 A91-41173
Low NOx rich-lean combustion concept application
[AIAA PAPER 91-1962] p 751 A91-44075

COMBUSTION STABILITY
CFD analysis of baffle flame stabilization
[AIAA PAPER 91-1967] p 773 A91-44078
Reduced pressure oscillations in a dump combustor with tapered corrugations
[AIAA PAPER 91-2354] p 753 A91-44208

COMBUSTION TEMPERATURE
Enhanced capability of the Combustion-Heated Scramjet Test Facility
[AIAA PAPER 91-2502] p 762 A91-44267

COMMERCIAL AIRCRAFT
Acquisition of statistical gust load data by commercial airplanes p 758 N91-26152
Improved reduction of gust loads data for gust intensity p 758 N91-26153

COMMUNICATION NETWORKS
A radar-data communication network for ATC in the Benelux nations and northern Germany p 736 A91-41853
TABS - An automated pre-flight planning system p 733 A91-42783
Functional baseline specification for ATC data link service implementation in the host computer system
[DOT/FAA/CT-91/12] p 779 N91-26433

COMPOSITE MATERIALS
Repair of F-104 aircraft nosedome by composite patching p 693 A91-43009

COMPOSITE STRUCTURES
Composites move into jet engine design p 755 A91-44339

COMPRESSED AIR
Thermodynamic analysis of gas turbine engines and plants at high air pressure levels p 743 A91-41171

COMPRESSED GAS
Parametric investigation into the combined effects of pressure and temperature distortion on compression system stability
[AIAA PAPER 91-1895] p 773 A91-44047

COMPRESSIBILITY EFFECTS
Progress in hypersonic turbulence modeling
[AIAA PAPER 91-1785] p 724 A91-43642

COMPRESSIBLE BOUNDARY LAYER
Compressible boundary layer stability analyzed with the PSE equations
[AIAA PAPER 91-1637] p 708 A91-42539
Compressible stability of growing boundary layers using parabolized stability equations
[AIAA PAPER 91-1636] p 720 A91-43564
Waves produced from a harmonic point source in a supersonic boundary layer
[AIAA PAPER 91-1646] p 720 A91-43571
A quiet flow Ludwieg tube for study of transition in compressible boundary layers: Design and feasibility
[NASA-CR-188499] p 731 N91-25107

COMPRESSIBLE FLOW
Hodograph solution for compressible flow past a corner and comparison with Euler numerical predictions
[AIAA PAPER 91-1547] p 697 A91-40722
Finite element simulation of compressible flows with shocks
[AIAA PAPER 91-1551] p 767 A91-40725
An implicit three-dimensional Navier-Stokes solver for compressible flow
[AIAA PAPER 91-1555] p 698 A91-40729
Diagonal implicit multigrid solution of compressible turbulent flows
[AIAA PAPER 91-1571] p 699 A91-40745
Direct numerical simulation of transition and turbulence in a spatially evolving boundary layer
[AIAA PAPER 91-1607] p 702 A91-40779
Parallel block multigrid solution of the compressible Navier-Stokes equations p 702 A91-40792
High resolution nonoscillatory schemes for unsteady gas dynamics p 702 A91-40795
New mixing-length model for turbulent high-speed flows p 707 A91-42277
Multigrid and upwind viscous flow solver on three-dimensional overlapped and embedded grids p 707 A91-42284
Dynamic stall experiments on a swept three-dimensional wing in compressible flow
[AIAA PAPER 91-1795] p 712 A91-42595
A method for correcting wall pressure measurements in subsonic compressible flow p 715 A91-42957
Assessment of meanflow solutions for instability analysis of transitioning flows
[AIAA PAPER 91-1638] p 720 A91-43565
On the use and the accuracy of compressible flow codes at low Mach numbers
[AIAA PAPER 91-1662] p 721 A91-43577
A quantitative study of unsteady compressible flow on an oscillating airfoil
[AIAA PAPER 91-1683] p 722 A91-43590
Mixing enhancement in compressible mixing layers - An experimental study
[AIAA PAPER 91-1721] p 723 A91-43612
A numerical study of compressible viscous flow in a novel exhaust system
[AIAA PAPER 91-1728] p 723 A91-43617
Laser velocimetry measurements of oscillating airfoil dynamic stall flow field
[AIAA PAPER 91-1799] p 725 A91-43648
A Finite Volume Lambda Formulation
[AIAA PAPER 91-2258] p 728 A91-44176
An extension of essentially nonoscillatory shock-capturing schemes to multidimensional systems of conservation laws p 776 N91-25355

COMPRESSIBLE FLUIDS
An experimental investigation of structure, mixing, and combustion in compressible turbulent shear layers
[AD-A235278] p 766 N91-26281

COMPRESSION RATIO
A compression ignition driver for a free piston shock tunnel p 759 A91-40638

COMPRESSIVE STRENGTH
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422

COMPRESSOR BLADES
Inlet turbulence distortion and viscous flow development in a controlled-diffusion compressor cascade at very high incidence
[AIAA PAPER 91-2004] p 704 A91-41673

COMPRESSOR EFFICIENCY
Performance implications of gas-turbine pressure-gain combustors
[AIAA PAPER 91-1879] p 744 A91-41641

COMPUTATION
Computation of broadband mixing noise from turbomachinery
[AD-A233991] p 784 N91-26878

COMPUTATIONAL FLUID DYNAMICS
A numerical analysis of the flow passing through a cascade with tip clearance - Subsonic flow through a linear cascade composed of flat plates p 695 A91-40575
AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers p 767 A91-40701
Areas for future CFD development as illustrated by transport aircraft applications
[AIAA PAPER 91-1527] p 696 A91-40703
Computational aspects of chemically reacting flows
[AIAA PAPER 91-1574] p 699 A91-40748
Collar grids for intersecting geometric components within the Chimera overlapped grid scheme
[AIAA PAPER 91-1587] p 700 A91-40761
Grid restructuring for moving boundaries
[AIAA PAPER 91-1589] p 700 A91-40763
Grid convergence for adaptive methods
[AIAA PAPER 91-1592] p 701 A91-40766
Adaptive EAGLE - Solution-adaptive and quality-enhancing multi-block grids for arbitrary domains
[AIAA PAPER 91-1593] p 701 A91-40767
Application of a solution adaptive grid scheme, SAGE, to complex three-dimensional flows
[AIAA PAPER 91-1594] p 701 A91-40768
Computation of unsteady viscous flow using an efficient algorithm
[AIAA PAPER 91-1597] p 701 A91-40770
On the validity of linearized unsteady Euler equations with shock capturing
[AIAA PAPER 91-1598] p 702 A91-40771
Quasi-3-D non-reflecting boundary conditions for Euler equations calculations
[AIAA PAPER 91-1603] p 702 A91-40775
Accelerated convergence to steady state by gradual far-field damping
[AIAA PAPER 91-1604] p 702 A91-40776
A numerical method for predicting transition in three-dimensional flows by spatial amplification theory
[AIAA PAPER 91-1606] p 702 A91-40778
Direct numerical simulation of transition and turbulence in a spatially evolving boundary layer
[AIAA PAPER 91-1607] p 702 A91-40779
Parallel block multigrid solution of the compressible Navier-Stokes equations p 702 A91-40792
Development of a new flux splitting scheme p 768 A91-40793
High resolution nonoscillatory schemes for unsteady gas dynamics p 702 A91-40795
A novel implementation of an implicit k-epsilon turbulence model coupled with an explicit Navier-Stokes solver p 703 A91-40796
Pressure-based flux vector splitting for blunt geometries p 703 A91-40797
A numerical investigation of turbulent baseflow p 703 A91-40799
Three-dimensional Navier-Stokes calculations using solution-adaptive grids p 703 A91-40802
Computational rotorcraft flowfield research at the U.S. Army AeroStructures Directorate p 703 A91-41148
CFD analysis of a hydrogen fueled ramjet engine at Mach 3.44
[AIAA PAPER 91-1919] p 745 A91-41653
Use of the PARC code for generic NASP nozzles operating at off-design transonic conditions
[AIAA PAPER 91-2154] p 705 A91-41713
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles
[AIAA PAPER 91-2273] p 760 A91-41741
Viscous/inviscid method for preliminary design of transonic cascades
[AIAA PAPER 91-2364] p 706 A91-41760
A three-dimensional Navier-Stokes stage analysis of the flow through a compact radial turbine
[AIAA PAPER 91-2564] p 748 A91-41815
A block-structured solution scheme with the multigrid method for three-dimensional inviscid transonic flows p 706 A91-42096
New mixing-length model for turbulent high-speed flows p 707 A91-42277
Vortical flow solutions using a time-lagged, thin-layer, Navier-Stokes algorithm p 707 A91-42279
Multigrid and upwind viscous flow solver on three-dimensional overlapped and embedded grids p 707 A91-42284
Numerical study of the X-31 high angle-of-attack flow characteristics
[AIAA PAPER 91-1630] p 708 A91-42538
Second-order Godunov methods and self-similar steady supersonic three-dimensional flowfields
[AIAA PAPER 91-1653] p 708 A91-42544
CFD evaluation of transonic-supersonic wave front propagation effects
[AIAA PAPER 91-1657] p 708 A91-42547
Navier-Stokes computations of hypersonic flow past a blunt edge delta wing at several angles of attack
[AIAA PAPER 91-1698] p 709 A91-42559
Computational and experimental aftbody flow fields for hypersonic, airbreathing configurations with scramjet exhaust flow simulation
[AIAA PAPER 91-1709] p 709 A91-42561
Hypersonic shock/boundary-layer interaction database
[AIAA PAPER 91-1763] p 711 A91-42581
Navier-Stokes calculations for attached and separated flows using different turbulence models
[AIAA PAPER 91-1791] p 712 A91-42594

Hopf bifurcation in viscous flows about airfoils at low speeds
[AIAA PAPER 91-1807] p 712 A91-42603
Some characteristics of and dynamic scaling behavior in strong vortex flows
[AIAA PAPER 91-1821] p 713 A91-42609
Structured and unstructured remeshing method for high-speed flows p 713 A91-42630
Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990 p 780 A91-42703
Computation and visualization of leading edge vortex flows p 714 A91-42721
Computational aerodynamics methodology for the Aerospace Plane p 714 A91-42728
Asymmetric separated flows over slender bodies at supersonic speeds p 714 A91-42730
A generalized patched-grid algorithm with application to the F-18 forebody with actuated control strake p 715 A91-42736
Turbulent flow predictions for afterbody/nozzle geometries including base effects p 715 A91-42813
Large-scale advanced propeller blade pressure distributions - Prediction and data p 715 A91-42820
Recent advances in hypersonic technology p 716 A91-43103
Effect of thickness on the unsteady aerodynamics of closely coupled oscillating airfoils p 716 A91-43308
An approximate viscous shock layer approach to calculating hypersonic flows about blunt-nosed bodies
[AIAA PAPER 91-1348] p 717 A91-43417
An analytical comparison of convective heat transfer correlations in supercritical hydrogen
[AIAA PAPER 91-1382] p 771 A91-43446
Viscous equilibrium computations using program LAURA
[AIAA PAPER 91-1389] p 717 A91-43452
Numerical simulation of hypersonic viscous flow for the design of H-II orbiting plane (HOPE). II
[AIAA PAPER 91-1390] p 717 A91-43453
A parametric study of the leading edge attachment line for the F-16XL
[AIAA PAPER 91-1621] p 718 A91-43555
Navier-Stokes solutions for an oscillating double-delta wing
[AIAA PAPER 91-1624] p 718 A91-43556
Airfoils admitting non-unique solutions of the Euler equations
[AIAA PAPER 91-1625] p 719 A91-43557
Computational fluid dynamics in the design of the YF-23 ATF prototype
[AIAA PAPER 91-1627] p 719 A91-43558
Flight test and numerical simulation of transonic flow around YAV-8B Harrier II wing
[AIAA PAPER 91-1628] p 719 A91-43559
CFD prediction of the near-field sonic boom environment for two low boom HSCT configurations --- High Speed Civil Transport
[AIAA PAPER 91-1631] p 784 A91-43560
Trim angle measurements in free-flight facilities
[AIAA PAPER 91-1632] p 719 A91-43561
Potential flow applications to complex configurations
[AIAA PAPER 91-1634] p 719 A91-43562
Assessment of meanflow solutions for instability analysis of transitioning flows
[AIAA PAPER 91-1638] p 720 A91-43565
Transition predictions using Reynolds-averaged Navier-Stokes and linear stability analysis methods
[AIAA PAPER 91-1641] p 720 A91-43567
CFD computations for aero-optical analysis of supersonic shear layers
[AIAA PAPER 91-1659] p 720 A91-43574
On the use and the accuracy of compressible flow codes at low Mach numbers
[AIAA PAPER 91-1662] p 721 A91-43577
Three-dimensional upwinding Navier-Stokes code with k-epsilon model for supersonic flows
[AIAA PAPER 91-1669] p 721 A91-43580
A numerical study on wind tunnel interference effects in external burning test at M = 1.5
[AIAA PAPER 91-1675] p 749 A91-43585
Numerical analysis of scramjet flows in a dump combustor
[AIAA PAPER 91-1676] p 749 A91-43586
Block-structured computation of three-dimensional transonic Euler equations
[AIAA PAPER 91-1679] p 721 A91-43588
Hypersonic waverider analysis - A comparison of numerical and experimental results
[AIAA PAPER 91-1696] p 739 A91-43596
A multidomain Euler code applied to hypersonic flows
[AIAA PAPER 91-1699] p 722 A91-43598
Multigrid solution of hypersonic flows using rational Runge-Kutta scheme
[AIAA PAPER 91-1703] p 722 A91-43602
A numerical study of the flow establishment time in hypersonic shock tunnels
[AIAA PAPER 91-1706] p 722 A91-43604
Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel
[AIAA PAPER 91-1725] p 723 A91-43615
A powered lift experiment for CFD validation
[AIAA PAPER 91-1731] p 723 A91-43619
On the quasi-conical flowfield structure of the swept shock wave-turbulent boundary layer interaction
[AIAA PAPER 91-1759] p 724 A91-43632
Numerical investigation on shock wave/boundary-layer interactions in a constant area diffuser at Mach 3
[AIAA PAPER 91-1766] p 724 A91-43635
Supersonic viscous flow calculations for axisymmetric, two and three-dimensional configurations
[AIAA PAPER 91-1802] p 725 A91-43649
Vortical flows about a long cylinder at M = 3.5 and alpha = 18 deg
[AIAA PAPER 91-1808] p 726 A91-43651
Numerical investigation of the effects of blowing on high angle of attack flow over delta wings
[AIAA PAPER 91-1809] p 726 A91-43652
Numerical simulation of the unsteady vortex structure over a delta wing
[AIAA PAPER 91-1811] p 726 A91-43653
High angle of attack aerodynamics of a glide vehicle
[AIAA PAPER 91-1813] p 726 A91-43654
Numerical simulation of vortex breakdown over a delta wing
[AIAA PAPER 91-1814] p 726 A91-43655
Time dependent calculations using multigrid, with applications to unsteady flows past airfoils and wings
[AIAA PAPER 91-1596] p 727 A91-43675
A new concept for a hubless rotary jet
[AIAA PAPER 91-1903] p 750 A91-44051
CFD analysis of baffle flame stabilization
[AIAA PAPER 91-1967] p 773 A91-44078
Computations of three-dimensional gas turbine combustor flows
[AIAA PAPER 91-2076] p 773 A91-44116
A comparison of the analytical and experimental performance of the solid version of a cooled radial rotor
[AIAA PAPER 91-2133] p 752 A91-44133
Application of a multiblock/multizone code (PAB3D) for the three-dimensional Navier-Stokes equations
[AIAA PAPER 91-2155] p 728 A91-44137
Computations of three-dimensional viscous flows in turbomachinery cascades
[AIAA PAPER 91-2237] p 728 A91-44164
Prediction of jet mean flow structure in support of HSCT noise suppression concepts --- High Speed Civilian Transport
[AIAA PAPER 91-2253] p 774 A91-44171
A Finite Volume Lambda Formulation
[AIAA PAPER 91-2258] p 728 A91-44176
C.F.D. of the base flow on a plane body between a subsonic flow on one side and a supersonic flow on the other
[AIAA PAPER 91-2372] p 729 A91-44215
Application of an unsteady Navier-Stokes solver to transonic turbine design
[AIAA PAPER 91-2468] p 729 A91-44254
Flowfield analysis of a backswept centrifugal impeller
[AIAA PAPER 91-2470] p 774 A91-44255
Navier-Stokes results for hypersonic inlet flows
[AIAA PAPER 91-2472] p 729 A91-44257
A numerical method for 3D boundary layers with a small crossflow
[AIAA PAPER 91-2473] p 775 A91-44258
A numerical investigation for supersonic inlet with throat cavity
[AIAA PAPER 91-2477] p 729 A91-44260
CFD-based 3D turbofan exhaust nozzle analysis system
[AIAA PAPER 91-2478] p 754 A91-44261
Inlet/fan cowl design for increased angle-of-attack requirements of transport aircraft - Methodology and test results
[AIAA PAPER 91-2481] p 730 A91-44263
CFD code validation for nozzle flowfields
[AIAA PAPER 91-2565] p 775 A91-44295
An efficient method in predicting rotor/stator interaction
[AIAA PAPER 91-3380] p 730 A91-44320
Development of IR sensor window cooling requirements for endoatmospheric interceptors
[AIAA PAPER 91-1439] p 764 A91-44338
A quiet flow Ludwieg tube for study of transition in compressible boundary layers: Design and feasibility
[NASA-CR-188499] p 731 N91-25107
The design/analysis of flows through turbomachinery: A viscous/inviscid approach
[NASA-TM-104447] p 755 N91-25148
Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions
[CPIA-PUBL-551] p 775 N91-25336
CFD calibration and application to the design of flow tailoring devices for simulating forebody influences on fighter aircraft inlet flows p 776 N91-25339
Sensitivity of inlet performance predictions to CFD numerical and physical modeling p 776 N91-25345
Computational simulations for fighter and hypersonic vehicle inlet-forebody interactions p 776 N91-25347
High-speed forebody-inlet code validation experience at MCAIR p 776 N91-25348
Viscous flow simulations of internal store carriage and separation
[NASA-CR-185343] p 732 N91-26123
CFD analysis of jet mixing in low NOx flametube combustors
[NASA-TM-104466] p 756 N91-26146

COMPUTATIONAL GRIDS

Surface heat transfer change induced by unsteady shock reflections and numerical simulations on shock reflection p 695 A91-40647
Implicit solvers for unstructured meshes
[AIAA PAPER 91-1537] p 696 A91-40712
An adaptively-refined Cartesian mesh solver for the Euler equations
[AIAA PAPER 91-1542] p 697 A91-40717
Unified zonal method based on the fortified Navier-Stokes concept
[AIAA PAPER 91-1558] p 698 A91-40732
Diagonal implicit multigrid solution of compressible turbulent flows
[AIAA PAPER 91-1571] p 699 A91-40745
Computer-aided block-structuring through the use of optimization and expert system techniques
[AIAA PAPER 91-1585] p 700 A91-40759
Unstructured meshes and surface fidelity for complex shapes
[AIAA PAPER 91-1591] p 701 A91-40765
Grid convergence for adaptive methods
[AIAA PAPER 91-1592] p 701 A91-40766
Application of a solution adaptive grid scheme, SAGE, to complex three-dimensional flows
[AIAA PAPER 91-1594] p 701 A91-40768
Three-dimensional Navier-Stokes calculations using solution-adaptive grids p 703 A91-40802
Multigrid and upwind viscous flow solver on three-dimensional overlapped and embedded grids p 707 A91-42284
A study of supersonic aerodynamic mixing in the scramjet combustor p 771 A91-43000
A multidomain Euler code applied to hypersonic flows
[AIAA PAPER 91-1699] p 722 A91-43598
Aerodynamic and heat transfer analysis of the low aspect ratio turbine using a 3D Navier-Stokes code
[AIAA PAPER 91-2240] p 774 A91-44166
Grid generation for three-dimensional turbomachinery geometries including tip clearance
[AIAA PAPER 91-2360] p 753 A91-44209
Application of an unsteady Navier-Stokes solver to transonic turbine design
[AIAA PAPER 91-2468] p 729 A91-44254
Effect of the grid system on heat transfer computations for high speed flows
[DE91-010874] p 777 N91-25375
Viscous flow simulations of internal store carriage and separation
[NASA-CR-185343] p 732 N91-26123

COMPUTER AIDED DESIGN

Surface reconstruction from scattered data through pruning of unstructured grids
[AIAA PAPER 91-1584] p 700 A91-40758
Design of a language processor for aviation engine testing p 760 A91-41164
MACGS - A zonal grid generation system for complex aero-propulsion configurations
[AIAA PAPER 91-2156] p 738 A91-41714
Automatic design of transonic airfoils to reduce the shock induced pressure drag p 716 A91-43078
Integrated computer systems in aircraft design and manufacture difficulties and implications p 781 A91-43079
Computational fluid dynamics in the design of the YF-23 ATF prototype
[AIAA PAPER 91-1627] p 719 A91-43558
Interactive design of hypersonic waverider geometries
[AIAA PAPER 91-1697] p 740 A91-43597
Seeking crashworthy seats p 740 A91-44345
Development of a system of interactive computer programs for airplane conceptual design and advanced airplane analysis p 740 N91-25144

COMPUTER AIDED MANUFACTURING
Integrated computer systems in aircraft design and manufacture difficulties and implications
p 781 A91-43079
Titanium alloy integrated centrifugal impeller 5 coordinate computer assisted manufacturing technology
[AD-A234797] p 766 N91-26300
COMPUTER ASSISTED INSTRUCTION
Development of a system of interactive computer programs for airplane conceptual design and advanced airplane analysis p 740 N91-25144
COMPUTER GRAPHICS
Format and basic geometry of a perspective display of air traffic for the cockpit
[NASA-TM-86680] p 743 N91-26142
COMPUTER NETWORKS
With us you fly right - The influence of modern technology on the development and operation of new aircraft
p 771 A91-43326
Introduction to the LaRC central scientific computing complex
[NASA-TM-104092] p 782 N91-25623
COMPUTER PROGRAMMING
Detection and avoidance of errors in computer software p 783 N91-25937
Autonomous aircraft initiative study
[NASA-CR-186013] p 742 N91-26140
COMPUTER PROGRAMS
A 3-D upwind Euler solver for unstructured meshes
[AIAA PAPER 91-1548] p 697 A91-40723
An implicit three-dimensional Navier-Stokes solver for compressible flow
[AIAA PAPER 91-1555] p 698 A91-40729
Application of a solution adaptive grid scheme, SAGE, to complex three-dimensional flows
[AIAA PAPER 91-1594] p 701 A91-40768
Computer-drawn charts for EROPS flights
p 735 A91-41446
Ground support equipment maintenance data analysis
p 760 A91-41538
Analysis of pressure distribution on hypersonic vehicles with power effects
[AIAA PAPER 91-2491] p 738 A91-41796
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies
p 771 A91-43310
Application of a multiblock/multizone code (PAB3D) for the three-dimensional Navier-Stokes equations
[AIAA PAPER 91-2155] p 728 A91-44137
Aerodynamic and heat transfer analysis of the low aspect ratio turbine using a 3D Navier-Stokes code
[AIAA PAPER 91-2240] p 774 A91-44166
C.F.D. of the base flow on a plane body between a subsonic flow on one side and a supersonic flow on the other
[AIAA PAPER 91-2372] p 729 A91-44215
Constraint management requirements for on-line aircraft route planning p 737 N91-25126
Integrated control and avionics for air superiority: A knowledge-based decision aiding system
p 743 N91-25138
Development of a system of interactive computer programs for airplane conceptual design and advanced airplane analysis p 740 N91-25144
Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions
[CPIA-PUBL-551] p 775 N91-25336
High-speed forebody-inlet code validation experience at MCAIR p 776 N91-25348
Mission planning systems for tactical aircraft (pre-flight and in-flight)
[AGARD-AR-296] p 783 N91-25750
Detection and avoidance of errors in computer software p 783 N91-25937
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113
How low can an unmanned air vehicle fly?
[RAND-P-7680-RGS] p 741 N91-26138
COMPUTER SYSTEMS PERFORMANCE
SEAN: A navigation aid expert system for combat aircraft p 737 N91-25137
Introduction to the LaRC central scientific computing complex
[NASA-TM-104092] p 782 N91-25623
COMPUTER SYSTEMS PROGRAMS
Autonomous aircraft initiative study
[NASA-CR-186013] p 742 N91-26140
COMPUTER TECHNIQUES
Areas for future CFD development as illustrated by transport aircraft applications
[AIAA PAPER 91-1527] p 696 A91-40703
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100
Opportunities for advanced speech processing in military computer-based systems
[AD-A233724] p 778 N91-26412
COMPUTERIZED SIMULATION
Surface heat transfer change induced by unsteady shock reflections and numerical simulations on shock reflection
p 695 A91-40647
Surface reconstruction from scattered data through pruning of unstructured grids
[AIAA PAPER 91-1584] p 700 A91-40758
Computer-aided block-structuring through the use of optimization and expert system techniques
[AIAA PAPER 91-1585] p 700 A91-40759
A CFD study of jet mixing in reduced flow areas for lower combustor emissions
[AIAA PAPER 91-2460] p 747 A91-41788
A three-dimensional Navier-Stokes stage analysis of the flow through a compact radial turbine
[AIAA PAPER 91-2564] p 748 A91-41815
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration
[AIAA PAPER 91-1689] p 748 A91-42556
Hypersonic rarefied flow about a delta wing - Direct simulation and comparison with experiment
[AIAA PAPER 91-1315] p 716 A91-43387
An efficient DSMC algorithm applied to a delta wing
[AIAA PAPER 91-1316] p 717 A91-43388
Direct simulation of waveriders in hypersonic rarefied flow
[AIAA PAPER 91-1317] p 717 A91-43389
Combusting flow simulations of detonation and shock-induced combustion waves for ram accelerator configurations with viscous effect
[AIAA PAPER 91-1674] p 721 A91-43584
Numerical simulation of vortex breakdown over a delta wing
[AIAA PAPER 91-1814] p 726 A91-43655
The laminar horseshoe vortex system formed at a cylinder/plate juncture
[AIAA PAPER 91-1826] p 727 A91-43659
Navier-Stokes simulation of the supersonic combustion flowfield in a ram accelerator
[AIAA PAPER 91-1916] p 773 A91-44057
Effects of streamwise pressure gradient on the suction surface boundary layer of a turbine airfoil
[AIAA PAPER 91-2030] p 727 A91-44097
A numerical method for 3D boundary layers with a small crossflow
[AIAA PAPER 91-2473] p 775 A91-44258
SEAN: A navigation aid expert system for combat aircraft p 737 N91-25137
Computer aiding for low-altitude helicopter flight
[NASA-TM-103861] p 737 N91-25142
Airport capacity and delay analyses
[DOT/FAA/CT-TN91/18] p 762 N91-25152
Navier-Stokes simulations of flows about complex configurations using domain decomposition techniques
p 777 N91-25362
Viscous flow simulations of internal store carriage and separation
[NASA-CR-185343] p 732 N91-26123
COMPUTERS
Introduction to the LaRC central scientific computing complex
[NASA-TM-104092] p 782 N91-25623
CONES
Mach 3.5 boundary-layer transition on a cone at angle of attack
[AIAA PAPER 91-1804] p 725 A91-43650
CONFERENCES
AIAA Computational Fluid Dynamics Conference, 10th, Honolulu, HI, June 24-27, 1991, Technical Papers
p 767 A91-40701
Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990 p 780 A91-42703
Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Collection of Papers and Supplement p 785 A91-43076
Technical evaluation report on the flight mechanics panel symposium on progress in military airlift
[AGARD-AR-300] p 733 N91-25119
Knowledge Based System Applications for Guidance and Control
[AGARD-CP-474] p 736 N91-25121
CONFORMAL MAPPING
A general method for practical conformal mapping of aerodynamic shapes p 715 A91-42902
CONGRESSIONAL REPORTS
Coordination and synchronization of loran-C and GPS to universal coordinated time
[AD-A233221] p 737 N91-25141
CONICAL BODIES
Laminar heat transfer to spherically blunted cones in high enthalpy hyper velocity flows p 695 A91-40646
Correlative behaviours of shock/boundary layer interaction induced by sharp fin and semicone
[AIAA PAPER 91-1756] p 711 A91-42577
CONICAL FLOW
On the quasi-conical flowfield structure of the swept shock wave-turbulent boundary layer interaction
[AIAA PAPER 91-1759] p 724 A91-43632
CONJUGATE GRADIENT METHOD
Generalized conjugate-gradient methods for the Navier-Stokes equations
[AIAA PAPER 91-1556] p 698 A91-40730
CONSERVATION LAWS
An extension of essentially nonoscillatory shock-capturing schemes to multidimensional systems of conservation laws p 776 N91-25355
CONSTRUCTION MATERIALS
Guidelines for design, construction, and evaluation of airport pavement drainage
[DOT/FAA/RD-90/31] p 763 N91-26161
CONTACT LOADS
Failure analysis and damage initiation in carbon-carbon composite materials under three-point bending
p 764 A91-41569
CONTINENTAL SHELVES
Comparison of aircraft synthetic aperture radar and buoy spectra during the Norwegian Continental Shelf Experiment of 1988 p 779 A91-42224
CONTRACTS
Sub-contractors play new strategic roles
p 694 A91-43273
CONTRAROTATING PROPELLERS
A study of aeroacoustic performance of a contra-rotating axial flow compressor stage p 706 A91-42248
CONTROL SIMULATION
A simulation evaluation of a four-engine jet transport using engine thrust modulation for flightpath control
[AIAA PAPER 91-2223] p 757 A91-44162
A simulation study of turbofan engine deterioration estimation using Kalman filtering techniques
[NASA-TM-104233] p 755 N91-25147
CONTROL SURFACES
The level of self-oscillations of aerodynamic control surfaces under nonseparating transonic gas flow
p 703 A91-41218
CONTROL SYSTEMS DESIGN
Feedback linearization for control of air breathing engines
[AIAA PAPER 91-2000] p 745 A91-41671
A simulation evaluation of a four-engine jet transport using engine thrust modulation for flightpath control
[AIAA PAPER 91-2223] p 757 A91-44162
A knowledge-based system design/information tool for aircraft flight control systems p 757 N91-25139
Handling qualities of unstable highly augmented aircraft
[AGARD-AR-279] p 740 N91-25146
Application of transformational ideas to automatic flight control design
[AD-A234758] p 758 N91-26148
Flight control law synthesis using neural network theory
[AD-A234990] p 758 N91-26149
Functional baseline specification for ATC data link service implementation in the host computer system
[DOT/FAA/CT-91/12] p 779 N91-26433
Structured representation for requirements and specifications
[NASA-CR-187522] p 783 N91-26797
CONTROL THEORY
Application of transformational ideas to automatic flight control design
[AD-A234758] p 758 N91-26148
CONTROLLABILITY
Handling qualities of unstable highly augmented aircraft
[AGARD-AR-279] p 740 N91-25146
CONTROLLERS
An integrated automatic ramjet engine control system tolerant to failures of the functional components
p 780 A91-41163
An optimal pole placement gain scheduling algorithm using output feedback p 782 N91-25643
CONVECTIVE FLOW
On the convection velocity of turbulent structures in supersonic shear layers
[AIAA PAPER 91-1724] p 723 A91-43614
An experimental investigation of structure, mixing, and combustion in compressible turbulent shear layers
[AD-A235278] p 766 N91-26281

CONVECTIVE HEAT TRANSFER
An analytical comparison of convective heat transfer correlations in supercritical hydrogen
[AIAA PAPER 91-1382] p 771 A91-43446
Enhancements to the high speed convective heating and viscous drag prediction techniques of the Aerodynamic Preliminary Analysis System (APAS)
[AIAA PAPER 91-1435] p 717 A91-43494
Three-dimensional Navier-Stokes analysis of turbine passage heat transfer
[AIAA PAPER 91-2241] p 774 A91-44167

CONVERGENCE
Accelerated convergence to steady state by gradual far-field damping
[AIAA PAPER 91-1604] p 702 A91-40776

CONVERGENT-DIVERGENT NOZZLES
Static performance of a multiaxis thrust vectoring cruciform nozzle
[AIAA PAPER 91-2137] p 745 A91-41707
Measured thrust losses associated with secondary air injection through nozzle walls
[AIAA PAPER 91-2244] p 705 A91-41734
Supersonic jet mixing enhancement by vortex generators
[AIAA PAPER 91-2263] p 705 A91-41738
Prediction of internal performance for two-dimensional convergent-divergent nozzles
[AIAA PAPER 91-2369] p 706 A91-41762
Vortex breakdown in a supersonic jet
[AIAA PAPER 91-1815] p 726 A91-43656

CONVOLUTION INTEGRALS
Application of indicial theory to the prediction of unsteady separation
[AIAA PAPER 91-1742] p 710 A91-42572
Gust design procedures p 759 N91-26155

COOLING
Heat pipe radiation cooling of advanced hypersonic propulsion system components
[AIAA PAPER 91-2358] p 746 A91-41759
Heat management concepts for hypersonic propulsion systems
[AIAA PAPER 91-2493] p 769 A91-41798
Secondary instability of high-speed flows and the influence of wall cooling and suction
[AIAA PAPER 91-1647] p 720 A91-43572

COOLING SYSTEMS
An analytical comparison of convective heat transfer correlations in supercritical hydrogen
[AIAA PAPER 91-1382] p 771 A91-43446

COORDINATION
Coordination and synchronization of loran-C and GPS to universal coordinated time
[AD-A233221] p 737 N91-25141

CORNER FLOW
Hodograph solution for compressible flow past a corner and comparison with Euler numerical predictions
[AIAA PAPER 91-1547] p 697 A91-40722

CORRUGATING
Reduced pressure oscillations in a dump combustor with tapered corrugations
[AIAA PAPER 91-2354] p 753 A91-44208

COST ANALYSIS
Properties of commercially available Al-Li alloys' possible use on civil aircraft p 766 A91-43920

COST ESTIMATES
VHSIC electronics and the cost of Air Force avionics in the 1990s
[RAND-R-3843-AF] p 743 N91-26143

COUNTER-ROTATING WHEELS
Wind tunnel results of counter rotation prop-fans designed with lifting line and Euler code methods
[AIAA PAPER 91-2499] p 755 A91-44265

COWLINGS
Inlet/fan cowl design for increased angle-of-attack requirements of transport aircraft - Methodology and test results
[AIAA PAPER 91-2481] p 730 A91-44263

CRACKING (FRACTURING)
Repair of F-104 aircraft nosedome by composite patching p 693 A91-43009

CRASHES
KC-135 ground collision avoidance system questionnaire
[AD-A234385] p 733 N91-26125

CRASHWORTHINESS
Seeking crashworthy seats p 740 A91-44345

CRITICAL LOADING
Post-critical behaviour of a uniform cantilever column subjected to a tip concentrated subtangential follower force with small damping p 768 A91-41584

CROSS FLOW
Mixing studies of helium in air at Mach 6
[AIAA PAPER 91-2268] p 705 A91-41739
Jet-wake thermal characteristics of heated turbulent jets in crossflow p 770 A91-42258
Observations of supersonic transverse jets
[AIAA PAPER 91-1723] p 772 A91-43613
Opportunities for applications of natural laminar flow technology at high-subsonic speeds
[AIAA PAPER 91-1773] p 724 A91-43638
Performance comparisons of Navier-Stokes codes for simulating three-dimensional hypersonic crossflow/jet interaction
[AIAA PAPER 91-2096] p 728 A91-44127
Intakes and boundary layer crossflows for hypersonic vehicles
[AIAA PAPER 91-2160] p 728 A91-44138
A numerical method for 3D boundary layers with a small crossflow
[AIAA PAPER 91-2473] p 775 A91-44258

CRYOGENIC FLUID STORAGE
Thermal modeling and analysis of a cryogenic tank design exposed to extreme heating profiles
[AIAA PAPER 91-1383] p 772 A91-43447

CRYOGENIC WIND TUNNELS
Comparison of cryogenic wind tunnel, flight, and computational results for a thin, low-aspect-ratio wing
[AIAA PAPER 91-1626] p 708 A91-42536

CURVE FITTING
An optimal pole placement gain scheduling algorithm using output feedback p 782 N91-25643

CYLINDRICAL BODIES
Experimental investigation of the shock wave and turbulent boundary layer interaction induced by a cylindrical protuberance p 695 A91-40604
Vortical flows about a long cylinder at M = 3.5 and alpha = 18 deg
[AIAA PAPER 91-1808] p 726 A91-43651

D

DAMAGE
Failure analysis and damage initiation in carbon-carbon composite materials under three-point bending
p 764 A91-41569

DAMPING
Accelerated convergence to steady state by gradual far-field damping
[AIAA PAPER 91-1604] p 702 A91-40776
Post-critical behaviour of a uniform cantilever column subjected to a tip concentrated subtangential follower force with small damping p 768 A91-41584

DATA ACQUISITION
NASA/Ames Research Center DC-8 data system
p 782 N91-25458
C-130 Automated Digital Data System (CADDS)
p 780 N91-25482
Guide to measurement of winds with instrumented aircraft
[NASA-CR-188601] p 780 N91-25553

DATA BASES
Hypersonic shock/boundary-layer interaction database
[AIAA PAPER 91-1763] p 711 A91-42581
Acquisition of statistical gust load data by commercial airplanes p 758 N91-26152

DATA FLOW ANALYSIS
The development of 'Radar data quality control and Radar Analysis Support System RDQC/RASS'
p 735 A91-41834

DATA LINKS
Functional baseline specification for ATC data link service implementation in the host computer system
[DOT/FAA/CT-91/12] p 779 N91-26433

DATA PROCESSING
Concept and results of the Azimuth Quick-Look Processor for aircraft SAR of the DLR
p 735 A91-41828
Intelligent radar data processing p 770 A91-41849
Knowledge Based System Applications for Guidance and Control
[AGARD-CP-474] p 736 N91-25121

DATA PROCESSING EQUIPMENT
NASA/Ames Research Center DC-8 data system
p 782 N91-25458

DATA RECORDING
NASA/Ames Research Center DC-8 data system
p 782 N91-25458

DATA REDUCTION
A neural network for the analysis of aircraft test data
p 781 N91-25133
Guide to measurement of winds with instrumented aircraft
[NASA-CR-188601] p 780 N91-25553
Measurement of atmospheric turbulence
p 780 N91-26151
Improved reduction of gust loads data for gust intensity p 758 N91-26153

DATA SMOOTHING
Grid restructuring for moving boundaries
[AIAA PAPER 91-1589] p 700 A91-40763
An identification algorithm based on smoothing
p 782 N91-25642

DATA SYSTEMS
NASA/Ames Research Center DC-8 data system
p 782 N91-25458
C-130 Automated Digital Data System (CADDS)
p 780 N91-25482

DATA TRANSMISSION
C-130 Automated Digital Data System (CADDS)
p 780 N91-25482
Digital signal conditioning for flight test, volume 19
[AGARD-AG-160-VOL-19] p 778 N91-26432

DC 8 AIRCRAFT
NASA/Ames Research Center DC-8 data system
p 782 N91-25458

DECISION MAKING
Knowledge Based System Applications for Guidance and Control
[AGARD-CP-474] p 736 N91-25121
Knowledge-based cockpit assistant for IFR operations
p 736 N91-25125
Integrated control and avionics for air superiority: A knowledge-based decision aiding system
p 743 N91-25138
Mission planning systems for tactical aircraft (pre-flight and in-flight)
[AGARD-AR-296] p 783 N91-25750

DECOMPOSITION
Navier-Stokes simulations of flows about complex configurations using domain decomposition techniques
p 777 N91-25362

DEICING
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies
p 771 A91-43310

DELTA WINGS
Control of vortex structure on a delta wing by small amplitude perturbations of angle-of-attack
p 706 A91-42094
Laser velocimetry measurements of supersonic vortex flows on a simple razor-edged delta wing
[AIAA PAPER 91-1684] p 709 A91-42553
Navier-Stokes computations of hypersonic flow past a blunt edge delta wing at several angles of attack
[AIAA PAPER 91-1698] p 709 A91-42559
The vortex kinematics associated with an oscillating delta wing
[AIAA PAPER 91-1797] p 712 A91-42596
Sources of high alpha vortex asymmetry at zero sideslip
[AIAA PAPER 91-1810] p 713 A91-42604
Chine forebody vortex manipulation by mechanical and pneumatic techniques on a delta wing configuration
[AIAA PAPER 91-1812] p 713 A91-42605
Visualization measurements of vortex flows
p 716 A91-43309
Hypersonic rarefied flow about a delta wing - Direct simulation and comparison with experiment
[AIAA PAPER 91-1315] p 716 A91-43387
An efficient DSMC algorithm applied to a delta wing
[AIAA PAPER 91-1316] p 717 A91-43388
Navier-Stokes solutions for an oscillating double-delta wing
[AIAA PAPER 91-1624] p 718 A91-43556
Effects of leading-edge flap oscillation on unsteady delta wing flow and rock control
[AIAA PAPER 91-1796] p 725 A91-43647
Numerical investigation of the effects of blowing on high angle of attack flow over delta wings
[AIAA PAPER 91-1809] p 726 A91-43652
Numerical simulation of the unsteady vortex structure over a delta wing
[AIAA PAPER 91-1811] p 726 A91-43653
Numerical simulation of vortex breakdown over a delta wing
[AIAA PAPER 91-1814] p 726 A91-43655
Velocity measurements inside the leading edge vortex formed on a delta wing
[NAL-TR-1087] p 732 N91-25115
Methods to enhance the accuracy of finite volume schemes 2
[FFA-147] p 779 N91-26466

DESCRIPTIVE GEOMETRY
Computational simulations for fighter and hypersonic vehicle inlet-forebody interactions p 776 N91-25347

DESIGN ANALYSIS
How failure prediction methodology affects electronic equipment design p 768 A91-40812
Dynamic analysis of advanced tip rotors including three-dimensional aerodynamics p 731 N91-25111
Development of a system of interactive computer programs for airplane conceptual design and advanced airplane analysis p 740 N91-25144
Unified methodology for airport pavement analysis and design. Volume 1: State of the art
[DOT/FAA/RD-91/15-VOL-1] p 762 N91-25154

Performance optimization of helicopter rotor blades
[NASA-TM-104054] p 741 N91-26137
Technology needs for high-speed rotorcraft, volume 1
[NASA-CR-177585] p 742 N91-26139
Certification procedures and requirements
p 759 N91-26154

DETECTION
Dynamic tester for rotor seals and bearings
[NASA-CASE-MFS-28493-1] p 763 N91-25155

DETONATION
Comparisons of numerical and exact solutions for oblique detonations with structure
[AIAA PAPER 91-1677] p 721 A91-43587

DETONATION WAVES
Combusting flow simulations of detonation and shock-induced combustion waves for ram accelerator configurations with viscous effect
[AIAA PAPER 91-1674] p 721 A91-43584
Comparisons of numerical and exact solutions for oblique detonations with structure
[AIAA PAPER 91-1677] p 721 A91-43587

DIELECTRICS
Reduction of the RCS of the leading edge of a conducting wing-shaped structure by means of lossless dielectric material p 770 A91-42241

DIESEL ENGINES
Ceramic technology for advanced heat engines project
[DE91-010451] p 766 N91-26384

DIFFERENTIAL EQUATIONS
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740

DIFFUSERS
Active unsteady aerodynamic suppression of rotating stall in an incompressible flow centrifugal compressor with vaned diffuser
[AIAA PAPER 91-1898] p 704 A91-41644

DIGITAL SIMULATION
Supersonic inlet flow computations using fortified Navier-Stokes approach
[AIAA PAPER 91-1730] p 710 A91-42567
A simulation model of a single rotor helicopter
p 739 A91-43080
Numerical simulation of hypersonic viscous flow for the design of H-II orbiting plane (HOPE). II
[AIAA PAPER 91-1390] p 717 A91-43453
Numerical performance estimates for a generic hypersonic forebody
[AIAA PAPER 91-1695] p 722 A91-43595
Unsteady hot streak simulation through a 1-1/2 stage turbine engine
[AIAA PAPER 91-3382] p 775 A91-44321

DIGITAL SYSTEMS
A look at digital nose wheel steering
[AD-A233944] p 741 N91-26131
Digital signal conditioning for flight test, volume 19
[AGARD-AG-160-VOL-19] p 778 N91-26432
Structured representation for requirements and specifications
[NASA-CR-187522] p 783 N91-26797

DIRECTION FINDING
An Omega/VLF radio compass p 734 A91-41437

DIRECTIONAL CONTROL
Optimal control problems with switching points
p 782 N91-25694

DISCONTINUITY
An extension of essentially nonoscillatory shock-capturing schemes to multidimensional systems of conservation laws p 776 N91-25355

DISCRETE FUNCTIONS
Gust design procedures p 759 N91-26155

DISPLAY DEVICES
Visual systems for ATC training p 761 A91-42792
Format and basic geometry of a perspective display of air traffic for the cockpit
[NASA-TM-86680] p 743 N91-26142

DISSIPATION
State space models for aeroelastic and viscoelastic systems
[AD-A234730] p 732 N91-26117

DOPPLER RADAR
Estimating the period length of periodic signals
p 770 A91-41846

DRAG
Nonlinear oscillations of a heavy axisymmetric body in a resistant medium with drag p 784 A91-43169
Self-propelled slender axisymmetric body flows: Errors in the Poisson equation field calculation
p 731 N91-25110

DRAG REDUCTION
Super/hypersonic aerodynamic characteristics for a transatmospheric vehicle concept having a minimum drag forebody
[AIAA PAPER 91-1694] p 709 A91-42558
Automatic design of transonic airfoils to reduce the shock induced pressure drag p 716 A91-43078
Synthesis of experimental riblet studies in transonic conditions p 716 A91-43142

DRAINAGE
Guidelines for design, construction, and evaluation of airport pavement drainage
[DOT/FAA/RD-90/31] p 763 N91-26161

DROP SIZE
Dynamics of discrete phase in a gas turbine co-axial, counter-swirling, combustor dome swirl cup
[AIAA PAPER 91-2353] p 746 A91-41758

DROPS (LIQUIDS)
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies
p 771 A91-43310

DUCTED FLOW
Numerical investigation on shock wave/boundary-layer interactions in a constant area diffuser at Mach 3
[AIAA PAPER 91-1766] p 724 A91-43635
Advanced high bypass mixed-flow exhaust system design study
[AIAA PAPER 91-2242] p 753 A91-44168

DUCTS
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fab simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106

DUMP COMBUSTORS
Experimental and computational investigation of isothermal swirling flow in an axisymmetric dump combustor p 749 A91-42806
Numerical analysis of scramjet flows in a dump combustor
[AIAA PAPER 91-1676] p 749 A91-43586
Reduced pressure oscillations in a dump combustor with tapered corrugations
[AIAA PAPER 91-2354] p 753 A91-44208

DYNAMIC CHARACTERISTICS
Size dependence of gaseous cluster reactivity and evaporation dynamics as a mechanistic probe
[AD-A233811] p 766 N91-26249

DYNAMIC CONTROL
Theoretical studies of the kinematics, dynamics, stability, and control of unsteady/vortical flows
[AD-A235190] p 779 N91-26477

DYNAMIC MODELS
A simulation study of turbofan engine deterioration estimation using Kalman filtering techniques
[NASA-TM-104233] p 755 N91-25147
Gust design procedures p 759 N91-26155
Analysis by the statistical discrete gust method
p 759 N91-26156

DYNAMIC PRESSURE
Parametric study of airframe-integrated scramjet cooling requirement p 749 A91-42817
Dynamic tester for rotor seals and bearings
[NASA-CASE-MFS-28493-1] p 763 N91-25155
Optimal control problems with switching points
p 782 N91-25694

DYNAMIC PROGRAMMING
Computer aiding for low-altitude helicopter flight
[NASA-TM-103861] p 737 N91-25142

DYNAMIC RESPONSE
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113
Analysis by the statistical discrete gust method
p 759 N91-26156

DYNAMIC STRUCTURAL ANALYSIS
Analysis of structural damping of titanium alloy shell structures as compared with that of aluminium alloy structures p 765 A91-41606
A new method for the vibration of thin-walled beams
p 772 A91-43706
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113

DYNAMIC TESTS
Dynamic tester for rotor seals and bearings
[NASA-CASE-MFS-28493-1] p 763 N91-25155

E

EARTH ORBITAL ENVIRONMENTS
Reflections on the spaceplane p 785 A91-41548

EDDY VISCOSITY
Numerical investigation of the flow within a turbofan lobed mixer p 749 A91-42812
On the quasi-conical flowfield structure of the swept shock wave-turbulent boundary layer interaction
[AIAA PAPER 91-1759] p 724 A91-43632

EFFICIENCY
Results of the aeronautical systems division critical process team on integrated product development
[AD-A235419] p 785 N91-26995

EIGENVALUES
An optimal pole placement gain scheduling algorithm using output feedback p 782 N91-25643

EIGENVECTORS
An optimal pole placement gain scheduling algorithm using output feedback p 782 N91-25643

EJECTION SEATS
Effect of shock waves upon seat mounted sensors in escape systems p 738 A91-41543

EJECTORS
An ejector performance correlation factor
[AIAA PAPER 91-2545] p 748 A91-41810
Improved methods of characterizing ejector pumping performance p 749 A91-42815
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821
Static performance tests of a flight-type STOVL ejector
[AIAA PAPER 91-1902] p 750 A91-44050
A new concept for a hubless rotary jet
[AIAA PAPER 91-1903] p 750 A91-44051
Mixer/ejector noise suppressors
[AIAA PAPER 91-2243] p 753 A91-44169

ELASTIC BENDING
Dynamics of elastic bending and torsion of hingeless rotors with dynamic stall
[AD-A234775] p 741 N91-26134

ELASTIC PROPERTIES
Post-critical behaviour of a uniform cantilever column subjected to a tip concentrated subtangential follower force with small damping p 768 A91-41584
Unified methodology for airport pavement analysis and design. Volume 1: State of the art
[DOT/FAA/RD-91/15-VOL-1] p 762 N91-25154

ELASTIC SHELLS
Gasdynamic interaction of flow with an oscillating shell
p 703 A91-41157

ELECTRIC CHOPPERS
Accurate airborne surface temperature measurements with chopper-stabilized radiometers p 742 A91-42142

ELECTRONIC CONTROL
Design optimization of an electronic fuel control unit featuring two digital actuators
[AIAA PAPER 91-2003] p 745 A91-41672
A knowledge-based system design/information tool for aircraft flight control systems p 757 N91-25139

ELECTRONIC EQUIPMENT
How failure prediction methodology affects electronic equipment design p 768 A91-40812

ELECTRONIC PACKAGING
Failure detection of liquid cooled electronics in sealed packages --- in airborne information management system
[AIAA PAPER 91-1423] p 742 A91-43482

ELLIPTIC DIFFERENTIAL EQUATIONS
Numerical investigation of the flow within a turbofan lobed mixer p 749 A91-42812

EMERGENCIES
A preliminary investigation of the use of throttles for emergency flight control
[AIAA PAPER 91-2222] p 756 A91-41731

ENERGY CONVERSION
Experimental investigation of a unique airbreathing pulsed laser propulsion concept
[AIAA PAPER 91-1922] p 751 A91-44059

ENERGY DISSIPATION
Dissipation additions to flux-difference splitting
[AIAA PAPER 91-1544] p 697 A91-40719
An implicit three-dimensional Navier-Stokes solver for compressible flow
[AIAA PAPER 91-1555] p 698 A91-40729
Aeroacoustic and aerodynamic applications of the theory of nonequilibrium thermodynamics
[NASA-TP-3118] p 776 N91-25352

ENERGY METHODS
A drag analysis of the early stages of large-scale high-altitude free balloon ascents p 731 N91-25108

ENGINE AIRFRAME INTEGRATION
MACGS - A zonal grid generation system for complex aero-propulsion configurations
[AIAA PAPER 91-2156] p 738 A91-41714
Testing a modern turboprop propulsion system
[AIAA PAPER 91-2480] p 747 A91-41791
Parametric study of airframe-integrated scramjet cooling requirement p 749 A91-42817
Rapid methodology for design and performance prediction of integrated supersonic combustion ramjet engine p 739 A91-42818
Optimized scramjet integration on a waverider
[AIAA PAPER 91-1693] p 739 A91-43594
Compressor exit temperature analysis. II
[AIAA PAPER 91-2008] p 751 A91-44090

Supersonic air-intake study aiming at future airbreathing engine
[AIAA PAPER 91-2012] p 751 A91-44092
Advanced high bypass mixed-flow exhaust system design study
[AIAA PAPER 91-2242] p 753 A91-44168
A numerical study of hypersonic forebody/inlet integration problem p 732 N91-25343

ENGINE CONTROL
An integrated automatic ramjet engine control system tolerant to failures of the functional components
p 780 A91-41163
Optimization of the turbofan engine control program during the cruising flight of subsonic transport aircraft
p 743 A91-41170
Feedback linearization for control of air breathing engines
[AIAA PAPER 91-2000] p 745 A91-41671
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089
A simulation study of turbofan engine deterioration estimation using Kalman filtering techniques
[NASA-TM-104233] p 755 N91-25147

ENGINE COOLANTS
Parametric study of airframe-integrated scramjet cooling requirement p 749 A91-42817

ENGINE DESIGN
Twenty-first century aero-engine design - The environmental factor p 744 A91-41539
Design of the high reliability GMA 2100 reduction gearbox
[AIAA PAPER 91-1905] p 768 A91-41647
Composite gearboxes, designing for the 90's
[AIAA PAPER 91-1910] p 769 A91-41651
A Western engine for an Eastern aircraft - Re-engining of CSFR LET 610 turboprop transport with the GE CT7-9
[AIAA PAPER 91-1911] p 744 A91-41652
CFD analysis of a hydrogen fueled ramjet engine at Mach 3.44
[AIAA PAPER 91-1919] p 745 A91-41653
A row-by-row off-design performance calculation method for turbines
[AIAA PAPER 91-2132] p 745 A91-41705
A parametric experimental study of isolated rectangular nozzles
[AIAA PAPER 91-2136] p 738 A91-41706
High-speed rotorcraft propulsion
[AIAA PAPER 91-2147] p 746 A91-41709
The importance of maintainability and reliability in the design process - An airline perspective
[AIAA PAPER 91-2374] p 693 A91-41765
Rapid methodology for design and performance prediction of integrated supersonic combustion ramjet engine p 739 A91-42818
Upgraded T55 engine for Special Forces MH-47E aircraft
[AIAA PAPER 91-2024] p 752 A91-44094
A comparison of the analytical and experimental performance of the solid version of a cooled radial rotor
[AIAA PAPER 91-2133] p 752 A91-44133
High speed rotorcraft propulsion system studies
[AIAA PAPER 91-2150] p 752 A91-44135
Comparative analysis of turbofan effective thrust with mixed and separated flows engines
[AIAA PAPER 91-2376] p 754 A91-44216
Application of an unsteady Navier-Stokes solver to transonic turbine design
[AIAA PAPER 91-2468] p 729 A91-44254
Wind tunnel results of counter rotation prop-fans designed with lifting line and Euler code methods
[AIAA PAPER 91-2499] p 755 A91-44265
A new concept on compressor and turbine for aerospace propulsion
[AIAA PAPER 91-2591] p 755 A91-44303

ENGINE FAILURE
Computer modelling of implanted component faults in a gas turbine engine
[AIAA PAPER 91-1912] p 750 A91-44053

ENGINE INLETS
APU exhaust plume effects in underbody installations
[AIAA PAPER 91-1904] p 744 A91-41646
Mixing enhancement of reacting parallel fuel jets in a supersonic combustor
[AIAA PAPER 91-1914] p 750 A91-44055
Three-dimensional Navier-Stokes analysis of turbine passage heat transfer
[AIAA PAPER 91-2241] p 774 A91-44167
On the use of CFD in HSCT inlet and nozzle design --- High Speed Civil Transport
[AIAA PAPER 91-2255] p 728 A91-44173
A design strategy for the use of vortex generators to manage inlet-engine distortion using computational fluid dynamics
[AIAA PAPER 91-2474] p 729 A91-44259
Inlet/fan cowl design for increased angle-of-attack requirements of transport aircraft - Methodology and test results
[AIAA PAPER 91-2481] p 730 A91-44263
The impact of LO-configured forebodies on inlet approach flowfields
[AIAA PAPER 91-2599] p 730 A91-44304
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fab simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106
Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions
[CPIA-PUBL-551] p 775 N91-25336
Tests in helium illustrate high Mach number inlet-forebody interactions p 776 N91-25338
Sensitivity of inlet performance predictions to CFD numerical and physical modeling p 776 N91-25345

ENGINE MONITORING INSTRUMENTS
Neural network based expert system for compressor stall monitoring
[AIAA PAPER 91-2500] p 781 A91-44266

ENGINE NOISE
Twenty-first century aero-engine design - The environmental factor p 744 A91-41539
Three-dimensional jet noise computations
[AIAA PAPER 91-2256] p 784 A91-44174

ENGINE PARTS
A theoretical study on the vibration damping of aircraft gearbox gears
[AIAA PAPER 91-2558] p 738 A91-41813
Ceramic composites for aircraft gas turbine engines
[AIAA PAPER 91-1892] p 750 A91-44045
Advanced technology engine casing designs
[AIAA PAPER 91-1893] p 750 A91-44046
Lightweight ceramic components for propulsion applications
[AIAA PAPER 91-2217] p 774 A91-44159
Ceramic technology for advanced heat engines project
[DE91-010451] p 766 N91-26384

ENGINE STARTERS
An approach to modeling continuous turbine engine operation from startup to shutdown
[AIAA PAPER 91-2373] p 747 A91-41764

ENGINE TESTS
Design of a language processor for aviation engine testing p 760 A91-41164
New capabilities for aeromechanical testing and evaluation of aircraft turbine engines
[AIAA PAPER 91-2498] p 747 A91-41801
Development of a vitiated air heater for engine test facilities
[AIAA PAPER 91-2501] p 761 A91-41802
Experimental and computational investigation of isothermal swirling flow in an axisymmetric dump combustor p 749 A91-42806
On the acoustical performances of noise suppressors with depressive networks for jet engines test rigs and supersonic wind tunnel facilities p 784 A91-42999
Performance evaluation of semi-freejet tests of the Generic High Speed Engine
[AIAA PAPER 91-2163] p 753 A91-44141
Hot-surface ignition and fire-suppression tests in an aircraft engine bay
[AIAA PAPER 91-2382] p 754 A91-44219
A demonstration of mode transition in a scramjet combustor
[AIAA PAPER 91-2395] p 754 A91-44225
Wind tunnel results of counter rotation prop-fans designed with lifting line and Euler code methods
[AIAA PAPER 91-2499] p 755 A91-44265
A neural network for the analysis of aircraft test data
p 781 N91-25133

ENTHALPY
New generation of free-piston shock tunnels
p 760 A91-40640
Laminar heat transfer to spherically blunted cones in high enthalpy hyper velocity flows p 695 A91-40646

ENTROPY
Aeroacoustic and aerodynamic applications of the theory of nonequilibrium thermodynamics
[NASA-TP-3118] p 776 N91-25352

ENVIRONMENT EFFECTS
Twenty-first century aero-engine design - The environmental factor p 744 A91-41539

EQUILIBRIUM FLOW
Viscous equilibrium computations using program LAURA
[AIAA PAPER 91-1389] p 717 A91-43452

EQUILIBRIUM METHODS
An investigation of hypersonic shock tunnel testing at an equilibrium interface condition of 4100 K - Theory and experiment
[AIAA PAPER 91-1707] p 761 A91-42560

ERROR CORRECTING CODES
Detection and avoidance of errors in computer software p 783 N91-25937

ERRORS
Detection and avoidance of errors in computer software p 783 N91-25937
The wild weasel development programs, one run, one hit, one error
[RAND-P-7661-RGS] p 778 N91-26431

ESCAPE SYSTEMS
Effect of shock waves upon seat mounted sensors in escape systems p 738 A91-41543

ESSENTIALLY NON-OSCILLATORY SCHEMES
An extension of essentially nonoscillatory shock-capturing schemes to multidimensional systems of conservation laws p 776 N91-25355

ESTIMATES
Estimation of the aeroelastic characteristics from flight test data of the STOL research aircraft ASKA
[NAL-TR-1083] p 740 N91-25145
An identification algorithm based on smoothing
p 782 N91-25642

ESTIMATING
Estimation of the aeroelastic characteristics from flight test data of the STOL research aircraft ASKA
[NAL-TR-1083] p 740 N91-25145

EULER EQUATIONS OF MOTION
Effect of a multi-dimensional flux function on the monotonicity of Euler and Navier-Stokes computations
[AIAA PAPER 91-1530] p 696 A91-40705
An explicit, rotated upwind algorithm for solution of the Euler/Navier-Stokes equations
[AIAA PAPER 91-1531] p 696 A91-40706
Higher order accuracy for upwind methods by using the compatibility equations
[AIAA PAPER 91-1543] p 697 A91-40718
A 3-D upwind Euler solver for unstructured meshes
[AIAA PAPER 91-1548] p 697 A91-40723
Finite element simulation of compressible flows with shocks
[AIAA PAPER 91-1551] p 767 A91-40725
The effect of artificial vorticity on the discrete solution of Euler equations
[AIAA PAPER 91-1553] p 698 A91-40727
Aerodynamic shape optimization using sensitivity analysis on third-order Euler equations
[AIAA PAPER 91-1577] p 699 A91-40751
A comparison of implicit multigrid Euler solvers implemented on a multiprocessor computer
[AIAA PAPER 91-1580] p 700 A91-40754
Grid convergence for adaptive methods
[AIAA PAPER 91-1592] p 701 A91-40766
On the validity of linearized unsteady Euler equations with shock capturing
[AIAA PAPER 91-1598] p 702 A91-40771
Quasi-3-D non-reflecting boundary conditions for Euler equations calculations
[AIAA PAPER 91-1603] p 702 A91-40775
Multiblock mesh generation for multiple element airfoils with Euler solutions p 714 A91-42719
Euler solver for arbitrary configurations - Further applications p 716 A91-43100
Airfoils admitting non-unique solutions of the Euler equations
[AIAA PAPER 91-1625] p 719 A91-43557
CFD prediction of the near-field sonic boom environment for two low boom HSCT configurations --- High Speed Civil Transport
[AIAA PAPER 91-1631] p 784 A91-43560
On the use and the accuracy of compressible flow codes at low Mach numbers
[AIAA PAPER 91-1662] p 721 A91-43577
Block-structured computation of three-dimensional transonic Euler equations
[AIAA PAPER 91-1679] p 721 A91-43588
An efficient method for estimating neighboring steady-state numerical solutions to the Euler equations
[AIAA PAPER 91-1680] p 722 A91-43589
A multidomain Euler code applied to hypersonic flows
[AIAA PAPER 91-1699] p 722 A91-43598
Aeropropulsion analysis of tactical aircraft - Status and plans
[AIAA PAPER 91-1528] p 740 A91-43673
A Finite Volume Lambda Formulation
[AIAA PAPER 91-2258] p 728 A91-44176
Prediction of unsteady aerodynamic loads in cascades using the linearized Euler equations on deforming grids
[AIAA PAPER 91-3378] p 730 A91-44318
Methods to enhance the accuracy of finite volume schemes 2
[FFA-147] p 779 N91-26466

EVALUATION
Technology needs for high-speed rotorcraft, volume 1
[NASA-CR-177585] p 742 N91-26139
EVAPORATION
Size dependence of gaseous cluster reactivity and evaporation dynamics as a mechanistic probe
[AD-A233811] p 766 N91-26249
EXHAUST DIFFUSERS
Aerodynamic free-jet nozzle performance augmentation using an exhaust diffuser
[AIAA PAPER 91-2270] p 705 A91-41740
EXHAUST EMISSION
A CFD study of jet mixing in reduced flow areas for lower combustor emissions
[AIAA PAPER 91-2460] p 747 A91-41788
IAE V2500 - Technology for the environment
p 749 A91-43118
EXHAUST FLOW SIMULATION
Static performance of a multiaxis thrust vectoring cruciform nozzle
[AIAA PAPER 91-2137] p 745 A91-41707
Computational and experimental aftbody flow fields for hypersonic, airbreathing configurations with scramjet exhaust flow simulation
[AIAA PAPER 91-1709] p 709 A91-42561
EXHAUST GASES
Release of benz(a)pyrene with the exhaust gases of gas turbine engines burning natural gas
p 764 A91-41173
APU exhaust plume effects in underbody installations
[AIAA PAPER 91-1904] p 744 A91-41646
Mixer/ejector noise suppressors
[AIAA PAPER 91-2243] p 753 A91-44169
EXHAUST NOZZLES
Thrust vectoring using non-axisymmetric nozzles with flexible contours
[AIAA PAPER 91-2368] p 746 A91-41761
A numerical study of compressible viscous flow in a novel exhaust system
[AIAA PAPER 91-1728] p 723 A91-43617
Advanced high bypass mixed-flow exhaust system design study
[AIAA PAPER 91-2242] p 753 A91-44168
CFD-based 3D turbofan exhaust nozzle analysis system
[AIAA PAPER 91-2478] p 754 A91-44261
EXHAUST SYSTEMS
Advanced high bypass mixed-flow exhaust system design study
[AIAA PAPER 91-2242] p 753 A91-44168
EXPERIMENT DESIGN
Aerothermal test methodology for the development of structural components for hypersonic vehicles
[AIAA PAPER 91-1441] p 764 A91-43498
EXPERT SYSTEMS
Computer-aided block-structuring through the use of optimization and expert system techniques
[AIAA PAPER 91-1585] p 700 A91-40759
Expert systems for training purposes
[AIAA PAPER 91-2508] p 780 A91-41805
An expert system for predicting flutter in turbomachines
[AIAA PAPER 91-2527] p 748 A91-41808
Systematic methods for knowledge acquisition and expert system development p 781 A91-43926
Neural network based expert system for compressor stall monitoring
[AIAA PAPER 91-2500] p 781 A91-44266
Knowledge Based System Applications for Guidance and Control
[AGARD-CP-474] p 736 N91-25121
The pilot's associate: Exploiting the intelligent advantage p 781 N91-25122
Knowledge-based cockpit assistant for IFR operations
p 736 N91-25125
Intelligent real-time knowledge based inflight mission management p 737 N91-25128
SEAN: A navigation aid expert system for combat aircraft p 737 N91-25137
Integrated control and avionics for air superiority: A knowledge-based decision aiding system
p 743 N91-25138
A knowledge-based system design/information tool for aircraft flight control systems p 757 N91-25139
EXTERNAL STORES
Potential flow applications to complex configurations
[AIAA PAPER 91-1634] p 719 A91-43562

F

F-104 AIRCRAFT
Repair of F-104 aircraft nosedome by composite patching p 693 A91-43009
F-117A AIRCRAFT
Stealth aircraft and technology from World War II to the Gulf. I - History and background p 743 A91-43772
F-14 AIRCRAFT
Computational simulations for fighter and hypersonic vehicle inlet-forebody interactions p 776 N91-25347
F-15 AIRCRAFT
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089
F-18 AIRCRAFT
A generalized patched-grid algorithm with application to the F-18 forebody with actuated control strake
p 715 A91-42736
F-4 AIRCRAFT
The wild weasel development programs, one run, one hit, one error
[RAND-P-7661-RGS] p 778 N91-26431
F-8 AIRCRAFT
Application of transformational ideas to automatic flight control design
[AD-A234758] p 758 N91-26148
FABRICATION
MBB Bo 108 - Serial construction begins
p 739 A91-43117
AGARD handbook on advanced casting
[AGARD-AG-299] p 775 N91-25302
FAILURE
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319
FAILURE ANALYSIS
How failure prediction methodology affects electronic equipment design p 768 A91-40812
An integrated automatic ramjet engine control system tolerant to failures of the functional components
p 780 A91-41163
Failure analysis and damage initiation in carbon-carbon composite materials under three-point bending
p 764 A91-41569
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799
Failure detection of liquid cooled electronics in sealed packages — in airborne information management system
[AIAA PAPER 91-1423] p 742 A91-43482
Failure analysis of structural systems
p 739 A91-43512
Development of an adaptive failure detection and identification system for detecting aircraft control element failures
[NASA-TP-3051] p 758 N91-25151
FAN BLADES
Inlet/fan cowl design for increased angle-of-attack requirements of transport aircraft - Methodology and test results
[AIAA PAPER 91-2481] p 730 A91-44263
Application of sweep to improve efficiency of a transonic fan. II - Performance and laser test results
[AIAA PAPER 91-2544] p 730 A91-44287
FANS
Influence of thickness and camber on the aeroelastic stability of supersonic throughflow fans
p 715 A91-42814
FAR FIELDS
Accelerated convergence to steady state by gradual far-field damping
[AIAA PAPER 91-1604] p 702 A91-40776
FATIGUE LIFE
Improved reduction of gust loads data for gust intensity p 758 N91-26153
FAULT TOLERANCE
FCS skewed sensors array - Practical considerations
p 742 A91-43082
Synchronization device of digital flight controlling computer and the algorithm for system scheduling
p 742 A91-43508
Development of an adaptive failure detection and identification system for detecting aircraft control element failures
[NASA-TP-3051] p 758 N91-25151
FAULT TREES
Computer modelling of implanted component faults in a gas turbine engine
[AIAA PAPER 91-1912] p 750 A91-44053
FEEDBACK CONTROL
Feedback linearization for control of air breathing engines
[AIAA PAPER 91-2000] p 745 A91-41671
An optimal pole placement gain scheduling algorithm using output feedback p 782 N91-25643
Applied high-speed imaging for the icing research program at NASA Lewis Research Center
[NASA-TM-104415] p 779 N91-26490
FIBER COMPOSITES
Spherical particle impact damage behaviour of a SiC fibre-reinforced chemical vapour infiltrated SiC composite p 765 A91-43752
FIBER OPTICS
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150
FIGHTER AIRCRAFT
Static and dynamic water tunnel flow visualization studies of a canard-configured X-31A-like fighter aircraft model
[AIAA PAPER 91-1629] p 708 A91-42537
Numerical study of the X-31 high angle-of-attack flow characteristics
[AIAA PAPER 91-1630] p 708 A91-42538
Computational fluid dynamics in the design of the YF-23 ATF prototype
[AIAA PAPER 91-1627] p 719 A91-43558
Forming of aluminum-lithium sheet for fighter aircraft applications p 765 A91-43913
Application of aluminum-lithium alloys to fighter aircraft
p 766 A91-43916
Systematic methods for knowledge acquisition and expert system development p 781 A91-43926
Propulsion systems for upgrades of current fighter aircraft
[AIAA PAPER 91-2026] p 752 A91-44095
The impact of LO-configured forebodies on inlet approach flowfields
[AIAA PAPER 91-2599] p 730 A91-44304
Flight control law synthesis using neural network theory
[AD-A234990] p 758 N91-26149
FILM COOLING
Supersonic film cooling effectiveness using air and helium for a range of injectant temperatures and Mach numbers
[AIAA PAPER 91-1416] p 772 A91-43477
Development of IR sensor window cooling requirements for endoatmospheric interceptors
[AIAA PAPER 91-1439] p 764 A91-44338
Investigation of hot streak migration and film cooling effects on the heat transfer in rotor/stator interacting flows
[AD-A235420] p 756 N91-26145
FINITE DIFFERENCE THEORY
Self-propelled slender axisymmetric body flows: Errors in the Poisson equation field calculation
p 731 N91-25110
A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114
Computation of broadband mixing noise from turbomachinery
[AD-A233991] p 784 N91-26878
FINITE ELEMENT METHOD
Finite element simulation of compressible flows with shocks
[AIAA PAPER 91-1551] p 767 A91-40725
A Runge-Kutta discontinuous finite element method for high speed flows
[AIAA PAPER 91-1575] p 699 A91-40749
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799
Reliability of initially compressed uncertain laminated plates in supersonic flow p 770 A91-42292
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113
FINITE VOLUME METHOD
Computational aspects of chemically reacting flows
[AIAA PAPER 91-1574] p 699 A91-40748
Vortical flow solutions using a time-lagged, thin-layer, Navier-Stokes algorithm p 707 A91-42279
Numerical investigation of the flow within a turbofan lobed mixer p 749 A91-42812
CFD prediction of the near-field sonic boom environment for two low boom HSCT configurations — High Speed Civil Transport
[AIAA PAPER 91-1631] p 784 A91-43560
On the use and the accuracy of compressible flow codes at low Mach numbers
[AIAA PAPER 91-1662] p 721 A91-43577
A Finite Volume Lambda Formulation
[AIAA PAPER 91-2258] p 728 A91-44176
Methods to enhance the accuracy of finite volume schemes 2
[FFA-147] p 779 N91-26466
FINNED BODIES
The peak surface pressure in fin-generated shock-wave boundary-layer interactions p 696 A91-40672

FINS
Correlative behaviours of shock/boundary layer interaction induced by sharp fin and semicone
[AIAA PAPER 91-1756] p 711 A91-42577
An experimental/computational study of heat transfer in sharp fin induced turbulent interactions at Mach 5
[AIAA PAPER 91-1764] p 724 A91-43633

FIRE PREVENTION
Hot-surface ignition and fire-suppression tests in an aircraft engine bay
[AIAA PAPER 91-2382] p 754 A91-44219

FLAME HOLDERS
Burning and flameholding characteristics of a miniature solid fuel ramjet combustor p 749 A91-42807

FLAME RETARDANTS
Hot-surface ignition and fire-suppression tests in an aircraft engine bay
[AIAA PAPER 91-2382] p 754 A91-44219

FLAME STABILITY
CFD analysis of baffle flame stabilization
[AIAA PAPER 91-1967] p 773 A91-44078

FLAME TEMPERATURE
A CFD study of jet mixing in reduced flow areas for lower combustor emissions
[AIAA PAPER 91-2460] p 747 A91-41788

FLAPPING
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102

FLAPS (CONTROL SURFACES)
Navier-Stokes solution for high-lift multielement airfoil system with flap separation
[AIAA PAPER 91-1623] p 707 A91-42535
A study of flow separation on an aspect ratio three flap at Mach number 2.4
[AIAA PAPER 91-1620] p 718 A91-43554
The delay of turbulent boundary layer separation by oscillatory active control
[ITN-91-85104] p 779 N91-26482

FLAT PLATES
A numerical analysis of the flow passing through a cascade with tip clearance - Subsonic flow through a linear cascade composed of flat plates p 695 A91-40575
Leading edge effect on rarefied hypersonic flow over a flat plate
[AIAA PAPER 91-1749] p 710 A91-42573

FLAT SURFACES
Mach 6 turbulent boundary layer characteristics on smooth and rough surfaces
[AIAA PAPER 91-1762] p 711 A91-42580

FLEXIBLE BODIES
Geogrid reinforced base course for flexible pavements for light aircraft: Literature review and test section design
[DOT/FAA/RD-90/28] p 763 N91-26160

FLEXIBLE WINGS
Fuzzy logic for control of roll and moment for a flexible wing aircraft p 757 A91-43932

FLIGHT CHARACTERISTICS
Determination of orientation accuracy in curved flight paths p 736 A91-41835
Euler solver for arbitrary configurations - Further applications p 716 A91-43100
A powered lift experiment for CFD validation
[AIAA PAPER 91-1731] p 723 A91-43619
Performance optimization of helicopter rotor blades
[NASA-TM-104054] p 741 N91-26137
Acquisition of statistical gust load data by commercial airplanes p 758 N91-26152

FLIGHT CONDITIONS
Prediction of helicopter rotor rotational noise p 784 A91-43503
Incompressible boundary layer transition flight experiments over a nonaxisymmetric fuselage forebody and comparisons with laminar boundary layer stability theory p 777 N91-25359
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124

FLIGHT CONTROL
A preliminary investigation of the use of throttles for emergency flight control
[AIAA PAPER 91-2222] p 756 A91-41731
FCS skewed sensors array - Practical considerations p 742 A91-43082
A simulation evaluation of a four-engine jet transport using engine thrust modulation for flightpath control
[AIAA PAPER 91-2223] p 757 A91-44162
A knowledge-based system design/information tool for aircraft flight control systems p 757 N91-25139
An optimal pole placement gain scheduling algorithm using output feedback p 782 N91-25643
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113
Establishment of a remotely piloted helicopter test flight program for higher harmonic control research
[AD-A234978] p 741 N91-26135
Flight control law synthesis using neural network theory
[AD-A234990] p 758 N91-26149
Structured representation for requirements and specifications
[NASA-CR-187522] p 783 N91-26797

FLIGHT CREWS
Seeking crashworthy seats p 740 A91-44345
Technical evaluation report on the flight mechanics panel symposium on progress in military airlift
[AGARD-AR-300] p 733 N91-25119

FLIGHT MANAGEMENT SYSTEMS
Constraint management requirements for on-line aircraft route planning p 737 N91-25126

FLIGHT MECHANICS
Technical evaluation report on the flight mechanics panel symposium on progress in military airlift
[AGARD-AR-300] p 733 N91-25119

FLIGHT OPERATIONS
ACAS in Europe - A U.K. view p 733 A91-41448

FLIGHT PATHS
A new threat detection criterion for airborne collision avoidance systems p 735 A91-41447
Determination of orientation accuracy in curved flight paths p 736 A91-41835
TABS - An automated pre-flight planning system p 733 A91-42783
Computer aiding for low-altitude helicopter flight
[NASA-TM-103861] p 737 N91-25142
How low can an unmanned air vehicle fly?
[RAND-P-7680-RGS] p 741 N91-26138

FLIGHT PLANS
Computer-drawn charts for EROPS flights p 735 A91-41446

FLIGHT SAFETY
The European ATC system - Constraints and traffic management p 734 A91-41439
The progressive improvement of European flow-management p 734 A91-41440
Alternative strategies for traffic flow-management in Europe p 734 A91-41442
Aging fleet - Maintaining airworthiness p 693 A91-43077

FLIGHT SIMULATORS
Creating a scene p 775 A91-44342

FLIGHT TEST INSTRUMENTS
Digital signal conditioning for flight test, volume 19
[AGARD-AG-160-VOL-19] p 778 N91-26432

FLIGHT TEST VEHICLES
Establishment of a remotely piloted helicopter test flight program for higher harmonic control research
[AD-A234978] p 741 N91-26135

FLIGHT TESTS
Stabilization of the sling load of a helicopter p 756 A91-41169
A simulation model of a single rotor helicopter p 739 A91-43080
In-flight measurement of static pressures and boundary-layer state with integrated sensors p 742 A91-43306
Flight test and numerical simulation of transonic flow around YAV-8B Harrier II wing
[AIAA PAPER 91-1628] p 719 A91-43559
Trim angle measurements in free-flight facilities
[AIAA PAPER 91-1632] p 719 A91-43561
Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis
[AIAA PAPER 91-1635] p 719 A91-43563
Static performance tests of a flight-type STOVL ejector
[AIAA PAPER 91-1902] p 750 A91-44050
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089
A knowledge-based system design/information tool for aircraft flight control systems p 757 N91-25139
Estimation of the aeroelastic characteristics from flight test data of the STOL research aircraft ASKA
[NAL-TR-1083] p 740 N91-25145
Observation of laminar boundary layer transition on light monoplane wing surface
[NAL-TR-1077] p 777 N91-25366
An identification algorithm based on smoothing p 782 N91-25642
Digital signal conditioning for flight test, volume 19
[AGARD-AG-160-VOL-19] p 778 N91-26432

FLOW CHAMBERS
A quiet flow Ludwieg tube for study of transition in compressible boundary layers: Design and feasibility
[NASA-CR-188499] p 731 N91-25107

FLOW CHARACTERISTICS
Numerical study of the X-31 high angle-of-attack flow characteristics
[AIAA PAPER 91-1630] p 708 A91-42538
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration
[AIAA PAPER 91-1689] p 748 A91-42556
Simple leakage flow model for brush seals
[AIAA PAPER 91-1913] p 773 A91-44054
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124

FLOW DISTORTION
Compressible stability of growing boundary layers using parabolized stability equations
[AIAA PAPER 91-1636] p 720 A91-43564
A design strategy for the use of vortex generators to manage inlet-engine distortion using computational fluid dynamics
[AIAA PAPER 91-2474] p 729 A91-44259

FLOW DISTRIBUTION
An explicit, rotated upwind algorithm for solution of the Euler/Navier-Stokes equations
[AIAA PAPER 91-1531] p 696 A91-40706
An adaptively-refined Cartesian mesh solver for the Euler equations
[AIAA PAPER 91-1542] p 697 A91-40717
Computational rotorcraft flowfield research at the U.S. Army AeroStructures Directorate p 703 A91-41148
CFD analysis of a hydrogen fueled ramjet engine at Mach 3.44
[AIAA PAPER 91-1919] p 745 A91-41653
Dynamics of discrete phase in a gas turbine co-axial, counter-swirling, combustor dome swirl cup
[AIAA PAPER 91-2353] p 746 A91-41758
A three-dimensional Navier-Stokes stage analysis of the flow through a compact radial turbine
[AIAA PAPER 91-2564] p 748 A91-41815
Effect of nose bluntness on flowfield over slender bodies in hypersonic flows p 707 A91-42256
Unsteady fluid dynamic model for propeller induced flow fields
[AIAA PAPER 91-1664] p 709 A91-42550
Investigation of the tip shape influence on the flowfield around hovering rotor blades
[AIAA PAPER 91-1754] p 711 A91-42576
The vortex kinematics associated with an oscillating delta wing
[AIAA PAPER 91-1797] p 712 A91-42596
Some characteristics of and dynamic scaling behavior in strong vortex flows
[AIAA PAPER 91-1821] p 713 A91-42609
Numerical investigation of the flow within a turbofan lobed mixer p 749 A91-42812
Study of cluster formation and its effects on Rayleigh and Raman scattering measurements in a Mach 6 wind tunnel
[AIAA PAPER 91-1496] p 718 A91-43547
CFD computations for aero-optical analysis of supersonic shear layers
[AIAA PAPER 91-1659] p 720 A91-43574
Numerical analysis of scramjet flows in a dump combustor
[AIAA PAPER 91-1676] p 749 A91-43586
Comparisons of numerical and exact solutions for oblique detonations with structure
[AIAA PAPER 91-1677] p 721 A91-43587
An efficient method for estimating neighboring steady-state numerical solutions to the Euler equations
[AIAA PAPER 91-1680] p 722 A91-43589
A quantitative study of unsteady compressible flow on an oscillating airfoil
[AIAA PAPER 91-1683] p 722 A91-43590
A multidomain Euler code applied to hypersonic flows
[AIAA PAPER 91-1699] p 722 A91-43598
Detailed measurements on unsteady properties in three-dimensional show wave/turbulent boundary layer interaction induced by blunt fin at Mach number 4
[AIAA PAPER 91-1755] p 723 A91-43629
Flow field structure and development near the root of a straight wing pitching at constant rate
[AIAA PAPER 91-1793] p 725 A91-43646
Vortical flows about a long cylinder at M = 3.5 and alpha = 18 deg
[AIAA PAPER 91-1808] p 726 A91-43651
High angle of attack aerodynamics of a glide vehicle
[AIAA PAPER 91-1813] p 726 A91-43654
Numerical simulation of vortex breakdown over a delta wing
[AIAA PAPER 91-1814] p 726 A91-43655
The vortex interaction in a propeller/stator flow field
[AIAA PAPER 91-1818] p 726 A91-43657
Interaction between a vortex dominated wake and a separated flowfield
[AIAA PAPER 91-1819] p 727 A91-43658

The laminar horseshoe vortex system formed at a cylinder/plate juncture
[AIAA PAPER 91-1826] p 727 A91-43659
Navier-Stokes simulation of the supersonic combustion flowfield in a ram accelerator
[AIAA PAPER 91-1916] p 773 A91-44057
Prediction of jet mean flow structure in support of HSCT noise suppression concepts --- High Speed Civilian Transport
[AIAA PAPER 91-2253] p 774 A91-44171
Analysis of losses in supersonic mixing and reacting flows
[AIAA PAPER 91-2266] p 774 A91-44180
Flowfield analysis of a backswept centrifugal impeller
[AIAA PAPER 91-2470] p 774 A91-44255
A design strategy for the use of vortex generators to manage inlet-engine distortion using computational fluid dynamics
[AIAA PAPER 91-2474] p 729 A91-44259
CFD code validation for nozzle flowfields
[AIAA PAPER 91-2565] p 775 A91-44295
The impact of LO-configured forebodies on inlet approach flowfields
[AIAA PAPER 91-2599] p 730 A91-44304
Self-propelled slender axisymmetric body flows: Errors in the Poisson equation field calculation
p 731 N91-25110
Velocity measurements inside the leading edge vortex formed on a delta wing
[NAL-TR-1087] p 732 N91-25115
The design/analysis of flows through turbomachinery: A viscous/inviscid approach
[NASA-TM-104447] p 755 N91-25148
Computational simulations for fighter and hypersonic vehicle inlet-forebody interactions p 776 N91-25347
High-speed forebody-inlet code validation experience at MCAIR p 776 N91-25348

FLOW EQUATIONS
Compressible boundary layer stability analyzed with the PSE equations
[AIAA PAPER 91-1637] p 708 A91-42539
An extension of essentially nonoscillatory shock-capturing schemes to multidimensional systems of conservation laws p 776 N91-25355

FLOW GEOMETRY
Collar grids for intersecting geometric components within the Chimera overlapped grid scheme
[AIAA PAPER 91-1587] p 700 A91-40761
Unstructured meshes and surface fidelity for complex shapes
[AIAA PAPER 91-1591] p 701 A91-40765
Potential flow applications to complex configurations
[AIAA PAPER 91-1634] p 719 A91-43562
A new concept for a hubless rotary jet
[AIAA PAPER 91-1903] p 750 A91-44051
Computations of three-dimensional viscous flows in turbomachinery cascades
[AIAA PAPER 91-2237] p 728 A91-44164

FLOW MEASUREMENT
A new vertical shock tube for Rayleigh-Taylor instability measurements p 759 A91-40637
Laser velocimetry measurements of supersonic vortex flows on a simple razor-edged delta wing
[AIAA PAPER 91-1684] p 709 A91-42553
LDV measurements in the roll-up region of the tip vortex from a rectangular wing
[AIAA PAPER 91-1685] p 709 A91-42554

FLOW STABILITY
Sources of high alpha vortex asymmetry at zero sideslip
[AIAA PAPER 91-1810] p 713 A91-42604
Influence of thickness and camber on the aeroelastic stability of supersonic throughflow fans
p 715 A91-42814
Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis
[AIAA PAPER 91-1635] p 719 A91-43563
Transition predictions using Reynolds-averaged Navier-Stokes and linear stability analysis methods
[AIAA PAPER 91-1641] p 720 A91-43567
Aeroacoustic and aerodynamic applications of the theory of nonequilibrium thermodynamics
[NASA-TP-3118] p 776 N91-25352
Methods to enhance the accuracy of finite volume schemes 2
[FFA-147] p 779 N91-26466
Theoretical studies of the kinematics, dynamics, stability, and control of unsteady/vortical flows
[AD-A235190] p 779 N91-26477

FLOW VELOCITY
Approximate analysis and sensitivity analysis methods for viscous flow involving variation of geometric shape
[AIAA PAPER 91-1569] p 767 A91-40743
A Runge-Kutta discontinuous finite element method for high speed flows
[AIAA PAPER 91-1575] p 699 A91-40749
Structured and unstructured remeshing method for high-speed flows p 713 A91-42630
Laser velocimetry measurements of oscillating airfoil dynamic stall flow field
[AIAA PAPER 91-1799] p 725 A91-43648
Effect of the grid system on heat transfer computations for high speed flows
[DE91-010874] p 777 N91-25375

FLOW VISUALIZATION
An adaptively-refined Cartesian mesh solver for the Euler equations
[AIAA PAPER 91-1542] p 697 A91-40717
Visualization of airblast atomized spray structure under varying air pressure conditions
[AIAA PAPER 91-2199] p 769 A91-41726
Static and dynamic water tunnel flow visualization studies of a canard-configured X-31A-like fighter aircraft model
[AIAA PAPER 91-1629] p 708 A91-42537
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration
[AIAA PAPER 91-1689] p 748 A91-42556
Vortex topology for rectangular wings in pictures, sketches and conjectures
[AIAA PAPER 91-1824] p 713 A91-42611
Combined tangential-normal injection into a supersonic flow p 715 A91-42816
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821
Visualization measurements of vortex flows
p 716 A91-43309
Instantaneous planar visualization of reacting supersonic flows using silane seeding
[AIAA PAPER 91-1690] p 772 A91-43593
An experimental/computational study of heat transfer in sharp fin induced turbulent interactions at Mach 5
[AIAA PAPER 91-1764] p 724 A91-43633
Flow field structure and development near the root of a straight wing pitching at constant rate
[AIAA PAPER 91-1793] p 725 A91-43646
Interaction between a vortex dominated wake and a separated flowfield
[AIAA PAPER 91-1819] p 727 A91-43658
Supersonic air-intake study aiming at future airbreathing engine
[AIAA PAPER 91-2012] p 751 A91-44092
Design and development of a compact bifurcated turboprop inlet
[AIAA PAPER 91-2017] p 727 A91-44093
Observation of laminar boundary layer transition on light monoplane wing surface
[NAL-TR-1077] p 777 N91-25366

FLUID DYNAMICS
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740

FLUID FLOW
Generalized conjugate-gradient methods for the Navier-Stokes equations
[AIAA PAPER 91-1556] p 698 A91-40730

FLUID INJECTION
Combined tangential-normal injection into a supersonic flow p 715 A91-42816

FLUID JETS
CFD analysis of jet mixing in low NOx flametube combustors
[NASA-TM-104466] p 756 N91-26146

FLUID MECHANICS
Calculated aerodynamics of wings in severe maneuver
[AD-A235241] p 732 N91-26120

FLUTTER
Flutter control of incompressible flow turbomachine blade rows by splitter blades
[AIAA PAPER 91-1900] p 704 A91-41645
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319

FLUTTER ANALYSIS
An expert system for predicting flutter in turbomachines
[AIAA PAPER 91-2527] p 748 A91-41808
Transonic flutter analysis of aerodynamic surfaces in the presence of structural nonlinearities
p 713 A91-42710
A study on the stiffness simulation calculation method of flutter models of after body and horizontal tail of a new type aeroplane p 739 A91-43511

FLUX VECTOR SPLITTING
Dissipation additions to flux-difference splitting
[AIAA PAPER 91-1544] p 697 A91-40719
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740
Development of a new flux splitting scheme
p 768 A91-40793
Pressure-based flux vector splitting for blunt geometries p 703 A91-40797
Numerical simulation of hypersonic viscous flow for the design of H-II orbiting plane (HOPE). II
[AIAA PAPER 91-1390] p 717 A91-43453
Theoretical study of supersonic flow separation over a rearward facing step
[AIAA PAPER 91-2161] p 753 A91-44139
Navier-Stokes results for hypersonic inlet flows
[AIAA PAPER 91-2472] p 729 A91-44257
Effect of the grid system on heat transfer computations for high speed flows
[DE91-010874] p 777 N91-25375

FLY BY WIRE CONTROL
FCS skewed sensors array - Practical considerations
p 742 A91-43082
Structured representation for requirements and specifications
[NASA-CR-187522] p 783 N91-26797

FOREBODIES
Super/hypersonic aerodynamic characteristics for a transatmospheric vehicle concept having a minimum drag forebody
[AIAA PAPER 91-1694] p 709 A91-42558
Chine forebody vortex manipulation by mechanical and pneumatic techniques on a delta wing configuration
[AIAA PAPER 91-1812] p 713 A91-42605
A generalized patched-grid algorithm with application to the F-18 forebody with actuated control strake
p 715 A91-42736
Numerical performance estimates for a generic hypersonic forebody
[AIAA PAPER 91-1695] p 722 A91-43595
The impact of LO-configured forebodies on inlet approach flowfields
[AIAA PAPER 91-2599] p 730 A91-44304
Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions
[CPIA-PUBL-551] p 775 N91-25336
Tests in helium illustrate high Mach number inlet-forebody interactions p 776 N91-25338
CFD calibration and application to the design of flow tailoring devices for simulating forebody influences on fighter aircraft inlet flows p 776 N91-25339
Computational simulations for fighter and hypersonic vehicle inlet-forebody interactions p 776 N91-25347
High-speed forebody-inlet code validation experience at MCAIR p 776 N91-25348
Incompressible boundary layer transition flight experiments over a nonaxisymmetric fuselage forebody and comparisons with laminar boundary layer stability theory p 777 N91-25359

FORGING
A comparison of large AA8090, AA8091 and AA7010 die forgings for helicopter structural applications
p 765 A91-43912

FORMING TECHNIQUES
Forming of aluminum-lithium sheet for fighter aircraft applications p 765 A91-43913

FOURIER TRANSFORMATION
Upwind implicit residual smoothing method for multi-stage schemes
[AIAA PAPER 91-1533] p 696 A91-40708

FREE FLOW
Jet-wake thermal characteristics of heated turbulent jets in crossflow p 770 A91-42258
Sizing supersonic freejet nozzle and inlet location for simulation of the transition phase in integral rocket ramjet p 763 A91-43084

FREE JETS
Aerodynamic free-jet nozzle performance augmentation using an exhaust diffuser
[AIAA PAPER 91-2270] p 705 A91-41740
Planar laser-induced fluorescence imaging of underexpanded free jet flow in a shock tunnel facility
[AIAA PAPER 91-1687] p 761 A91-43592

FREE-PISTON ENGINES
A compression ignition driver for a free piston shock tunnel p 759 A91-40638

FRICTION FACTOR
An experimental investigation into the effects turbulator profile and spacing have on heat transfer coefficients and friction factors in small cooled turbine airfoils
[AIAA PAPER 91-2033] p 773 A91-44099

FUEL COMBUSTION
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets
p 748 A91-42805

Burning and flameholding characteristics of a miniature solid fuel ramjet combustor p 749 A91-42807
Fuel-rich, catalytic reaction experimental results --- fuel development for high-speed civil transport aircraft
[AIAA PAPER 91-2463] p 754 A91-44250

FUEL CONSUMPTION
Optimization of the turbofan engine control program during the cruising flight of subsonic transport aircraft p 743 A91-41170
Combined energy management and calculus of variations approach for optimizing hypersonic vehicle trajectories p 739 A91-42738

FUEL CONTROL
Characteristics of the working cycle of a low-pressure pneumatic nozzle with a sector structure of the fuel jet p 744 A91-41174
Design optimization of an electronic fuel control unit featuring two digital actuators
[AIAA PAPER 91-2003] p 745 A91-41672
The PC as a generic developmental fuel control for expendable turbojet engines
[AIAA PAPER 91-3399] p 755 A91-44329

FUEL INJECTION
Visualization of airblast atomized spray structure under varying air pressure conditions
[AIAA PAPER 91-2199] p 769 A91-41726
Model for airblast atomization p 771 A91-42801
Vortex breakdown in a supersonic jet
[AIAA PAPER 91-1815] p 726 A91-43656
Mixing enhancement of reacting parallel fuel jets in a supersonic combustor
[AIAA PAPER 91-1914] p 750 A91-44055
Effects of nozzle lip geometry on spray atomization and emissions advanced gas turbine combustors
[AIAA PAPER 91-2201] p 753 A91-44153
Analysis of losses in supersonic mixing and reacting flows
[AIAA PAPER 91-2266] p 774 A91-44180

FUEL SPRAYS
Characteristics of the working cycle of a low-pressure pneumatic nozzle with a sector structure of the fuel jet p 744 A91-41174
Model for airblast atomization p 771 A91-42801

FUEL SYSTEMS
Survey of current aircraft engine conditions
[AD-A235143] p 756 N91-26144

FUEL TANKS
Thermal modeling and analysis of a cryogenic tank design exposed to extreme heating profiles
[AIAA PAPER 91-1383] p 772 A91-43447

FUEL TESTS
Survey of current aircraft engine conditions
[AD-A235143] p 756 N91-26144

FUEL-AIR RATIO
Combined tangential-normal injection into a supersonic flow p 715 A91-42816

FUELS
What fuels our future?
[AD-A233674] p 767 N91-26387

FULL SCALE TESTS
Geogrid reinforced base course for flexible pavements for light aircraft: Literature review and test section design
[DOT/FAA/RD-90/28] p 763 N91-26160

FUNCTIONAL DESIGN SPECIFICATIONS
Functional baseline specification for ATC data link service implementation in the host computer system
[DOT/FAA/CT-91/12] p 779 N91-26433

FUSELAGES
A method for calculating the characteristics of a rotor with allowance for shaft vibrations p 768 A91-41155
An approach to aerodynamic characteristics of low radar cross-section fuselages p 718 A91-43501
Computational simulations for fighter and hypersonic vehicle inlet-forebody interactions p 776 N91-25347
Incompressible boundary layer transition flight experiments over a nonaxisymmetric fuselage forebody and comparisons with laminar boundary layer stability theory p 777 N91-25359

FUZZY SETS
Fuzzy logic for control of roll and moment for a flexible wing aircraft p 757 A91-43932

G

GALERKIN METHOD
A Runge-Kutta discontinuous finite element method for high speed flows
[AIAA PAPER 91-1575] p 699 A91-40749
A numerical study of surge and rotating stall in axial compressors
[AIAA PAPER 91-1896] p 727 A91-44048

GAS DENSITY
Multi-cascade compression - Effective means to obtain high temperature dense gas in piston gas dynamic units (PGU) p 760 A91-40641

GAS DYNAMICS
A 3-D upwind Euler solver for unstructured meshes
[AIAA PAPER 91-1548] p 697 A91-40723
High resolution nonoscillatory schemes for unsteady gas dynamics p 702 A91-40795
Gasdynamic interaction of flow with an oscillating shell p 703 A91-41157
A primary study of Reynolds number effect in transonic flow p 718 A91-43502
An extension of essentially nonoscillatory shock-capturing schemes to multidimensional systems of conservation laws p 776 N91-25355

GAS EXPANSION
Size dependence of gaseous cluster reactivity and evaporation dynamics as a mechanistic probe
[AD-A233811] p 766 N91-26249

GAS FLOW
Multi-cascade compression - Effective means to obtain high temperature dense gas in piston gas dynamic units (PGU) p 760 A91-40641
LU implicit TVD scheme for the solution of viscous two dimensional high speed flows
[AIAA PAPER 91-1573] p 699 A91-40747
The level of self-oscillations of aerodynamic control surfaces under nonseparating transonic gas flow p 703 A91-41218
Advanced high work turbine technology
[AIAA PAPER 91-2028] p 752 A91-44096

GAS GUNS
Experiments on hypersonic ramjet propulsion cycles using a ram accelerator
[AIAA PAPER 91-2489] p 762 A91-44264

GAS INJECTION
Mixing studies of helium in air at Mach 6
[AIAA PAPER 91-2268] p 705 A91-41739
Supersonic film cooling effectiveness using air and helium for a range of injectant temperatures and Mach numbers
[AIAA PAPER 91-1416] p 772 A91-43477

GAS MIXTURES
Mixing studies of helium in air at Mach 6
[AIAA PAPER 91-2268] p 705 A91-41739

GAS TURBINE ENGINES
Thermodynamic analysis of gas turbine engines and plants at high air pressure levels p 743 A91-41171
Release of benz(a)pyrene with the exhaust gases of gas turbine engines burning natural gas p 764 A91-41173
The wear mechanisms occurring in abradable seals of gas turbines p 768 A91-41508
Design optimization of an electronic fuel control unit featuring two digital actuators
[AIAA PAPER 91-2003] p 745 A91-41672
A row-by-row off-design performance calculation method for turbines
[AIAA PAPER 91-2132] p 745 A91-41705
Visualization of airblast atomized spray structure under varying air pressure conditions
[AIAA PAPER 91-2199] p 769 A91-41726
Aircraft gas turbine performance for the year 2000
[AIAA PAPER 91-2233] p 746 A91-41733
Viscous/inviscid method for preliminary design of transonic cascades
[AIAA PAPER 91-2364] p 706 A91-41760
Testing a modern turboprop propulsion system
[AIAA PAPER 91-2480] p 747 A91-41791
Expert systems for training purposes
[AIAA PAPER 91-2508] p 780 A91-41805
Model for airblast atomization p 771 A91-42801
Three-dimensional analysis of gas turbine combustors p 749 A91-42819
Ceramic composites for aircraft gas turbine engines
[AIAA PAPER 91-1892] p 750 A91-44045
Computer modelling of implanted component faults in a gas turbine engine
[AIAA PAPER 91-1912] p 750 A91-44053
Simple leakage flow model for brush seals
[AIAA PAPER 91-1913] p 773 A91-44054
Low NOx rich-lean combustion concept application
[AIAA PAPER 91-1962] p 751 A91-44075
Prediffuser-combustor model studies under conditions of water ingestion in engines
[AIAA PAPER 91-1965] p 751 A91-44077
Computations of three-dimensional gas turbine combustor flows
[AIAA PAPER 91-2076] p 773 A91-44116
Effects of nozzle lip geometry on spray atomization and emissions advanced gas turbine combustors
[AIAA PAPER 91-2201] p 753 A91-44153
Three-dimensional Navier-Stokes analysis of turbine passage heat transfer
[AIAA PAPER 91-2241] p 774 A91-44167
Fuel-rich, catalytic reaction experimental results --- fuel development for high-speed civil transport aircraft
[AIAA PAPER 91-2463] p 754 A91-44250
Survey of current aircraft engine conditions
[AD-A235143] p 756 N91-26144
Ceramic technology for advanced heat engines project
[DE91-010451] p 766 N91-26384

GAS TURBINES
Performance implications of gas-turbine pressure-gain combustors
[AIAA PAPER 91-1879] p 744 A91-41641
Dynamics of discrete phase in a gas turbine co-axial, counter-swirling, combustor dome swirl cup
[AIAA PAPER 91-2353] p 746 A91-41758
Effects of streamwise pressure gradient on the suction surface boundary layer of a turbine airfoil
[AIAA PAPER 91-2030] p 727 A91-44097
Improved turbulence modeling for gas turbine application
[AIAA PAPER 91-2239] p 728 A91-44165
CFD analysis of jet mixing in low NOx flametube combustors
[NASA-TM-104466] p 756 N91-26146

GEARS
Design of the high reliability GMA 2100 reduction gearbox
[AIAA PAPER 91-1905] p 768 A91-41647
Composite gearboxes, designing for the 90's
[AIAA PAPER 91-1910] p 769 A91-41651
A theoretical study on the vibration damping of aircraft gearbox gears
[AIAA PAPER 91-2558] p 738 A91-41813
Acoustical analysis of gear housing vibration
[NASA-TM-103691] p 777 N91-25411
Advanced Rotorcraft Transmission (ART) program-Boeing helicopters status report
[NASA-TM-104474] p 778 N91-25412

GEODETIC SURVEYS
GPS and airborne gravimetry - Recent progress and future plans p 742 A91-43315

GIBBS PHENOMENON
An extension of essentially nonoscillatory shock-capturing schemes to multidimensional systems of conservation laws p 776 N91-25355

GLIDERS
High angle of attack aerodynamics of a glide vehicle
[AIAA PAPER 91-1813] p 726 A91-43654

GLOBAL POSITIONING SYSTEM
Interoperability versus integration of Omega and GPS p 735 A91-41443
Combined satellite navigation systems could lead to more reliable and more precise air navigation p 736 A91-42780
GPS and airborne gravimetry - Recent progress and future plans p 742 A91-43315
Coordination and synchronization of loran-C and GPS to universal coordinated time
[AD-A233221] p 737 N91-25141

GOERTLER INSTABILITY
Goertler instability and hypersonic quiet nozzle design
[AIAA PAPER 91-1648] p 708 A91-42542

GOVERNMENT/INDUSTRY RELATIONS
Trends in aircraft engine materials
[AIAA PAPER 91-1890] p 693 A91-41643

GRAPHITE-EPOXY COMPOSITES
Composites move into jet engine design p 755 A91-44339

GRAVIMETRY
GPS and airborne gravimetry - Recent progress and future plans p 742 A91-43315

GRAVITY WAVES
Comparison of aircraft synthetic aperture radar and buoy spectra during the Norwegian Continental Shelf Experiment of 1988 p 779 A91-42224

GRID GENERATION (MATHEMATICS)
Implicit solvers for unstructured meshes
[AIAA PAPER 91-1537] p 696 A91-40712
Surface reconstruction from scattered data through pruning of unstructured grids
[AIAA PAPER 91-1584] p 700 A91-40758
Collar grids for intersecting geometric components within the Chimera overlapped grid scheme
[AIAA PAPER 91-1587] p 700 A91-40761
Grid restructuring for moving boundaries
[AIAA PAPER 91-1589] p 700 A91-40763
Grid convergence for adaptive methods
[AIAA PAPER 91-1592] p 701 A91-40766
Adaptive EAGLE - Solution-adaptive and quality-enhancing multi-block grids for arbitrary domains
[AIAA PAPER 91-1593] p 701 A91-40767
MACGS - A zonal grid generation system for complex aero-propulsion configurations
[AIAA PAPER 91-2156] p 738 A91-41714
Multigrid solutions of the three-dimensional grid equations p 706 A91-42098

Hopf bifurcation in viscous flows about airfoils at low speeds
[AIAA PAPER 91-1807] p 712 A91-42603
Structured and unstructured remeshing method for high-speed flows p 713 A91-42630
Multiblock mesh generation for multiple element airfoils with Euler solutions p 714 A91-42719
Airfoils admitting non-unique solutions of the Euler equations
[AIAA PAPER 91-1625] p 719 A91-43557
Grid generation for three-dimensional turbomachinery geometries including tip clearance
[AIAA PAPER 91-2360] p 753 A91-44209
Prediction of unsteady aerodynamic loads in cascades using the linearized Euler equations on deforming grids
[AIAA PAPER 91-3378] p 730 A91-44318
The design/analysis of flows through turbomachinery: A viscous/inviscid approach
[NASA-TM-104447] p 755 N91-25148
Navier-Stokes simulations of flows about complex configurations using domain decomposition techniques p 777 N91-25362

GROUND BASED CONTROL
Ground-based 4-D guidance of flights in strong winds p 734 A91-41438

GROUND EFFECT (AERODYNAMICS)
Low-speed, powered ground effects of a generic, hypersonic configuration
[NASA-TP-3092] p 730 N91-25103

GROUND SUPPORT EQUIPMENT
Ground support equipment maintenance data analysis p 760 A91-41538

GROUND TESTS
A knowledge-based system design/information tool for aircraft flight control systems p 757 N91-25139

GROUND-AIR-GROUND COMMUNICATION
Functional baseline specification for ATC data link service implementation in the host computer system
[DOT/FAA/CT-91/12] p 779 N91-26433

GUIDANCE SENSORS
Interoperability versus integration of Omega and GPS p 735 A91-41443

GUST ALLEVIATORS
Manual on the flight of flexible aircraft in turbulence
[AGARD-AG-317] p 758 N91-26150
Measurement of atmospheric turbulence p 780 N91-26151

GUST LOADS
Calculating time-correlated gust loads using matched filter and random process theories p 739 A91-43312
Manual on the flight of flexible aircraft in turbulence
[AGARD-AG-317] p 758 N91-26150
Acquisition of statistical gust load data by commercial airplanes p 758 N91-26152
Improved reduction of gust loads data for gust intensity p 758 N91-26153
Gust design procedures p 759 N91-26155
Analysis by the statistical discrete gust method p 759 N91-26156

GUSTS
Measurement of atmospheric turbulence p 780 N91-26151
Acquisition of statistical gust load data by commercial airplanes p 758 N91-26152
Improved reduction of gust loads data for gust intensity p 758 N91-26153
Certification procedures and requirements p 759 N91-26154
Gust design procedures p 759 N91-26155
Analysis by the statistical discrete gust method p 759 N91-26156

GYROSCOPIC STABILITY
A chart of unstable aircraft motions due to cross constraints of various origins p 756 A91-41156

H

HANDBOOKS
AGARD handbook on advanced casting
[AGARD-AG-299] p 775 N91-25302

HARMONIC CONTROL
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
Establishment of a remotely piloted helicopter test flight program for higher harmonic control research
[AD-A234978] p 741 N91-26135

HARMONIC GENERATIONS
Waves produced from a harmonic point source in a supersonic boundary layer
[AIAA PAPER 91-1646] p 720 A91-43571

HARRIER AIRCRAFT
Flight test and numerical simulation of transonic flow around YAV-8B Harrier II wing
[AIAA PAPER 91-1628] p 719 A91-43559
Refurbishing AV-8 on-board oxygen generation system beds
[AD-A235083] p 741 N91-26136

HEAT BALANCE
Heat management concepts for hypersonic propulsion systems
[AIAA PAPER 91-2493] p 769 A91-41798

HEAT FLUX
An experimental evaluation of thermochromic liquid crystals for surface temperature and heat flux measurements in shock tube flows p 767 A91-40645
Effect of the grid system on heat transfer computations for high speed flows
[DE91-010874] p 777 N91-25375

HEAT MEASUREMENT
An experimental evaluation of thermochromic liquid crystals for surface temperature and heat flux measurements in shock tube flows p 767 A91-40645

HEAT OF COMBUSTION
Enhanced capability of the Combustion-Heated Scramjet Test Facility
[AIAA PAPER 91-2502] p 762 A91-44267

HEAT PIPES
Heat pipe radiation cooling of advanced hypersonic propulsion system components
[AIAA PAPER 91-2358] p 746 A91-41759

HEAT TRANSFER
Surface heat transfer change induced by unsteady shock reflections and numerical simulations on shock reflection p 695 A91-40647
Application of shock tunnel at pressure and heat transfer experiments on turbine blade p 760 A91-40649
Studies of shock/shock interaction on smooth and transpiration-cooled hemispherical nosetips in hypersonic flow
[AIAA PAPER 91-1765] p 724 A91-43634
Improved turbulence modeling for gas turbine application
[AIAA PAPER 91-2239] p 728 A91-44165
Aerodynamic and heat transfer analysis of the low aspect ratio turbine using a 3D Navier-Stokes code
[AIAA PAPER 91-2240] p 774 A91-44166
Effect of the grid system on heat transfer computations for high speed flows
[DE91-010874] p 777 N91-25375
Investigation of hot streak migration and film cooling effects on the heat transfer in rotor/stator interacting flows
[AD-A235420] p 756 N91-26145

HEAT TRANSFER COEFFICIENTS
An experimental investigation into the effects turbulator profile and spacing have on heat transfer coefficients and friction factors in small cooled turbine airfoils
[AIAA PAPER 91-2033] p 773 A91-44099

HELICOPTER CONTROL
Stabilization of the sling load of a helicopter p 756 A91-41169

HELICOPTER DESIGN
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1906] p 769 A91-41648
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1909] p 769 A91-41650
A simulation model of a single rotor helicopter p 739 A91-43080
MBB Bo 108 - Serial construction begins p 739 A91-43117
Technology needs for high-speed rotorcraft, volume 1
[NASA-CR-177585] p 742 N91-26139

HELICOPTER ENGINES
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1906] p 769 A91-41648
Upgraded T55 engine for Special Forces MH-47E aircraft
[AIAA PAPER 91-2024] p 752 A91-44094
High speed rotorcraft propulsion system studies
[AIAA PAPER 91-2150] p 752 A91-44135

HELICOPTER PROPELLER DRIVE
Advanced Rotorcraft Transmission (ART) program-Boeing helicopters status report
[NASA-TM-104474] p 778 N91-25412

HELICOPTER WAKES
Experimental investigation of the near wake structure of a helicopter rotor in forward flight
[AIAA PAPER 91-1753] p 711 A91-42575

HELICOPTERS
A comparison of large AA8090, AA8091 and AA7010 die forgings for helicopter structural applications p 765 A91-43912
Computer aiding for low-altitude helicopter flight
[NASA-TM-103861] p 737 N91-25142
Establishment of a remotely piloted helicopter test flight program for higher harmonic control research
[AD-A234978] p 741 N91-26135
Performance optimization of helicopter rotor blades
[NASA-TM-104054] p 741 N91-26137

HELIUM
Mixing studies of helium in air at Mach 6
[AIAA PAPER 91-2268] p 705 A91-41739
Tests in helium illustrate high Mach number inlet-forebody interactions p 776 N91-25338

HESSIAN MATRICES
An identification algorithm based on smoothing p 782 N91-25642

HIGH ALTITUDE
Science requirements and feasibility/design studies of a very-high-altitude aircraft for atmospheric research p 740 N91-25481

HIGH ALTITUDE BALLOONS
A drag analysis of the early stages of large-scale high-altitude free balloon ascents p 731 N91-25108

HIGH POWER LASERS
Combustion-driven blowdown facilities for chemical laser research
[AIAA PAPER 91-1455] p 772 A91-43528

HIGH PRESSURE
Thermodynamic analysis of gas turbine engines and plants at high air pressure levels p 743 A91-41171

HIGH REYNOLDS NUMBER
New generation of free-piston shock tunnels p 760 A91-40640

HIGH SPEED
Tests in helium illustrate high Mach number inlet-forebody interactions p 776 N91-25338
High-speed forebody-inlet code validation experience at MCAIR p 776 N91-25348
Technology needs for high-speed rotorcraft, volume 1
[NASA-CR-177585] p 742 N91-26139
Applied high-speed imaging for the icing research program at NASA Lewis Research Center
[NASA-TM-104415] p 779 N91-26490

HIGH SPEED CAMERAS
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets p 748 A91-42805

HIGH SPEED PHOTOGRAPHY
Visualization of airblast atomized spray structure under varying air pressure conditions
[AIAA PAPER 91-2199] p 769 A91-41726

HIGH TEMPERATURE
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150

HIGH TEMPERATURE GASES
Multi-cascade compression - Effective means to obtain high temperature dense gas in piston gas dynamic units (PGU) p 760 A91-40641
Advanced high work turbine technology
[AIAA PAPER 91-2028] p 752 A91-44096

HIGH TEMPERATURE TESTS
Investigation of coatings at high temperature for use in turbomachinery p 744 A91-41507

HINGES
Unified treatment for dealing with auxiliary conditions in blade dynamics p 770 A91-42294
Pivoting seat for fighter aircraft
[AD-D014822] p 733 N91-25120

HISTORIES
Stealth aircraft and technology from World War II to the Gulf. I - History and background p 743 A91-43772

HODOGRAPHS
Hodograph solution for compressible flow past a corner and comparison with Euler numerical predictions
[AIAA PAPER 91-1547] p 697 A91-40722

HOMING DEVICES
CFD computations for aero-optical analysis of supersonic shear layers
[AIAA PAPER 91-1659] p 720 A91-43574
The wild weasel development programs, one run, one hit, one error
[RAND-P-7661-RGS] p 778 N91-26431

HONEYCOMB CORES
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422

HORIZONTAL FLIGHT
Dynamics of elastic bending and torsion of hingeless rotors with dynamic stall
[AD-A234775] p 741 N91-26134
Performance optimization of helicopter rotor blades
[NASA-TM-104054] p 741 N91-26137

HORIZONTAL TAIL SURFACES
A study on the stiffness simulation calculation method of flutter models of after body and horizontal tail of a new type aeroplane p 739 A91-43511

HORSESHOE VORTICES
Numerical study of juncture flows
[AIAA PAPER 91-1660] p 720 A91-43575
The laminar horseshoe vortex system formed at a cylinder/plate juncture
[AIAA PAPER 91-1826] p 727 A91-43659

HOT SURFACES
Hot-surface ignition and fire-suppression tests in an aircraft engine bay
[AIAA PAPER 91-2382] p 754 A91-44219
HOUSINGS
Acoustical analysis of gear housing vibration
[NASA-TM-103691] p 777 N91-25411
HOVERING
Investigation of the tip shape influence on the flowfield around hovering rotor blades
[AIAA PAPER 91-1754] p 711 A91-42576
Dynamics of elastic bending and torsion of hingeless rotors with dynamic stall
[AD-A234775] p 741 N91-26134
HOVERING STABILITY
An investigation of a hovering rotor in ground effect
p 704 A91-41462
HUMAN FACTORS ENGINEERING
Development of a system of interactive computer programs for airplane conceptual design and advanced airplane analysis p 740 N91-25144
HYDROCARBON COMBUSTION
CFD analysis of baffle flame stabilization
[AIAA PAPER 91-1967] p 773 A91-44078
HYDROCARBON FUELS
Fuel-rich, catalytic reaction experimental results --- fuel development for high-speed civil transport aircraft
[AIAA PAPER 91-2463] p 754 A91-44250
HYDROGEN
An analytical comparison of convective heat transfer correlations in supercritical hydrogen
[AIAA PAPER 91-1382] p 771 A91-43446
HYDROGEN ENGINES
CFD analysis of a hydrogen fueled ramjet engine at Mach 3.44
[AIAA PAPER 91-1919] p 745 A91-41653
HYDROGEN FUELS
A demonstration of mode transition in a scramjet combustor
[AIAA PAPER 91-2395] p 754 A91-44225
HYPERSONIC AIRCRAFT
Recent advances in hypersonic technology
p 716 A91-43103
An analytical comparison of convective heat transfer correlations in supercritical hydrogen
[AIAA PAPER 91-1382] p 771 A91-43446
Low-speed, powered ground effects of a generic, hypersonic configuration
[NASA-TP-3092] p 730 N91-25103
HYPERSONIC BOUNDARY LAYER
Secondary instability of high-speed flows and the influence of wall cooling and suction
[AIAA PAPER 91-1647] p 720 A91-43572
HYPERSONIC COMBUSTION
Heat pipe radiation cooling of advanced hypersonic propulsion system components
[AIAA PAPER 91-2358] p 746 A91-41759
HYPERSONIC FLIGHT
Reflections on the spaceplane p 785 A91-41548
Heat management concepts for hypersonic propulsion systems
[AIAA PAPER 91-2493] p 769 A91-41798
Mach 6 turbulent boundary layer characteristics on smooth and rough surfaces
[AIAA PAPER 91-1762] p 711 A91-42580
Thermal modeling and analysis of a cryogenic tank design exposed to extreme heating profiles
[AIAA PAPER 91-1383] p 772 A91-43447
CFD code validation for nozzle flowfields
[AIAA PAPER 91-2565] p 775 A91-44295
HYPERSONIC FLOW
Laminar heat transfer to spherically blunted cones in high enthalpy hyper velocity flows p 695 A91-40646
A new Lagrangian random choice method for steady two-dimensional supersonic/hypersonic flow
[AIAA PAPER 91-1546] p 697 A91-40721
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740
Multigrid for hypersonic viscous two- and three-dimensional flows
[AIAA PAPER 91-1572] p 699 A91-40746
Asynchronous, macrotasked relaxation strategies for the solution of viscous, hypersonic flows
[AIAA PAPER 91-1579] p 700 A91-40753
Application of a solution adaptive grid scheme, SAGE, to complex three-dimensional flows
[AIAA PAPER 91-1594] p 701 A91-40768
A numerical investigation of turbulent baseflow
p 703 A91-40799
Mixing studies of helium in air at Mach 6
[AIAA PAPER 91-2268] p 705 A91-41739
Effect of nose bluntness on flowfield over slender bodies in hypersonic flows p 707 A91-42256
Navier-Stokes computations of hypersonic flow past a blunt edge delta wing at several angles of attack
[AIAA PAPER 91-1698] p 709 A91-42559
Leading edge effect on rarefied hypersonic flow over a flat plate
[AIAA PAPER 91-1749] p 710 A91-42573
Hypersonic shock/boundary-layer interaction database
[AIAA PAPER 91-1763] p 711 A91-42581
Structured and unstructured remeshing method for high-speed flows p 713 A91-42630
Hypersonic rarefied flow about a compression corner - DSMC simulation and experiment
[AIAA PAPER 91-1313] p 716 A91-43385
Hypersonic rarefied flow about a delta wing - Direct simulation and comparison with experiment
[AIAA PAPER 91-1315] p 716 A91-43387
Direct simulation of waveriders in hypersonic rarefied flow
[AIAA PAPER 91-1317] p 717 A91-43389
An approximate viscous shock layer approach to calculating hypersonic flows about blunt-nosed bodies
[AIAA PAPER 91-1348] p 717 A91-43417
Numerical simulation of hypersonic viscous flow for the design of H-II orbiting plane (HOPE). II
[AIAA PAPER 91-1390] p 717 A91-43453
Numerical performance estimates for a generic hypersonic forebody
[AIAA PAPER 91-1695] p 722 A91-43595
A multidomain Euler code applied to hypersonic flows
[AIAA PAPER 91-1699] p 722 A91-43598
Multigrid solution of hypersonic flows using rational Runge-Kutta scheme
[AIAA PAPER 91-1703] p 722 A91-43602
A numerical study of the flow establishment time in hypersonic shock tunnels
[AIAA PAPER 91-1706] p 722 A91-43604
Studies of shock/shock interaction on smooth and transpiration-cooled hemispherical nosetips in hypersonic flow
[AIAA PAPER 91-1765] p 724 A91-43634
Progress in hypersonic turbulence modeling
[AIAA PAPER 91-1785] p 724 A91-43642
Performance comparisons of Navier-Stokes codes for simulating three-dimensional hypersonic crossflow/jet interaction
[AIAA PAPER 91-2096] p 728 A91-44127
Navier-Stokes results for hypersonic inlet flows
[AIAA PAPER 91-2472] p 729 A91-44257
HYPERSONIC HEAT TRANSFER
Heat management concepts for hypersonic propulsion systems
[AIAA PAPER 91-2493] p 769 A91-41798
HYPERSONIC INLETS
3-D Navier-Stokes analysis of crossing, glancing shocks/turbulent boundary layer interactions
[AIAA PAPER 91-1758] p 723 A91-43631
Intakes and boundary layer crossflows for hypersonic vehicles
[AIAA PAPER 91-2160] p 728 A91-44138
Computational simulations for fighter and hypersonic vehicle inlet-forebody interactions p 776 N91-25347
HYPERSONIC NOZZLES
Goertler instability and hypersonic quiet nozzle design
[AIAA PAPER 91-1648] p 708 A91-42542
HYPERSONIC REENTRY
Multigrid solution of hypersonic flows using rational Runge-Kutta scheme
[AIAA PAPER 91-1703] p 722 A91-43602
HYPERSONIC SHOCK
An investigation of hypersonic shock tunnel testing at an equilibrium interface condition of 4100 K - Theory and experiment
[AIAA PAPER 91-1707] p 761 A91-42560
HYPERSONIC SPEED
Some aspects of shock-wave boundary layer interaction at hypersonic speeds p 695 A91-40578
Laminar heat transfer to spherically blunted cones in high enthalpy hyper velocity flows p 695 A91-40646
HYPERSONIC VEHICLES
Reflections on the spaceplane p 785 A91-41548
Analysis of pressure distribution on hypersonic vehicles with power effects
[AIAA PAPER 91-2491] p 738 A91-41796
Super/hypersonic aerodynamic characteristics for a transatmospheric vehicle concept having a minimum drag forebody
[AIAA PAPER 91-1694] p 709 A91-42558
Computational and experimental aftbody flow fields for hypersonic, airbreathing configurations with scramjet exhaust flow simulation
[AIAA PAPER 91-1709] p 709 A91-42561
Computational aerodynamics methodology for the Aerospace Plane p 714 A91-42728
Combined energy management and calculus of variations approach for optimizing hypersonic vehicle trajectories p 739 A91-42738
Rapid methodology for design and performance prediction of integrated supersonic combustion ramjet engine p 739 A91-42818
Thermostructural concepts for hypervelocity vehicles
p 764 A91-43311
Enhancements to the high speed convective heating and viscous drag prediction techniques of the Aerodynamic Preliminary Analysis System (APAS)
[AIAA PAPER 91-1435] p 717 A91-43494
Aerothermal test methodology for the development of structural components for hypersonic vehicles
[AIAA PAPER 91-1441] p 764 A91-43498
Hypersonic waverider analysis - A comparison of numerical and experimental results
[AIAA PAPER 91-1696] p 739 A91-43596
Interactive design of hypersonic waverider geometries
[AIAA PAPER 91-1697] p 740 A91-43597
Intakes and boundary layer crossflows for hypersonic vehicles
[AIAA PAPER 91-2160] p 728 A91-44138
Experiments on hypersonic ramjet propulsion cycles using a ram accelerator
[AIAA PAPER 91-2489] p 762 A91-44264
Development of IR sensor window cooling requirements for endoatmospheric interceptors
[AIAA PAPER 91-1439] p 764 A91-44338
Computational simulations for fighter and hypersonic vehicle inlet-forebody interactions p 776 N91-25347
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422
HYPERSONIC WIND TUNNELS
New generation of free-piston shock tunnels
p 760 A91-40640
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles
[AIAA PAPER 91-2273] p 760 A91-41741
Goertler instability and hypersonic quiet nozzle design
[AIAA PAPER 91-1648] p 708 A91-42542
A numerical study of the flow establishment time in hypersonic shock tunnels
[AIAA PAPER 91-1706] p 722 A91-43604
HYPERSONICS
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799
A numerical study of hypersonic forebody/inlet integration problem p 732 N91-25343

I

ICE FORMATION
Applied high-speed imaging for the icing research program at NASA Lewis Research Center
[NASA-TM-104415] p 779 N91-26490
IGNITION
Hot-surface ignition and fire-suppression tests in an aircraft engine bay
[AIAA PAPER 91-2382] p 754 A91-44219
IGNITION LIMITS
A compression ignition driver for a free piston shock tunnel p 759 A91-40638
IMAGE MOTION COMPENSATION
Specification of an inertial navigation system for experimental SAR p 735 A91-41829
IMAGE PROCESSING
Creating a scene p 775 A91-44342
Applied high-speed imaging for the icing research program at NASA Lewis Research Center
[NASA-TM-104415] p 779 N91-26490
IMAGING TECHNIQUES
A physical model of the swept shock wave/boundary-layer interaction flowfield
[AIAA PAPER 91-1768] p 712 A91-42582
Applied high-speed imaging for the icing research program at NASA Lewis Research Center
[NASA-TM-104415] p 779 N91-26490
IMPACT
KC-135 ground collision avoidance system questionnaire
[AD-A234385] p 733 N91-26125
Evaluation of the C/EC/KC-135 Ground Collision Avoidance System (GCAS), study 1
[AD-A235301] p 737 N91-26130
IMPACT DAMAGE
Spherical particle impact damage behaviour of a SiC fibre-reinforced chemical vapour infiltrated SiC composite p 765 A91-43752
IMPELLERS
Flowfield analysis of a backswept centrifugal impeller
[AIAA PAPER 91-2470] p 774 A91-44255
Titanium alloy integrated centrifugal impeller 5 coordinate computer assisted manufacturing technology
[AD-A234797] p 766 N91-26300

IMPINGEMENT
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies
p 771 A91-43310
IN-FLIGHT MONITORING
Condition monitoring of aircraft high lift systems
p 738 A91-41535
In-flight measurement of static pressures and boundary-layer state with integrated sensors
p 742 A91-43306
NASA/Ames Research Center DC-8 data system
p 782 N91-25458
INCOMPRESSIBLE BOUNDARY LAYER
Incompressible boundary layer transition flight experiments over a nonaxisymmetric fuselage forebody and comparisons with laminar boundary layer stability theory p 777 N91-25359
INCOMPRESSIBLE FLOW
The effect of artificial vorticity on the discrete solution of Euler equations
[AIAA PAPER 91-1553] p 698 A91-40727
Adaptive EAGLE - Solution-adaptive and quality-enhancing multi-block grids for arbitrary domains
[AIAA PAPER 91-1593] p 701 A91-40767
A numerical method for predicting transition in three-dimensional flows by spatial amplification theory
[AIAA PAPER 91-1606] p 702 A91-40778
Pressure-based flux vector splitting for blunt geometries p 703 A91-40797
Active unsteady aerodynamic suppression of rotating stall in an incompressible flow centrifugal compressor with vaned diffuser
[AIAA PAPER 91-1898] p 704 A91-41644
Flutter control of incompressible flow turbomachine blade rows by splitter blades
[AIAA PAPER 91-1900] p 704 A91-41645
Navier-Stokes solution of complete turbulent flow past finite axisymmetric bodies p 707 A91-42298
Low-dimensional description of the dynamics in separated flow past thick airfoils
[AIAA PAPER 91-1622] p 707 A91-42534
Numerical evaluation of vortex flow control devices
[AIAA PAPER 91-1825] p 713 A91-42612
Effect of thickness on the unsteady aerodynamics of closely coupled oscillating airfoils p 716 A91-43308
An experimental investigation of structure, mixing, and combustion in compressible turbulent shear layers
[AD-A235278] p 766 N91-26281
INCOMPRESSIBLE FLUIDS
An experimental investigation of structure, mixing, and combustion in compressible turbulent shear layers
[AD-A235278] p 766 N91-26281
INERTIAL NAVIGATION
Specification of an inertial navigation system for experimental SAR p 735 A91-41829
SEAN: A navigation aid expert system for combat aircraft p 737 N91-25137
INFRARED WINDOWS
Development of IR sensor window cooling requirements for endoatmospheric interceptors
[AIAA PAPER 91-1439] p 764 A91-44338
INGESTION
Wake ingestion propulsion benefit
[AIAA PAPER 91-2007] p 769 A91-41676
INGESTION (ENGINES)
Transient performance of fan engine with water ingestion
[AIAA PAPER 91-1897] p 750 A91-44049
Prediffuser-combustor model studies under conditions of water ingestion in engines
[AIAA PAPER 91-1965] p 751 A91-44077
Turbofan engine bird ingestion testing
[AIAA PAPER 91-2380] p 754 A91-44218
INLET AIRFRAME CONFIGURATIONS
Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions
[CPIA-PUBL-551] p 775 N91-25336
Tests in helium illustrate high Mach number inlet-forebody interactions p 776 N91-25338
A numerical study of hypersonic forebody/inlet integration problem p 732 N91-25343
Computational simulations for fighter and hypersonic vehicle inlet-forebody interactions p 776 N91-25347
High-speed forebody-inlet code validation experience at MCAIR p 776 N91-25348
INLET FLOW
Inlet turbulence distortion and viscous flow development in a controlled-diffusion compressor cascade at very high incidence
[AIAA PAPER 91-2004] p 704 A91-41673
Supersonic inlet flow computations using fortified Navier-Stokes approach
[AIAA PAPER 91-1730] p 710 A91-42567
On the use of CFD in HSCT inlet and nozzle design --- High Speed Civil Transport
[AIAA PAPER 91-2255] p 728 A91-44173
Navier-Stokes results for hypersonic inlet flows
[AIAA PAPER 91-2472] p 729 A91-44257
CFD calibration and application to the design of flow tailoring devices for simulating forebody influences on fighter aircraft inlet flows p 776 N91-25339
A numerical study of hypersonic forebody/inlet integration problem p 732 N91-25343
Computational simulations for fighter and hypersonic vehicle inlet-forebody interactions p 776 N91-25347
High-speed forebody-inlet code validation experience at MCAIR p 776 N91-25348
INLET PRESSURE
High-speed forebody-inlet code validation experience at MCAIR p 776 N91-25348
INLET TEMPERATURE
APU exhaust plume effects in underbody installations
[AIAA PAPER 91-1904] p 744 A91-41646
INSTRUMENT FLIGHT RULES
Knowledge-based cockpit assistant for IFR operations
p 736 N91-25125
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153
INTAKE SYSTEMS
Design and development of a compact bifurcated turboprop inlet
[AIAA PAPER 91-2017] p 727 A91-44093
INTERACTIONAL AERODYNAMICS
The peak surface pressure in fin-generated shock-wave boundary-layer interactions p 696 A91-40672
Unified zonal method based on the fortified Navier-Stokes concept
[AIAA PAPER 91-1558] p 698 A91-40732
Computational rotorcraft flowfield research at the U.S. Army AeroStructures Directorate p 703 A91-41148
Gasdynamic interaction of flow with an oscillating shell
p 703 A91-41157
Hypersonic shock/boundary-layer interaction database
[AIAA PAPER 91-1763] p 711 A91-42581
A physical model of the swept shock wave/boundary-layer interaction flowfield
[AIAA PAPER 91-1768] p 712 A91-42582
Numerical simulation of a three-dimensional shock wave-turbulent boundary layer interaction generated by a sharp fin at Mach 4 p 714 A91-42726
Rapid methodology for design and performance prediction of integrated supersonic combustion ramjet engine p 739 A91-42818
Hypersonic rarefied flow about a compression corner - DSMC simulation and experiment
[AIAA PAPER 91-1313] p 716 A91-43385
Detailed measurements on unsteady properties in three-dimensional show wave/turbulent boundary layer interaction induced by blunt fin at Mach number 4
[AIAA PAPER 91-1755] p 723 A91-43629
Supersonic viscous flow calculations for axisymmetric, two and three-dimensional configurations
[AIAA PAPER 91-1802] p 725 A91-43649
The vortex interaction in a propeller/stator flow field
[AIAA PAPER 91-1818] p 726 A91-43657
Interaction between a vortex dominated wake and a separated flowfield
[AIAA PAPER 91-1819] p 727 A91-43658
Performance comparisons of Navier-Stokes codes for simulating three-dimensional hypersonic crossflow/jet interaction
[AIAA PAPER 91-2096] p 728 A91-44127
INTERCEPTORS
Development of IR sensor window cooling requirements for endoatmospheric interceptors
[AIAA PAPER 91-1439] p 764 A91-44338
INTERFERENCE DRAG
A numerical study on wind tunnel interference effects in external burning test at M = 1.5
[AIAA PAPER 91-1675] p 749 A91-43585
INTERFEROMETRY
Dynamics of discrete phase in a gas turbine co-axial, counter-swirling, combustor dome swirl cup
[AIAA PAPER 91-2353] p 746 A91-41758
A quantitative study of unsteady compressible flow on an oscillating airfoil
[AIAA PAPER 91-1683] p 722 A91-43590
INTERNAL COMBUSTION ENGINES
Expert systems for training purposes
[AIAA PAPER 91-2508] p 780 A91-41805
INTERNATIONAL COOPERATION
MBB Bo 108 - Serial construction begins
p 739 A91-43117
INTERNATIONAL TRADE
Sub-contractors play new strategic roles
p 694 A91-43273
INVISCID FLOW
Higher order accuracy for upwind methods by using the compatibility equations
[AIAA PAPER 91-1543] p 697 A91-40718
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740
Unstructured meshes and surface fidelity for complex shapes
[AIAA PAPER 91-1591] p 701 A91-40765
A block-structured solution scheme with the multigrid method for three-dimensional inviscid transonic flows
p 706 A91-42096
On three-dimensional flow separation criteria
[AIAA PAPER 91-1740] p 710 A91-42571
Structured and unstructured remeshing method for high-speed flows p 713 A91-42630
Combusting flow simulations of detonation and shock-induced combustion waves for ram accelerator configurations with viscous effect
[AIAA PAPER 91-1674] p 721 A91-43584
An efficient method for estimating neighboring steady-state numerical solutions to the Euler equations
[AIAA PAPER 91-1680] p 722 A91-43589
The design/analysis of flows through turbomachinery: A viscous/inviscid approach
[NASA-TM-104447] p 755 N91-25148
ISOTHERMAL FLOW
Computations of three-dimensional gas turbine combustor flows
[AIAA PAPER 91-2076] p 773 A91-44116
ISOTHERMAL PROCESSES
Experimental and computational investigation of isothermal swirling flow in an axisymmetric dump combustor p 749 A91-42806

J

JET AIRCRAFT
Re-engining - The sound case for aircraft noise reduction
[AIAA PAPER 91-2144] p 783 A91-41708
JET AIRCRAFT NOISE
Mixer/ejector noise suppressors
[AIAA PAPER 91-2243] p 753 A91-44169
JET ENGINE FUELS
Fuel-rich, catalytic reaction experimental results --- fuel development for high-speed civil transport aircraft
[AIAA PAPER 91-2463] p 754 A91-44250
What fuels our future?
[AD-A233674] p 767 N91-26387
JET ENGINES
On the acoustical performances of noise suppressors with depressive networks for jet engines test rigs and supersonic wind tunnel facilities p 784 A91-42999
A new concept for a hubless rotary jet
[AIAA PAPER 91-1903] p 750 A91-44051
Composites move into jet engine design
p 755 A91-44339
JET FLOW
Planar laser-induced fluorescence imaging of underexpanded free jet flow in a shock tunnel facility
[AIAA PAPER 91-1687] p 761 A91-43592
On the use of CFD in HSCT inlet and nozzle design --- High Speed Civil Transport
[AIAA PAPER 91-2255] p 728 A91-44173
Three-dimensional jet noise computations
[AIAA PAPER 91-2256] p 784 A91-44174
JET IMPINGEMENT
Numerical and experimental study of fountain flows produced by multijet impingement on a ground plane
[AIAA PAPER 91-1806] p 771 A91-42602
Observations of supersonic transverse jets
[AIAA PAPER 91-1723] p 772 A91-43613
JET MIXING FLOW
Supersonic jet mixing enhancement by vortex generators
[AIAA PAPER 91-2263] p 705 A91-41738
Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41768
A CFD study of jet mixing in reduced flow areas for lower combustor emissions
[AIAA PAPER 91-2460] p 747 A91-41788
Jet-wake thermal characteristics of heated turbulent jets in crossflow p 770 A91-42258
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821
Mixing enhancement of reacting parallel fuel jets in a supersonic combustor
[AIAA PAPER 91-1914] p 750 A91-44055
Performance comparisons of Navier-Stokes codes for simulating three-dimensional hypersonic crossflow/jet interaction
[AIAA PAPER 91-2096] p 728 A91-44127

Mixer/ejector noise suppressors
[AIAA PAPER 91-2243] p 753 A91-44169
CFD analysis of jet mixing in low NOx flametube combustors
[NASA-TM-104466] p 756 N91-26146

JET NOZZLES
Aerodynamic free-jet nozzle performance augmentation using an exhaust diffuser
[AIAA PAPER 91-2270] p 705 A91-41740
On the use of CFD in HSCT inlet and nozzle design --- High Speed Civil Transport
[AIAA PAPER 91-2255] p 728 A91-44173

JET THRUST
Analysis of losses in supersonic mixing and reacting flows
[AIAA PAPER 91-2266] p 774 A91-44180

JOINED WINGS
A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114

JP-8 JET FUEL
What fuels our future?
[AD-A233674] p 767 N91-26387

K

K-EPSILON TURBULENCE MODEL
A novel implementation of an implicit k-epsilon turbulence model coupled with an explicit Navier-Stokes solver p 703 A91-40796
Numerical and experimental study of fountain flows produced by multijet impingement on a ground plane
[AIAA PAPER 91-1806] p 771 A91-42602
Numerical investigation of the flow within a turbofan lobed mixer p 749 A91-42812
Three-dimensional upwinding Navier-Stokes code with k-epsilon model for supersonic flows
[AIAA PAPER 91-1669] p 721 A91-43580
Progress in hypersonic turbulence modeling
[AIAA PAPER 91-1785] p 724 A91-43642

KALMAN FILTERS
Estimation of aircraft attitude by angular rate measurements p 757 A91-43095
A simulation study of turbofan engine deterioration estimation using Kalman filtering techniques
[NASA-TM-104233] p 755 N91-25147

KELVIN-HELMHOLTZ INSTABILITY
Numerical simulation of the unsteady vortex structure over a delta wing
[AIAA PAPER 91-1811] p 726 A91-43653

KERNEL FUNCTIONS
Kernel function occurring in subsonic unsteady potential flow p 707 A91-42280

KEROSENE
Visualization of airblast atomized spray structure under varying air pressure conditions
[AIAA PAPER 91-2199] p 769 A91-41726

KINEMATICS
The vortex kinematics associated with an oscillating delta wing
[AIAA PAPER 91-1797] p 712 A91-42596
An identification algorithm based on smoothing p 782 N91-25642
Theoretical studies of the kinematics, dynamics, stability, and control of unsteady/vortical flows
[AD-A235190] p 779 N91-26477

KINETIC ENERGY
Size dependence of gaseous cluster reactivity and evaporation dynamics as a mechanistic probe
[AD-A233811] p 766 N91-26249

KNOWLEDGE BASES (ARTIFICIAL INTELLIGENCE)
Expert systems for training purposes
[AIAA PAPER 91-2508] p 780 A91-41805
A knowledge-based tracker for aircraft formations --- using radar systems p 736 A91-41851
Systematic methods for knowledge acquisition and expert system development p 781 A91-43926
Integrated control and avionics for air superiority: A knowledge-based decision aiding system p 743 N91-25138
A knowledge-based system design/information tool for aircraft flight control systems p 757 N91-25139

KNUDSEN FLOW
Direct simulation of waveriders in hypersonic rarefied flow
[AIAA PAPER 91-1317] p 717 A91-43389

L

LAGRANGE MULTIPLIERS
Unified treatment for dealing with auxiliary conditions in blade dynamics p 770 A91-42294

LAMINAR BOUNDARY LAYER
Some aspects of shock-wave boundary layer interaction at hypersonic speeds p 695 A91-40578
Numerical evaluation of vortex flow control devices
[AIAA PAPER 91-1825] p 713 A91-42612
A parametric study of the leading edge attachment line for the F-16XL
[AIAA PAPER 91-1621] p 718 A91-43555
Transition predictions using Reynolds-averaged Navier-Stokes and linear stability analysis methods
[AIAA PAPER 91-1641] p 720 A91-43567
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116
Incompressible boundary layer transition flight experiments over a nonaxisymmetric fuselage forebody and comparisons with laminar boundary layer stability theory p 777 N91-25359
Observation of laminar boundary layer transition on light monoplane wing surface
[NAL-TR-1077] p 777 N91-25366

LAMINAR FLOW
Goertler instability and hypersonic quiet nozzle design
[AIAA PAPER 91-1648] p 708 A91-42542
Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis
[AIAA PAPER 91-1635] p 719 A91-43563
Numerical study of juncture flows
[AIAA PAPER 91-1660] p 720 A91-43575
Opportunities for applications of natural laminar flow technology at high-subsonic speeds
[AIAA PAPER 91-1773] p 724 A91-43638
A quiet flow Ludwieg tube for study of transition in compressible boundary layers: Design and feasibility
[NASA-CR-188499] p 731 N91-25107

LAMINAR HEAT TRANSFER
Laminar heat transfer to spherically blunted cones in high enthalpy hyper velocity flows p 695 A91-40646

LAMINATES
Failure analysis and damage initiation in carbon-carbon composite materials under three-point bending p 764 A91-41569
Reliability of initially compressed uncertain laminated plates in supersonic flow p 770 A91-42292

LANDING AIDS
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153

LANDING GEAR
Failure analysis of structural systems p 739 A91-43512
The reduction of cavity noise at subsonic speeds
[NAL-TR-1081] p 784 N91-25815

LASER ANEMOMETERS
Application of sweep to improve efficiency of a transonic fan. II - Performance and laser test results
[AIAA PAPER 91-2544] p 730 A91-44287

LASER APPLICATIONS
Velocity measurements in turbine engines - New developments using the laser two-focus method p 771 A91-43328

LASER DOPPLER VELOCIMETERS
Inlet turbulence distortion and viscous flow development in a controlled-diffusion compressor cascade at very high incidence
[AIAA PAPER 91-2004] p 704 A91-41673
Laser velocimetry measurements of supersonic vortex flows on a simple razor-edged delta wing
[AIAA PAPER 91-1684] p 709 A91-42553
LDV measurements in the roll-up region of the tip vortex from a rectangular wing
[AIAA PAPER 91-1685] p 709 A91-42554
Laser velocimetry measurements of oscillating airfoil dynamic stall flow field
[AIAA PAPER 91-1799] p 725 A91-43648

LASER INDUCED FLUORESCENCE
Planar laser-induced fluorescence imaging of underexpanded free jet flow in a shock tunnel facility
[AIAA PAPER 91-1687] p 761 A91-43592

LASER PROPULSION
Experimental investigation of a unique airbreathing pulsed laser propulsion concept
[AIAA PAPER 91-1922] p 751 A91-44059

LASERS
Size dependence of gaseous cluster reactivity and evaporation dynamics as a mechanistic probe
[AD-A233811] p 766 N91-26249

LATERAL CONTROL
Fuzzy logic for control of roll and moment for a flexible wing aircraft p 757 A91-43932

LAUNCH VEHICLES
HOTOL space transport for the twenty-first century p 763 A91-41537

LEADING EDGE FLAPS
Effects of leading-edge flap oscillation on unsteady delta wing flow and rock control
[AIAA PAPER 91-1796] p 725 A91-43647

LEADING EDGES
Condition monitoring of aircraft high lift systems p 738 A91-41535
Leading edge effect on rarefied hypersonic flow over a flat plate
[AIAA PAPER 91-1749] p 710 A91-42573
Numerical investigation of the effect of leading edge geometry on dynamic stall of airfoils
[AIAA PAPER 91-1798] p 712 A91-42597
Computation and visualization of leading edge vortex flows p 714 A91-42721
A parametric study of the leading edge attachment line for the F-16XL
[AIAA PAPER 91-1621] p 718 A91-43555
Interactive design of hypersonic waverider geometries
[AIAA PAPER 91-1697] p 740 A91-43597
Detailed measurements on unsteady properties in three-dimensional show wave/turbulent boundary layer interaction induced by blunt fin at Mach number 4
[AIAA PAPER 91-1755] p 723 A91-43629
Flow field structure and development near the root of a straight wing pitching at constant rate
[AIAA PAPER 91-1793] p 725 A91-43646
Application of sweep to improve efficiency of a transonic fan. II - Performance and laser test results
[AIAA PAPER 91-2544] p 730 A91-44287
Velocity measurements inside the leading edge vortex formed on a delta wing
[NAL-TR-1087] p 732 N91-25115
Calculated aerodynamics of wings in severe maneuver
[AD-A235241] p 732 N91-26120

LEAKAGE
Simple leakage flow model for brush seals
[AIAA PAPER 91-1913] p 773 A91-44054

LEAST SQUARES METHOD
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles
[AIAA PAPER 91-2273] p 760 A91-41741

LIFE CYCLE COSTS
VHSIC electronics and the cost of Air Force avionics in the 1990s
[RAND-R-3843-AF] p 743 N91-26143

LIFT
The effect of artificial vorticity on the discrete solution of Euler equations
[AIAA PAPER 91-1553] p 698 A91-40727
Drag and lift in nonadiabatic transonic flow
[AIAA PAPER 91-1716] p 710 A91-42564
Piaggio P180 Avanti - Efficiency using three levels of aerodynamic lift p 739 A91-43119

LIFT AUGMENTATION
Navier-Stokes solution for high-lift multielement airfoil system with flap separation
[AIAA PAPER 91-1623] p 707 A91-42535

LIFTING BODIES
Condition monitoring of aircraft high lift systems p 738 A91-41535
Piaggio P180 Avanti - Efficiency using three levels of aerodynamic lift p 739 A91-43119

LIGHT (VISIBLE RADIATION)
CFD evaluation of transonic-supersonic wave front propagation effects
[AIAA PAPER 91-1657] p 708 A91-42547

LIGHT AIRCRAFT
Geogrid reinforced base course for flexible pavements for light aircraft: Literature review and test section design
[DOT/FAA/RD-90/28] p 763 N91-26160

LINEARIZATION
Feedback linearization for control of air breathing engines
[AIAA PAPER 91-2000] p 745 A91-41671

LIQUID COOLING
Failure detection of liquid cooled electronics in sealed packages --- in airborne information management system
[AIAA PAPER 91-1423] p 742 A91-43482

LIQUID CRYSTALS
An experimental evaluation of thermochromic liquid crystals for surface temperature and heat flux measurements in shock tube flows p 767 A91-40645
An experimental investigation into the effects turbulator profile and spacing have on heat transfer coefficients and friction factors in small cooled turbine airfoils
[AIAA PAPER 91-2033] p 773 A91-44099

LITHIUM ALLOYS
The fatigue response of the aluminium-lithium alloy, 8090 p 765 A91-43857
Aluminium-lithium weldable alloy 1420 - Alloying system Al-Li-Mg-Zr p 765 A91-43891

A comparison of large AA8090, AA8091 and AA7010 die forgings for helicopter structural applications
p 765 A91-43912
Forming of aluminum-lithium sheet for fighter aircraft applications p 765 A91-43913
Application of aluminum-lithium alloys to fighter aircraft
p 766 A91-43916
Properties of commercially available Al-Li alloys' possible use on civil aircraft p 766 A91-43920

LORAN C
Coordination and synchronization of loran-C and GPS to universal coordinated time
[AD-A233221] p 737 N91-25141

LOSS OF COOLANT
Aerodynamic losses due to pressure side coolant ejection in a transonic turbine cascade
[AIAA PAPER 91-2032] p 745 A91-41684

LOW ALTITUDE
Computer aiding for low-altitude helicopter flight
[NASA-TM-103861] p 737 N91-25142

LOW ASPECT RATIO
Aerodynamic and heat transfer analysis of the low aspect ratio turbine using a 3D Navier-Stokes code
[AIAA PAPER 91-2240] p 774 A91-44166

LOW ASPECT RATIO WINGS
Comparison of cryogenic wind tunnel, flight, and computational results for a thin, low-aspect-ratio wing
[AIAA PAPER 91-1626] p 708 A91-42536
Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel
[AIAA PAPER 91-1725] p 723 A91-43615

LOW COST
Results of the aeronautical systems division critical process team on integrated product development
[AD-A235419] p 785 N91-26995

LOW DENSITY MATERIALS
Lightweight ceramic components for propulsion applications
[AIAA PAPER 91-2217] p 774 A91-44159

LOW REYNOLDS NUMBER
Approximate analysis and sensitivity analysis methods for viscous flow involving variation of geometric shape
[AIAA PAPER 91-1569] p 767 A91-40743
Progress in hypersonic turbulence modeling
[AIAA PAPER 91-1785] p 724 A91-43642
Supersonic wind tunnel diffuser performance with high model blockage at moderate to low Reynolds numbers
[AIAA PAPER 91-2274] p 761 A91-44183

LOW SPEED
Hopf bifurcation in viscous flows about airfoils at low speeds
[AIAA PAPER 91-1807] p 712 A91-42603
Low-speed, powered ground effects of a generic, hypersonic configuration
[NASA-TP-3092] p 730 N91-25103

LOW SPEED WIND TUNNELS
Chine forebody vortex manipulation by mechanical and pneumatic techniques on a delta wing configuration
[AIAA PAPER 91-1812] p 713 A91-42605
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fan simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106
A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114
Applied high-speed imaging for the icing research program at NASA Lewis Research Center
[NASA-TM-104415] p 779 N91-26490

M

MACH NUMBER
Mixing studies of helium in air at Mach 6
[AIAA PAPER 91-2268] p 705 A91-41739
Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41768
Mach 6 turbulent boundary layer characteristics on smooth and rough surfaces
[AIAA PAPER 91-1762] p 711 A91-42580
Parametric study of airframe-integrated scramjet cooling requirement p 749 A91-42817
Supersonic film cooling effectiveness using air and helium for a range of injectant temperatures and Mach numbers
[AIAA PAPER 91-1416] p 772 A91-43477
A study of flow separation on an aspect ratio three flap at Mach number 2.4
[AIAA PAPER 91-1620] p 718 A91-43554
On the use and the accuracy of compressible flow codes at low Mach numbers
[AIAA PAPER 91-1662] p 721 A91-43577
A numerical study on wind tunnel interference effects in external burning test at M = 1.5
[AIAA PAPER 91-1675] p 749 A91-43585
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116
Tests in helium illustrate high Mach number inlet-forebody interactions p 776 N91-25338

MACH REFLECTION
Second-order Godunov methods and self-similar steady supersonic three-dimensional flowfields
[AIAA PAPER 91-1653] p 708 A91-42544

MAGNETIC BEARINGS
Magnetic bearings-state of the art
[NASA-TM-104465] p 778 N91-25413

MAGNETIC COMPASSES
An Omega/VLF radio compass p 734 A91-41437

MAGNETIC FIELDS
Magnetic bearings-state of the art
[NASA-TM-104465] p 778 N91-25413

MAGNETIC LEVITATION VEHICLES
The potential role of maglev in short-haul airline operations
[DE91-010813] p 777 N91-25408

MAGNETIC SUSPENSION
Magnetic bearings-state of the art
[NASA-TM-104465] p 778 N91-25413

MAGNETOMETERS
Estimation of aircraft attitude by angular rate measurements p 757 A91-43095

MAINTENANCE
Expert systems for training purposes
[AIAA PAPER 91-2508] p 780 A91-41805
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100

MAN MACHINE SYSTEMS
Design of a language processor for aviation engine testing p 760 A91-41164
Constraint management requirements for on-line aircraft route planning p 737 N91-25126

MAN-COMPUTER INTERFACE
Format and basic geometry of a perspective display of air traffic for the cockpit
[NASA-TM-86680] p 743 N91-26142

MANAGEMENT METHODS
The European ATC system - Constraints and traffic management p 734 A91-41439
The progressive improvement of European flow-management p 734 A91-41440
The airline's perception of air traffic management
p 734 A91-41441
Alternative strategies for traffic flow-management in Europe p 734 A91-41442
Ground support equipment maintenance data analysis
p 760 A91-41538

MANAGEMENT SYSTEMS
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100

MANIPULATORS
Synthesis of experimental riblet studies in transonic conditions p 716 A91-43142

MARKET RESEARCH
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126

MASS TRANSFER
An ejector performance correlation factor
[AIAA PAPER 91-2545] p 748 A91-41810

MATCHED FILTERS
Calculating time-correlated gust loads using matched filter and random process theories p 739 A91-43312

MATHEMATICAL MODELS
Determination of the stress-strain state of a soft lifting system --- Single-Shell Parachute Airfoil
p 704 A91-41320
An approach to modeling continuous turbine engine operation from startup to shutdown
[AIAA PAPER 91-2373] p 747 A91-41764
A numerical study of surge and rotating stall in axial compressors
[AIAA PAPER 91-1896] p 727 A91-44048
A neural network for the analysis of aircraft test data
p 781 N91-25133
Navier-Stokes simulations of flows about complex configurations using domain decomposition techniques
p 777 N91-25362
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113
State space models for aeroelastic and viscoelastic systems
[AD-A234730] p 732 N91-26117
Performance optimization of helicopter rotor blades
[NASA-TM-104054] p 741 N91-26137
Certification procedures and requirements
p 759 N91-26154
Guidelines for design, construction, and evaluation of airport pavement drainage
[DOT/FAA/RD-90/31] p 763 N91-26161
Applied high-speed imaging for the icing research program at NASA Lewis Research Center
[NASA-TM-104415] p 779 N91-26490

MATRIX METHODS
Implicit solvers for unstructured meshes
[AIAA PAPER 91-1537] p 696 A91-40712

MAXIMUM LIKELIHOOD ESTIMATES
Estimating the period length of periodic signals
p 770 A91-41846
An identification algorithm based on smoothing
p 782 N91-25642

MEASURING INSTRUMENTS
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150
Guide to measurement of winds with instrumented aircraft
[NASA-CR-188601] p 780 N91-25553

MECHANICAL DRIVES
Condition monitoring of aircraft high lift systems
p 738 A91-41535

MECHANICAL ENGINEERING
Structural mechanics research in the DLR
p 771 A91-43334

MECHANICAL PROPERTIES
A comparison of large AA8090, AA8091 and AA7010 die forgings for helicopter structural applications
p 765 A91-43912
Properties of commercially available Al-Li alloys' possible use on civil aircraft p 766 A91-43920
AGARD handbook on advanced casting
[AGARD-AG-299] p 775 N91-25302

MESSAGE PROCESSING
KC-135 ground collision avoidance system questionnaire
[AD-A234385] p 733 N91-26125

METAL COMBUSTION
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets
p 748 A91-42805

METAL FATIGUE
The fatigue response of the aluminium-lithium alloy, 8090 p 765 A91-43857

METAL MATRIX COMPOSITES
Advanced technology engine casing designs
[AIAA PAPER 91-1893] p 750 A91-44046

METAL PROPELLANTS
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets
p 748 A91-42805

METAL SHEETS
Forming of aluminum-lithium sheet for fighter aircraft applications p 765 A91-43913

MICROCOMPUTERS
Ground support equipment maintenance data analysis
p 760 A91-41538
ATC simulators do not have to replicate operational systems physically p 761 A91-42789

MILITARY AIRCRAFT
The origins and evolution of design requirements for British military aircraft p 785 A91-41541
A knowledge-based tracker for aircraft formations --- using radar systems p 736 A91-41851
Aeropropulsion analysis of tactical aircraft - Status and plans
[AIAA PAPER 91-1528] p 740 A91-43673
Creating a scene p 775 A91-44342

MILITARY HELICOPTERS
Upgraded T55 engine for Special Forces MH-47E aircraft
[AIAA PAPER 91-2024] p 752 A91-44094

MILITARY OPERATIONS
Technical evaluation report on the flight mechanics panel symposium on progress in military airlift
[AGARD-AR-300] p 733 N91-25119

MILITARY TECHNOLOGY
Opportunities for advanced speech processing in military computer-based systems
[AD-A233724] p 778 N91-26412

MIMO (CONTROL SYSTEMS)
Fuzzy logic for control of roll and moment for a flexible wing aircraft p 757 A91-43932

MISSION PLANNING
Intelligent real-time knowledge based inflight mission management p 737 N91-25128
Computer aiding for low-altitude helicopter flight
[NASA-TM-103861] p 737 N91-25142

Mission planning systems for tactical aircraft (pre-flight and in-flight)
[AGARD-AR-296] p 783 N91-25750

MIXERS
Advanced high bypass mixed-flow exhaust system design study
[AIAA PAPER 91-2242] p 753 A91-44168

MIXING LAYERS (FLUIDS)
Combined tangential-normal injection into a supersonic flow p 715 A91-42816
Mixing enhancement in compressible mixing layers - An experimental study
[AIAA PAPER 91-1721] p 723 A91-43612

MIXING LENGTH FLOW THEORY
New mixing-length model for turbulent high-speed flows p 707 A91-42277
Improved methods of characterizing ejector pumping performance p 749 A91-42815
Mixing enhancement in compressible mixing layers - An experimental study
[AIAA PAPER 91-1721] p 723 A91-43612

MOMENT DISTRIBUTION
An approximate computation method to compute low-speed aerodynamic characteristics of wing with separation p 718 A91-43510

MOMENTS OF INERTIA
Concepts for reduction of turbine rotor inertia
[AIAA PAPER 91-2031] p 752 A91-44098

MOMENTUM TRANSFER
An ejector performance correlation factor
[AIAA PAPER 91-2545] p 748 A91-41810

MONITORS
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153

MONOPLANES
Observation of laminar boundary layer transition on light monoplane wing surface
[NAL-TR-1077] p 777 N91-25366

MONTE CARLO METHOD
Hypersonic rarefied flow about a compression corner - DSMC simulation and experiment
[AIAA PAPER 91-1313] p 716 A91-43385
Hypersonic rarefied flow about a delta wing - Direct simulation and comparison with experiment
[AIAA PAPER 91-1315] p 716 A91-43387
An efficient DSMC algorithm applied to a delta wing
[AIAA PAPER 91-1316] p 717 A91-43388
Direct simulation of waveriders in hypersonic rarefied flow
[AIAA PAPER 91-1317] p 717 A91-43389

MULTIGRID METHODS
A comparison of implicit multigrid Euler solvers implemented on a multiprocessor computer
[AIAA PAPER 91-1580] p 700 A91-40754
Adaptive EAGLE - Solution-adaptive and quality-enhancing multi-block grids for arbitrary domains
[AIAA PAPER 91-1593] p 701 A91-40767
Parallel block multigrid solution of the compressible Navier-Stokes equations p 702 A91-40792
MACGS - A zonal grid generation system for complex aero-propulsion configurations
[AIAA PAPER 91-2156] p 738 A91-41714
A block-structured solution scheme with the multigrid method for three-dimensional inviscid transonic flows p 706 A91-42096
Multigrid solutions of the three-dimensional grid equations p 706 A91-42098
Multiblock mesh generation for multiple element airfoils with Euler solutions p 714 A91-42719
A generalized patched-grid algorithm with application to the F-18 forebody with actuated control strake p 715 A91-42736
Multigrid solution of hypersonic flows using rational Runge-Kutta scheme
[AIAA PAPER 91-1703] p 722 A91-43602
Time dependent calculations using multigrid, with applications to unsteady flows past airfoils and wings
[AIAA PAPER 91-1596] p 727 A91-43675

MULTIPROCESSING (COMPUTERS)
A comparison of implicit multigrid Euler solvers implemented on a multiprocessor computer
[AIAA PAPER 91-1580] p 700 A91-40754

N

NACELLES
A Western engine for an Eastern aircraft - Re-engining of CSFR LET 610 turboprop transport with the GE CT7-9
[AIAA PAPER 91-1911] p 744 A91-41652

NASA PROGRAMS
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046

NATIONAL AEROSPACE PLANE PROGRAM
Use of the PARC code for generic NASP nozzles operating at off-design transonic conditions
[AIAA PAPER 91-2154] p 705 A91-41713
Performance evaluation of semi-freejet tests of the Generic High Speed Engine
[AIAA PAPER 91-2163] p 753 A91-44141

NATIONAL AIRSPACE SYSTEM
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100

NATURAL GAS
Release of benz(a)pyrene with the exhaust gases of gas turbine engines burning natural gas p 764 A91-41173

NAVIER-STOKES EQUATION
Effect of a multi-dimensional flux function on the monotonicity of Euler and Navier-Stokes computations
[AIAA PAPER 91-1530] p 696 A91-40705
An explicit, rotated upwind algorithm for solution of the Euler/Navier-Stokes equations
[AIAA PAPER 91-1531] p 696 A91-40706
A vertex-centroid scheme for improved finite-volume solution of the Navier-Stokes equations
[AIAA PAPER 91-1540] p 697 A91-40715
Higher order accuracy for upwind methods by using the compatibility equations
[AIAA PAPER 91-1543] p 697 A91-40718
An implicit three-dimensional Navier-Stokes solver for compressible flow
[AIAA PAPER 91-1555] p 698 A91-40729
Generalized conjugate-gradient methods for the Navier-Stokes equations
[AIAA PAPER 91-1556] p 698 A91-40730
Unified zonal method based on the fortified Navier-Stokes concept
[AIAA PAPER 91-1558] p 698 A91-40732
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740
Approximate analysis and sensitivity analysis methods for viscous flow involving variation of geometric shape
[AIAA PAPER 91-1569] p 767 A91-40743
Multigrid for hypersonic viscous two- and three-dimensional flows
[AIAA PAPER 91-1572] p 699 A91-40746
Asynchronous, macrotasked relaxation strategies for the solution of viscous, hypersonic flows
[AIAA PAPER 91-1579] p 700 A91-40753
A three-dimensional Navier-Stokes/full-potential coupled analysis for viscous transonic flow
[AIAA PAPER 91-1595] p 701 A91-40769
Computation of unsteady viscous flow using an efficient algorithm
[AIAA PAPER 91-1597] p 701 A91-40770
Parallel block multigrid solution of the compressible Navier-Stokes equations p 702 A91-40792
A novel implementation of an implicit k-epsilon turbulence model coupled with an explicit Navier-Stokes solver p 703 A91-40796
Three-dimensional Navier-Stokes calculations using solution-adaptive grids p 703 A91-40802
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles
[AIAA PAPER 91-2273] p 760 A91-41741
A three-dimensional Navier-Stokes stage analysis of the flow through a compact radial turbine
[AIAA PAPER 91-2564] p 748 A91-41815
Vortical flow solutions using a time-lagged, thin-layer, Navier-Stokes algorithm p 707 A91-42279
Navier-Stokes solution of complete turbulent flow past finite axisymmetric bodies p 707 A91-42298
Navier-Stokes solution for high-lift multielement airfoil system with flap separation
[AIAA PAPER 91-1623] p 707 A91-42535
Navier-Stokes computations of hypersonic flow past a blunt edge delta wing at several angles of attack
[AIAA PAPER 91-1698] p 709 A91-42559
Supersonic inlet flow computations using fortified Navier-Stokes approach
[AIAA PAPER 91-1730] p 710 A91-42567
Steady and unsteady solutions of the Navier-Stokes equations for flows about airfoils at low speeds
[AIAA PAPER 91-1733] p 710 A91-42568
Navier-Stokes correlation of a swept helicopter rotor tip at high alpha
[AIAA PAPER 91-1752] p 711 A91-42574
Navier-Stokes calculations for attached and separated flows using different turbulence models
[AIAA PAPER 91-1791] p 712 A91-42594
Numerical investigation of the effect of leading edge geometry on dynamic stall of airfoils
[AIAA PAPER 91-1798] p 712 A91-42597
Some characteristics of and dynamic scaling behavior in strong vortex flows
[AIAA PAPER 91-1821] p 713 A91-42609
A parametric study of the leading edge attachment line for the F-16XL
[AIAA PAPER 91-1621] p 718 A91-43555
Trim angle measurements in free-flight facilities
[AIAA PAPER 91-1632] p 719 A91-43561
A numerical study of the flow establishment time in hypersonic shock tunnels
[AIAA PAPER 91-1706] p 722 A91-43604
Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel
[AIAA PAPER 91-1725] p 723 A91-43615
3-D Navier-Stokes analysis of crossing, glancing shocks/turbulent boundary layer interactions
[AIAA PAPER 91-1758] p 723 A91-43631
Application of a Reynolds Stress turbulence model to a supersonic hydrogen-air diffusion flame
[AIAA PAPER 91-1786] p 725 A91-43643
Effects of leading-edge flap oscillation on unsteady delta wing flow and rock control
[AIAA PAPER 91-1796] p 725 A91-43647
Supersonic viscous flow calculations for axisymmetric, two and three-dimensional configurations
[AIAA PAPER 91-1802] p 725 A91-43649
High angle of attack aerodynamics of a glide vehicle
[AIAA PAPER 91-1813] p 726 A91-43654
Numerical simulation of vortex breakdown over a delta wing
[AIAA PAPER 91-1814] p 726 A91-43655
The laminar horseshoe vortex system formed at a cylinder/plate juncture
[AIAA PAPER 91-1826] p 727 A91-43659
Aeropropulsion analysis of tactical aircraft - Status and plans
[AIAA PAPER 91-1528] p 740 A91-43673
Navier-Stokes simulation of the supersonic combustion flowfield in a ram accelerator
[AIAA PAPER 91-1916] p 773 A91-44057
Performance comparisons of Navier-Stokes codes for simulating three-dimensional hypersonic crossflow/jet interaction
[AIAA PAPER 91-2096] p 728 A91-44127
Application of a multiblock/multizone code (PAB3D) for the three-dimensional Navier-Stokes equations
[AIAA PAPER 91-2155] p 728 A91-44137
Aerodynamic and heat transfer analysis of the low aspect ratio turbine using a 3D Navier-Stokes code
[AIAA PAPER 91-2240] p 774 A91-44166
Three-dimensional Navier-Stokes analysis of turbine passage heat transfer
[AIAA PAPER 91-2241] p 774 A91-44167
Prediction of jet mean flow structure in support of HSCT noise suppression concepts --- High Speed Civilian Transport
[AIAA PAPER 91-2253] p 774 A91-44171
Application of an unsteady Navier-Stokes solver to transonic turbine design
[AIAA PAPER 91-2468] p 729 A91-44254
Navier-Stokes results for hypersonic inlet flows
[AIAA PAPER 91-2472] p 729 A91-44257
A design strategy for the use of vortex generators to manage inlet-engine distortion using computational fluid dynamics
[AIAA PAPER 91-2474] p 729 A91-44259
Navier-Stokes simulations of flows about complex configurations using domain decomposition techniques p 777 N91-25362

NAVIGATION
An Omega/VLF radio compass p 734 A91-41437

NAVIGATION AIDS
Computer-drawn charts for EROPS flights p 735 A91-41446
Systematic methods for knowledge acquisition and expert system development p 781 A91-43926
SEAN: A navigation aid expert system for combat aircraft p 737 N91-25137

NAVIGATION INSTRUMENTS
Autonomous aircraft initiative study
[NASA-CR-186013] p 742 N91-26140

NAVIGATION SATELLITES
Combined satellite navigation systems could lead to more reliable and more precise air navigation p 736 A91-42780

NEAR WAKES
Experimental investigation of the near wake structure of a helicopter rotor in forward flight
[AIAA PAPER 91-1753] p 711 A91-42575

NEODYMIUM LASERS
Experimental investigation of a unique airbreathing pulsed laser propulsion concept
[AIAA PAPER 91-1922] p 751 A91-44059
NETWORK SYNTHESIS
Flight control law synthesis using neural network theory
[AD-A234990] p 758 N91-26149
NEURAL NETS
Neural network based expert system for compressor stall monitoring
[AIAA PAPER 91-2500] p 781 A91-44266
A neural network for the analysis of aircraft test data p 781 N91-25133
Flight control law synthesis using neural network theory
[AD-A234990] p 758 N91-26149
NITRIC OXIDE
IAE V2500 - Technology for the environment p 749 A91-43118
NITROGEN OXIDES
Low NOx rich-lean combustion concept application
[AIAA PAPER 91-1962] p 751 A91-44075
CFD analysis of jet mixing in low NOx flametube combustors
[NASA-TM-104466] p 756 N91-26146
NITROUS OXIDES
A CFD study of jet mixing in reduced flow areas for lower combustor emissions
[AIAA PAPER 91-2460] p 747 A91-41788
NOISE (SOUND)
Computation of broadband mixing noise from turbomachinery
[AD-A233991] p 784 N91-26878
NOISE PREDICTION (AIRCRAFT)
Re-engining - The sound case for aircraft noise reduction
[AIAA PAPER 91-2144] p 783 A91-41708
Prediction of helicopter rotor rotational noise p 784 A91-43503
Three-dimensional jet noise computations
[AIAA PAPER 91-2256] p 784 A91-44174
Acoustical analysis of gear housing vibration
[NASA-TM-103691] p 777 N91-25411
NOISE REDUCTION
The design and commissioning of an acoustic liner for propeller noise testing in the ARA transonic wind tunnel p 783 A91-41540
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1909] p 769 A91-41650
Re-engining - The sound case for aircraft noise reduction
[AIAA PAPER 91-2144] p 783 A91-41708
On the acoustical performances of noise suppressors with depressive networks for jet engines test rigs and supersonic wind tunnel facilities p 784 A91-42999
Mixer/ejector noise suppressors
[AIAA PAPER 91-2243] p 753 A91-44169
Prediction of jet mean flow structure in support of HSCT noise suppression concepts --- High Speed Civilian Transport
[AIAA PAPER 91-2253] p 774 A91-44171
Three-dimensional jet noise computations
[AIAA PAPER 91-2256] p 784 A91-44174
The reduction of cavity noise at subsonic speeds
[NAL-TR-1081] p 784 N91-25815
Aircraft interior noise reduction by alternate resonance tuning
[NASA-CR-185453] p 785 N91-26889
NONADIABATIC CONDITIONS
Drag and lift in nonadiabatic transonic flow
[AIAA PAPER 91-1716] p 710 A91-42564
NONEQUILIBRIUM THERMODYNAMICS
Aeroacoustic and aerodynamic applications of the theory of nonequilibrium thermodynamics
[NASA-TP-3118] p 776 N91-25352
NONLINEAR PROGRAMMING
An identification algorithm based on smoothing p 782 N91-25642
NONLINEAR SYSTEMS
Transonic flutter analysis of aerodynamic surfaces in the presence of structural nonlinearities p 713 A91-42710
Application of transformational ideas to automatic flight control design
[AD-A234758] p 758 N91-26148
NONLINEARITY
An identification algorithm based on smoothing p 782 N91-25642
NOSE CONES
Effect of nose bluntness on flowfield over slender bodies in hypersonic flows p 707 A91-42256
Repair of F-104 aircraft nosedome by composite patching p 693 A91-43009
NOSE TIPS
Studies of shock/shock interaction on smooth and transpiration-cooled hemispherical nosetips in hypersonic flow
[AIAA PAPER 91-1765] p 724 A91-43634
NOSE WHEELS
A look at digital nose wheel steering
[AD-A233944] p 741 N91-26131
NOSES (FOREBODIES)
An approximate viscous shock layer approach to calculating hypersonic flows about blunt-nosed bodies
[AIAA PAPER 91-1348] p 717 A91-43417
NOZZLE DESIGN
Characteristics of the working cycle of a low-pressure pneumatic nozzle with a sector structure of the fuel jet p 744 A91-41174
Two-dimensional thrust vector control nozzle
[AIAA PAPER 91-2101] p 745 A91-41696
Use of the PARC code for generic NASP nozzles operating at off-design transonic conditions
[AIAA PAPER 91-2154] p 705 A91-41713
Goertler instability and hypersonic quiet nozzle design
[AIAA PAPER 91-1648] p 708 A91-42542
CFD computations for aero-optical analysis of supersonic shear layers
[AIAA PAPER 91-1659] p 720 A91-43574
Scale model test results of several STOVL ventral nozzle concepts
[AIAA PAPER 91-2134] p 752 A91-44134
Advanced high bypass mixed-flow exhaust system design study
[AIAA PAPER 91-2242] p 753 A91-44168
CFD-based 3D turbofan exhaust nozzle analysis system
[AIAA PAPER 91-2478] p 754 A91-44261
A quiet flow Ludwieg tube for study of transition in compressible boundary layers: Design and feasibility
[NASA-CR-188499] p 731 N91-25107
NOZZLE FLOW
Approximate analysis and sensitivity analysis methods for viscous flow involving variation of geometric shape
[AIAA PAPER 91-1569] p 767 A91-40743
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles
[AIAA PAPER 91-2273] p 760 A91-41741
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821
An efficient method for estimating neighboring steady-state numerical solutions to the Euler equations
[AIAA PAPER 91-1680] p 722 A91-43589
Scale model test results of several STOVL ventral nozzle concepts
[AIAA PAPER 91-2134] p 752 A91-44134
Intakes and boundary layer crossflows for hypersonic vehicles
[AIAA PAPER 91-2160] p 728 A91-44138
CFD code validation for nozzle flowfields
[AIAA PAPER 91-2565] p 775 A91-44295
NOZZLE GEOMETRY
A parametric experimental study of isolated rectangular nozzles
[AIAA PAPER 91-2136] p 738 A91-41706
Static performance of a multiaxis thrust vectoring cruciform nozzle
[AIAA PAPER 91-2137] p 745 A91-41707
Measured thrust losses associated with secondary air injection through nozzle walls
[AIAA PAPER 91-2244] p 705 A91-41734
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles
[AIAA PAPER 91-2273] p 760 A91-41741
Thrust vectoring using non-axisymmetric nozzles with flexible contours
[AIAA PAPER 91-2368] p 746 A91-41761
Turbulent flow predictions for afterbody/nozzle geometries including base effects p 715 A91-42813
Sizing supersonic freejet nozzle and inlet location for simulation of the transition phase in integral rocket ramjet p 763 A91-43084
Effects of nozzle lip geometry on spray atomization and emissions advanced gas turbine combustors
[AIAA PAPER 91-2201] p 753 A91-44153
NOZZLE THRUST COEFFICIENTS
Scale model test results of several STOVL ventral nozzle concepts
[AIAA PAPER 91-2134] p 752 A91-44134
NUMERICAL ANALYSIS
A numerical study of hypersonic forebody/inlet integration problem p 732 N91-25343
NUMERICAL CONTROL
Synchronization device of digital flight controlling computer and the algorithm for system scheduling p 742 A91-43508
NUMERICAL FLOW VISUALIZATION
Computation and visualization of leading edge vortex flows p 714 A91-42721
Numerical simulation of a three-dimensional shock wave-turbulent boundary layer interaction generated by a sharp fin at Mach 4 p 714 A91-42726
A numerical study of compressible viscous flow in a novel exhaust system
[AIAA PAPER 91-1728] p 723 A91-43617

O

OBLIQUE SHOCK WAVES
Second-order Godunov methods and self-similar steady supersonic three-dimensional flowfields
[AIAA PAPER 91-1653] p 708 A91-42544
Comparisons of numerical and exact solutions for oblique detonations with structure
[AIAA PAPER 91-1677] p 721 A91-43587
Interactive design of hypersonic waverider geometries
[AIAA PAPER 91-1697] p 740 A91-43597
OBLIQUE WINGS
Static aeroelastic analysis of a three-dimensional oblique wing p 714 A91-42711
OCEAN CURRENTS
Comparison of aircraft synthetic aperture radar and buoy spectra during the Norwegian Continental Shelf Experiment of 1988 p 779 A91-42224
OGIVES
Vortical flows about a long cylinder at M = 3.5 and alpha = 18 deg
[AIAA PAPER 91-1808] p 726 A91-43651
OMEGA NAVIGATION SYSTEM
An Omega/VLF radio compass p 734 A91-41437
Interoperability versus integration of Omega and GPS p 735 A91-41443
ON-LINE SYSTEMS
Constraint management requirements for on-line aircraft route planning p 737 N91-25126
ONBOARD DATA PROCESSING
NASA/Ames Research Center DC-8 data system p 782 N91-25458
C-130 Automated Digital Data System (CADDS) p 780 N91-25482
OPERATORS (MATHEMATICS)
Upwind implicit residual smoothing method for multi-stage schemes
[AIAA PAPER 91-1533] p 696 A91-40708
Implicit solvers for unstructured meshes
[AIAA PAPER 91-1537] p 696 A91-40712
OPTIMAL CONTROL
Optimization of the turbofan engine control program during the cruising flight of subsonic transport aircraft p 743 A91-41170
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
Computer aiding for low-altitude helicopter flight
[NASA-TM-103861] p 737 N91-25142
Optimal control problems with switching points p 782 N91-25694
OPTIMIZATION
Aerodynamic shape optimization using sensitivity analysis on third-order Euler equations
[AIAA PAPER 91-1577] p 699 A91-40751
Computer-aided block-structuring through the use of optimization and expert system techniques
[AIAA PAPER 91-1585] p 700 A91-40759
Design optimization of an electronic fuel control unit featuring two digital actuators
[AIAA PAPER 91-2003] p 745 A91-41672
Compressor exit temperature analysis. II
[AIAA PAPER 91-2008] p 751 A91-44090
Performance optimization of helicopter rotor blades
[NASA-TM-104054] p 741 N91-26137
ORR-SOMMERFELD EQUATIONS
A numerical method for predicting transition in three-dimensional flows by spatial amplification theory
[AIAA PAPER 91-1606] p 702 A91-40778
OSCILLATING FLOW
Effect of a multi-dimensional flux function on the monotonicity of Euler and Navier-Stokes computations
[AIAA PAPER 91-1530] p 696 A91-40705
OXIDATION RESISTANCE
Lightweight ceramic components for propulsion applications
[AIAA PAPER 91-2217] p 774 A91-44159
OXYGEN PRODUCTION
Refurbishing AV-8 on-board oxygen generation system beds
[AD-A235083] p 741 N91-26136
OZONE
Science requirements and feasibility/design studies of a very-high-altitude aircraft for atmospheric research p 740 N91-25481

P

PANEL FLUTTER
Gasdynamic interaction of flow with an oscillating shell p 703 A91-41157
PANEL METHOD (FLUID DYNAMICS)
Effect of thickness on the unsteady aerodynamics of closely coupled oscillating airfoils p 716 A91-43308
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fab simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106
A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114
PANELS
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422
Aircraft interior noise reduction by alternate resonance tuning
[NASA-CR-185453] p 785 N91-26889
PARACHUTE DESCENT
Nonlinear oscillations of a heavy axisymmetric body in a resistant medium with drag p 784 A91-43169
PARACHUTES
Determination of the stress-strain state of a soft lifting system --- Single-Shell Parachute Airfoil p 704 A91-41320
PARALLEL COMPUTERS
Parallel block multigrid solution of the compressible Navier-Stokes equations p 702 A91-40792
With us you fly right - The influence of modern technology on the development and operation of new aircraft p 771 A91-43326
PARALLEL PROCESSING (COMPUTERS)
Block-structured computation of three-dimensional transonic Euler equations
[AIAA PAPER 91-1679] p 721 A91-43588
PARAMETER IDENTIFICATION
An identification algorithm based on smoothing p 782 N91-25642
PARTIAL DIFFERENTIAL EQUATIONS
Self-propelled slender axisymmetric body flows: Errors in the Poisson equation field calculation p 731 N91-25110
PARTICLE TRAJECTORIES
Investigation of coatings at high temperature for use in turbomachinery p 744 A91-41507
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies p 771 A91-43310
PASSENGER AIRCRAFT
Condition monitoring of aircraft high lift systems p 738 A91-41535
Seeking crashworthy seats p 740 A91-44345
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126
PATTERN RECOGNITION
A neural network for the analysis of aircraft test data p 781 N91-25133
PAVEMENTS
Unified methodology for airport pavement analysis and design. Volume 1: State of the art
[DOT/FAA/RD-91/15-VOL-1] p 762 N91-25154
Geogrid reinforced base course for flexible pavements for light aircraft: Literature review and test section design
[DOT/FAA/RD-90/28] p 763 N91-26160
Guidelines for design, construction, and evaluation of airport pavement drainage
[DOT/FAA/RD-90/31] p 763 N91-26161
PAYLOADS
Science requirements and feasibility/design studies of a very-high-altitude aircraft for atmospheric research p 743 N91-25481
PERFORMANCE PREDICTION
How failure prediction methodology affects electronic equipment design p 768 A91-40812
A row-by-row off-design performance calculation method for turbines
[AIAA PAPER 91-2132] p 745 A91-41705
Prediction of internal performance for two-dimensional convergent-divergent nozzles
[AIAA PAPER 91-2369] p 706 A91-41762
An expert system for predicting flutter in turbomachines
[AIAA PAPER 91-2527] p 748 A91-41808
A simulation study of turbofan engine deterioration estimation using Kalman filtering techniques
[NASA-TM-104233] p 755 N91-25147
Sensitivity of inlet performance predictions to CFD numerical and physical modeling p 775 N91-25345
PERFORMANCE TESTS
The effect of square trailing edges on turbine blade performance
[AIAA PAPER 91-2130] p 704 A91-41704
Aircraft gas turbine performance for the year 2000
[AIAA PAPER 91-2233] p 746 A91-41733
Compressor exit temperature analysis. II
[AIAA PAPER 91-2008] p 751 A91-44090
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153
Guidelines for design, construction, and evaluation of airport pavement drainage
[DOT/FAA/RD-90/31] p 763 N91-26161
PERIODIC VARIATIONS
Effect of model cooling on periodic transonic flow
[AIAA PAPER 91-1714] p 709 A91-42562
PERSONAL COMPUTERS
The PC as a generic developmental fuel control for expendable turbojet engines
[AIAA PAPER 91-3399] p 755 A91-44329
PERTURBATION THEORY
Control of vortex structure on a delta wing by small amplitude perturbations of angle-of-attack p 706 A91-42094
PHASE ERROR
Specification of an inertial navigation system for experimental SAR p 735 A91-41829
PILOT PERFORMANCE
Knowledge Based System Applications for Guidance and Control
[AGARD-CP-474] p 736 N91-25121
Knowledge-based cockpit assistant for IFR operations p 736 N91-25125
PILOT TRAINING
Simulating a new species of bird p 694 A91-44340
PISTONS
New generation of free-piston shock tunnels p 760 A91-40640
Multi-cascade compression - Effective means to obtain high temperature dense gas in piston gas dynamic units (PGU) p 760 A91-40641
PITCH (INCLINATION)
Flow field structure and development near the root of a straight wing pitching at constant rate
[AIAA PAPER 91-1793] p 725 A91-43646
PIVOTS
Pivoting seat for fighter aircraft
[AD-D014822] p 733 N91-25120
PLANFORMS
Dynamic analysis of advanced tip rotors including three-dimensional aerodynamics p 731 N91-25111
PLASTIC AIRCRAFT STRUCTURES
Composite gearboxes, designing for the 90's
[AIAA PAPER 91-1910] p 769 A91-41651
PLATE THEORY
Reliability of initially compressed uncertain laminated plates in supersonic flow p 770 A91-42292
POINT SOURCES
Waves produced from a harmonic point source in a supersonic boundary layer
[AIAA PAPER 91-1646] p 720 A91-43571
POISSON EQUATION
Self-propelled slender axisymmetric body flows: Errors in the Poisson equation field calculation p 731 N91-25110
POLLUTION CONTROL
IAE V2500 - Technology for the environment p 749 A91-43118
POLYMER MATRIX COMPOSITES
Composite gearboxes, designing for the 90's
[AIAA PAPER 91-1910] p 769 A91-41651
POROUS MATERIALS
Limiting thermal loads in porous structures p 768 A91-41159
POTENTIAL FLOW
Kernel function occurring in subsonic unsteady potential flow p 707 A91-42280
Navier-Stokes correlation of a swept helicopter rotor tip at high alpha
[AIAA PAPER 91-1752] p 711 A91-42574
Potential flow applications to complex configurations
[AIAA PAPER 91-1634] p 719 A91-43562
C.F.D. of the base flow on a plane body between a subsonic flow on one side and a supersonic flow on the other
[AIAA PAPER 91-2372] p 729 A91-44215
A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114
POWER EFFICIENCY
Wind tunnel results of counter rotation prop-fans designed with lifting line and Euler code methods
[AIAA PAPER 91-2499] p 755 A91-44265
POWER SPECTRA
Measurement of atmospheric turbulence p 780 N91-26151
POWERED LIFT AIRCRAFT
Static performance tests of a flight-type STOVL ejector
[AIAA PAPER 91-1902] p 750 A91-44050
PREDICTION ANALYSIS TECHNIQUES
Hodograph solution for compressible flow past a corner and comparison with Euler numerical predictions
[AIAA PAPER 91-1547] p 697 A91-40722
Turbulent flow predictions for afterbody/nozzle geometries including base effects p 715 A91-42813
Enhancements to the high speed convective heating and viscous drag prediction techniques of the Aerodynamic Preliminary Analysis System (APAS)
[AIAA PAPER 91-1435] p 717 A91-43494
Uncertainty analysis of turbine aerodynamic performance measurements in short duration test facilities
[AIAA PAPER 91-2131] p 761 A91-44132
PREFLIGHT OPERATIONS
TABS - An automated pre-flight planning system p 733 A91-42783
PRESSURE DISTRIBUTION
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740
Analysis of pressure distribution on hypersonic vehicles with power effects
[AIAA PAPER 91-2491] p 738 A91-41796
Large-scale advanced propeller blade pressure distributions - Prediction and data p 715 A91-42820
A study of flow separation on an aspect ratio three flap at Mach number 2.4
[AIAA PAPER 91-1620] p 718 A91-43554
Trim angle measurements in free-flight facilities
[AIAA PAPER 91-1632] p 719 A91-43561
An experimental/computational study of heat transfer in sharp fin induced turbulent interactions at Mach 5
[AIAA PAPER 91-1764] p 724 A91-43633
Parametric investigation into the combined effects of pressure and temperature distortion on compression system stability
[AIAA PAPER 91-1895] p 773 A91-44047
PRESSURE DRAG
Drag and lift in nonadiabatic transonic flow
[AIAA PAPER 91-1716] p 710 A91-42564
Automatic design of transonic airfoils to reduce the shock induced pressure drag p 716 A91-43078
PRESSURE EFFECTS
Pressure-based flux vector splitting for blunt geometries p 703 A91-40797
Effect of shock waves upon seat mounted sensors in escape systems p 738 A91-41543
PRESSURE GRADIENTS
Effect of a multi-dimensional flux function on the monotonicity of Euler and Navier-Stokes computations
[AIAA PAPER 91-1530] p 696 A91-40705
Effects of streamwise pressure gradient on the suction surface boundary layer of a turbine airfoil
[AIAA PAPER 91-2030] p 727 A91-44097
PRESSURE MEASUREMENT
A method for correcting wall pressure measurements in subsonic compressible flow p 715 A91-42957
In-flight measurement of static pressures and boundary-layer state with integrated sensors p 742 A91-43306
PRESSURE OSCILLATIONS
Reduced pressure oscillations in a dump combustor with tapered corrugations
[AIAA PAPER 91-2354] p 753 A91-44208
PROBABILITY THEORY
How low can an unmanned air vehicle fly?
[RAND-P-7680-RGS] p 741 N91-26138
PROCEDURES
Mission planning systems for tactical aircraft (pre-flight and in-flight)
[AGARD-AR-296] p 783 N91-25750
PRODUCT DEVELOPMENT
Sub-contractors play new strategic roles p 694 A91-43273
The wild weasel development programs, one run, one hit, one error
[RAND-P-7661-RGS] p 778 N91-26431
Results of the aeronautical systems division critical process team on integrated product development
[AD-A235419] p 785 N91-26995
PROGRAM VERIFICATION (COMPUTERS)
Hypersonic shock/boundary-layer interaction database
[AIAA PAPER 91-1763] p 711 A91-42581
PROGRAMMING (SCHEDULING)
Synchronization device of digital flight controlling computer and the algorithm for system scheduling p 742 A91-43508

PROGRAMMING LANGUAGES
Design of a language processor for aviation engine testing p 760 A91-41164
PROJECT MANAGEMENT
The pilot's associate: Exploiting the intelligent advantage p 781 N91-25122
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046
PROJECTILES
Navier-Stokes simulation of the supersonic combustion flowfield in a ram accelerator
[AIAA PAPER 91-1916] p 773 A91-44057
PROP-FAN TECHNOLOGY
Large-scale advanced propeller blade pressure distributions - Prediction and data p 715 A91-42820
Wind tunnel results of counter rotation prop-fans designed with lifting line and Euler code methods
[AIAA PAPER 91-2499] p 755 A91-44265
PROPELLER BLADES
Periodic blade loads of a high speed propeller at small angle of attack
[AIAA PAPER 91-2250] p 705 A91-41735
Large-scale advanced propeller blade pressure distributions - Prediction and data p 715 A91-42820
The vortex interaction in a propeller/stator flow field
[AIAA PAPER 91-1818] p 726 A91-43657
PROPELLER NOISE
The design and commissioning of an acoustic liner for propeller noise testing in the ARA transonic wind tunnel p 783 A91-41540
PROPELLER SLIPSTREAMS
Unsteady fluid dynamic model for propeller induced flow fields
[AIAA PAPER 91-1664] p 709 A91-42550
Self-propelled slender axisymmetric body flows: Errors in the Poisson equation field calculation p 731 N91-25110
PROPELLERS
Piaggio P180 Avanti - Efficiency using three levels of aerodynamic lift p 739 A91-43119
Computation of broadband mixing noise from turbomachinery
[AD-A233991] p 784 N91-26878
PROPULSION SYSTEM CONFIGURATIONS
Propulsion systems for upgrades of current fighter aircraft
[AIAA PAPER 91-2026] p 752 A91-44095
PROPULSION SYSTEM PERFORMANCE
Wake ingestion propulsion benefit
[AIAA PAPER 91-2007] p 769 A91-41676
High-speed rotorcraft propulsion
[AIAA PAPER 91-2147] p 746 A91-41709
An ejector performance correlation factor
[AIAA PAPER 91-2545] p 748 A91-41810
Aeropropulsion analysis of tactical aircraft - Status and plans
[AIAA PAPER 91-1528] p 740 A91-43673
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089
Performance evaluation of semi-freejet tests of the Generic High Speed Engine
[AIAA PAPER 91-2163] p 753 A91-44141
PROPULSIVE EFFICIENCY
Advanced Rotorcraft Transmission (ART) program-Boeing helicopters status report
[NASA-TM-104474] p 778 N91-25412
PROTECTIVE COATINGS
Investigation of coatings at high temperature for use in turbomachinery p 744 A91-41507
The wear mechanisms occurring in abradable seals of gas turbines p 768 A91-41508
PROTOTYPES
The pilot's associate: Exploiting the intelligent advantage p 781 N91-25122
Constraint management requirements for on-line aircraft route planning p 737 N91-25126
PROTUBERANCES
Experimental investigation of the shock wave and turbulent boundary layer interaction induced by a cylindrical protuberance p 695 A91-40604
PUBLIC LAW
Re-engining - The sound case for aircraft noise reduction
[AIAA PAPER 91-2144] p 783 A91-41708
PULSED LASERS
Experimental investigation of a unique airbreathing pulsed laser propulsion concept
[AIAA PAPER 91-1922] p 751 A91-44059
PYROLYSIS
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets p 748 A91-42805

Q

QUALITY CONTROL
The development of 'Radar data quality control and Radar Analysis Support System RDQC/RASS' p 735 A91-41834
AGARD handbook on advanced casting
[AGARD-AG-299] p 775 N91-25302
QUASI-STEADY STATES
Nonlinear oscillations of a heavy axisymmetric body in a resistant medium with drag p 784 A91-43169

R

RADAR
Evaluation of the C/EC/KC-135 Ground Collision Avoidance System (GCAS), study 1
[AD-A235301] p 737 N91-26130
RADAR ABSORBERS
Stealth aircraft and technology from World War II to the Gulf. I - History and background p 743 A91-43772
RADAR CROSS SECTIONS
Reduction of the RCS of the leading edge of a conducting wing-shaped structure by means of lossless dielectric material p 770 A91-42241
An approach to aerodynamic characteristics of low radar cross-section fuselages p 718 A91-43501
Stealth aircraft and technology from World War II to the Gulf. I - History and background p 743 A91-43772
RADAR DATA
The development of 'Radar data quality control and Radar Analysis Support System RDQC/RASS' p 735 A91-41834
Intelligent radar data processing p 770 A91-41849
A knowledge-based tracker for aircraft formations --- using radar systems p 736 A91-41851
A radar-data communication network for ATC in the Benelux nations and northern Germany p 736 A91-41853
RADAR DETECTION
The wild weasel development programs, one run, one hit, one error
[RAND-P-7661-RGS] p 778 N91-26431
RADAR EQUIPMENT
Determination of orientation accuracy in curved flight paths p 736 A91-41835
RADAR IMAGERY
Concept and results of the Azimuth Quick-Look Processor for aircraft SAR of the DLR p 735 A91-41828
Comparison of aircraft synthetic aperture radar and buoy spectra during the Norwegian Continental Shelf Experiment of 1988 p 779 A91-42224
RADAR NETWORKS
A radar-data communication network for ATC in the Benelux nations and northern Germany p 736 A91-41853
RADAR SCATTERING
Determination of orientation accuracy in curved flight paths p 736 A91-41835
Comparison of aircraft synthetic aperture radar and buoy spectra during the Norwegian Continental Shelf Experiment of 1988 p 779 A91-42224
RADAR TRANSMISSION
A radar-data communication network for ATC in the Benelux nations and northern Germany p 736 A91-41853
RADIAL FLOW
A three-dimensional Navier-Stokes stage analysis of the flow through a compact radial turbine
[AIAA PAPER 91-2564] p 748 A91-41815
A comparison of the analytical and experimental performance of the solid version of a cooled radial rotor
[AIAA PAPER 91-2133] p 752 A91-44133
RADIANT COOLING
Effect of model cooling on periodic transonic flow
[AIAA PAPER 91-1714] p 709 A91-42562
RADIANT HEATING
Pareto-optimal shapes of axisymmetric bodies moving at high supersonic velocities p 707 A91-42330
RADIATIVE HEAT TRANSFER
Heat pipe radiation cooling of advanced hypersonic propulsion system components
[AIAA PAPER 91-2358] p 746 A91-41759
RADIO BEACONS
An Omega/VLF radio compass p 734 A91-41437
RADIO EQUIPMENT
Evaluation of the C/EC/KC-135 Ground Collision Avoidance System (GCAS), study 1
[AD-A235301] p 737 N91-26130
RADIOMETERS
Accurate airborne surface temperature measurements with chopper-stabilized radiometers p 742 A91-42142
RAIL TRANSPORTATION
The potential role of maglev in short-haul airline operations
[DE91-010813] p 777 N91-25408
Geogrid reinforced base course for flexible pavements for light aircraft: Literature review and test section design
[DOT/FAA/RD-90/28] p 763 N91-26160
RAINDROPS
Transient performance of fan engine with water ingestion
[AIAA PAPER 91-1897] p 750 A91-44049
RAMAN SPECTRA
Study of cluster formation and its effects on Rayleigh and Raman scattering measurements in a Mach 6 wind tunnel
[AIAA PAPER 91-1496] p 718 A91-43547
RAMJET ENGINES
An integrated automatic ramjet engine control system tolerant to failures of the functional components p 780 A91-41163
Heat pipe radiation cooling of advanced hypersonic propulsion system components
[AIAA PAPER 91-2358] p 746 A91-41759
Heat management concepts for hypersonic propulsion systems
[AIAA PAPER 91-2493] p 769 A91-41798
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets p 748 A91-42805
Burning and flameholding characteristics of a miniature solid fuel ramjet combustor p 749 A91-42807
Sizing supersonic freejet nozzle and inlet location for simulation of the transition phase in integral rocket ramjet p 763 A91-43084
Combusting flow simulations of detonation and shock-induced combustion waves for ram accelerator configurations with viscous effect
[AIAA PAPER 91-1674] p 721 A91-43584
Reduced pressure oscillations in a dump combustor with tapered corrugations
[AIAA PAPER 91-2354] p 753 A91-44208
Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions
[CPIA-PUBL-551] p 775 N91-25336
RANDOM PROCESSES
Calculating time-correlated gust loads using matched filter and random process theories p 739 A91-43312
RANKING
Technology needs for high-speed rotorcraft, volume 1
[NASA-CR-177585] p 742 N91-26139
RAPID TRANSIT SYSTEMS
The potential role of maglev in short-haul airline operations
[DE91-010813] p 777 N91-25408
RAREFIED GAS DYNAMICS
Leading edge effect on rarefied hypersonic flow over a flat plate
[AIAA PAPER 91-1749] p 710 A91-42573
Hypersonic rarefied flow about a compression corner - DSMC simulation and experiment
[AIAA PAPER 91-1313] p 716 A91-43385
Hypersonic rarefied flow about a delta wing - Direct simulation and comparison with experiment
[AIAA PAPER 91-1315] p 716 A91-43387
Direct simulation of waveriders in hypersonic rarefied flow
[AIAA PAPER 91-1317] p 717 A91-43389
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124
RAYLEIGH SCATTERING
Study of cluster formation and its effects on Rayleigh and Raman scattering measurements in a Mach 6 wind tunnel
[AIAA PAPER 91-1496] p 718 A91-43547
Vortex breakdown in a supersonic jet
[AIAA PAPER 91-1815] p 726 A91-43656
RAYLEIGH-RITZ METHOD
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422
REACTING FLOW
Numerical analysis of scramjet flows in a dump combustor
[AIAA PAPER 91-1676] p 749 A91-43586
Computations of three-dimensional gas turbine combustor flows
[AIAA PAPER 91-2076] p 773 A91-44116
REACTION KINETICS
Instantaneous planar visualization of reacting supersonic flows using silane seeding
[AIAA PAPER 91-1690] p 772 A91-43593

Fuel-rich, catalytic reaction experimental results --- fuel development for high-speed civil transport aircraft
[AIAA PAPER 91-2463] p 754 A91-44250
REAL GASES
Computational aspects of chemically reacting flows
[AIAA PAPER 91-1574] p 699 A91-40748
REAL TIME OPERATION
Concept and results of the Azimuth Quick-Look Processor for aircraft SAR of the DLR
p 735 A91-41828
Intelligent real-time knowledge based inflight mission management p 737 N91-25128
NASA/Ames Research Center DC-8 data system
p 782 N91-25458
RECONNAISSANCE
How low can an unmanned air vehicle fly?
[RAND-P-7680-RGS] p 741 N91-26138
RECTANGULAR WINGS
LDV measurements in the roll-up region of the tip vortex from a rectangular wing
[AIAA PAPER 91-1685] p 709 A91-42554
Vortex topology for rectangular wings in pictures, sketches and conjectures
[AIAA PAPER 91-1824] p 713 A91-42611
REFRACTORY MATERIALS
Ceramic composites for aircraft gas turbine engines
[AIAA PAPER 91-1892] p 750 A91-44045
Advanced technology engine casing designs
[AIAA PAPER 91-1893] p 750 A91-44046
REGULATIONS
Improved reduction of gust loads data for gust intensity p 758 N91-26153
Gust design procedures p 759 N91-26155
REINFORCEMENT (STRUCTURES)
Geogrid reinforced base course for flexible pavements for light aircraft: Literature review and test section design
[DOT/FAA/RD-90/28] p 763 N91-26160
RELAXATION METHOD (MATHEMATICS)
Asynchronous, macrotasked relaxation strategies for the solution of viscous, hypersonic flows
[AIAA PAPER 91-1579] p 700 A91-40753
Multigrid solutions of the three-dimensional grid equations p 706 A91-42098
RELIABILITY
Reliability of initially compressed uncertain laminated plates in supersonic flow p 770 A91-42292
RELIABILITY ANALYSIS
How failure prediction methodology affects electronic equipment design p 768 A91-40812
REMOTE CONTROL
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100
REMOTELY PILOTED VEHICLES
Establishment of a remotely piloted helicopter test flight program for higher harmonic control research
[AD-A234978] p 741 N91-26135
How low can an unmanned air vehicle fly?
[RAND-P-7680-RGS] p 741 N91-26138
RESEARCH AIRCRAFT
Estimation of the aeroelastic characteristics from flight test data of the STOL research aircraft ASKA
[NAL-TR-1083] p 740 N91-25145
An optimal pole placement gain scheduling algorithm using output feedback p 782 N91-25643
Acquisition of statistical gust load data by commercial airplanes p 758 N91-26152
RESEARCH AND DEVELOPMENT
Langley aerospace test highlights, 1990
[NASA-TM-104090] p 786 N91-26112
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046
RESONANCE
Aircraft interior noise reduction by alternate resonance tuning
[NASA-CR-185453] p 785 N91-26889
REYNOLDS EQUATION
Navier-Stokes simulation of the supersonic combustion flowfield in a ram accelerator
[AIAA PAPER 91-1916] p 773 A91-44057
REYNOLDS NUMBER
A primary study of Reynolds number effect in transonic flow p 718 A91-43502
Mach 3.5 boundary-layer transition on a cone at angle of attack
[AIAA PAPER 91-1804] p 725 A91-43650
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116
REYNOLDS STRESS
Application of a Reynolds Stress turbulence model to a supersonic hydrogen-air diffusion flame
[AIAA PAPER 91-1786] p 725 A91-43643
RIBLETS
Synthesis of experimental riblet studies in transonic conditions p 716 A91-43142
RICHARDSON NUMBER
Viscous airfoil computations using Richardson extrapolation
[AIAA PAPER 91-1559] p 698 A91-40733
RIGID ROTORS
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
Dynamics of elastic bending and torsion of hingeless rotors with dynamic stall
[AD-A234775] p 741 N91-26134
ROCKET ENGINE CASES
Composites move into jet engine design
p 755 A91-44339
ROCKET ENGINE DESIGN
Composites move into jet engine design
p 755 A91-44339
ROCKET ENGINES
Lightweight ceramic components for propulsion applications
[AIAA PAPER 91-2217] p 774 A91-44159
ROCKET NOZZLES
Analysis of pressure distribution on hypersonic vehicles with power effects
[AIAA PAPER 91-2491] p 738 A91-41796
ROTARY ENGINES
A new concept for a hubless rotary jet
[AIAA PAPER 91-1903] p 750 A91-44051
ROTARY WING AIRCRAFT
Computational rotorcraft flowfield research at the U.S. Army AeroStructures Directorate p 703 A91-41148
Technology needs for high-speed rotorcraft, volume 1
[NASA-CR-177585] p 742 N91-26139
ROTARY WINGS
Estimating the period length of periodic signals
p 770 A91-41846
Unified treatment for dealing with auxiliary conditions in blade dynamics p 770 A91-42294
Navier-Stokes correlation of a swept helicopter rotor tip at high alpha
[AIAA PAPER 91-1752] p 711 A91-42574
Experimental investigation of the near wake structure of a helicopter rotor in forward flight
[AIAA PAPER 91-1753] p 711 A91-42575
A simulation model of a single rotor helicopter
p 739 A91-43080
Prediction of helicopter rotor rotational noise
p 784 A91-43503
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
Dynamic analysis of advanced tip rotors including three-dimensional aerodynamics p 731 N91-25111
Performance optimization of helicopter rotor blades
[NASA-TM-104054] p 741 N91-26137
ROTATING FLUIDS
Grid restructuring for moving boundaries
[AIAA PAPER 91-1589] p 700 A91-40763
ROTATING STALLS
Active unsteady aerodynamic suppression of rotating stall in an incompressible flow centrifugal compressor with vaned diffuser
[AIAA PAPER 91-1898] p 704 A91-41644
A study of aeroacoustic performance of a contra-rotating axial flow compressor stage p 706 A91-42248
A numerical study of surge and rotating stall in axial compressors
[AIAA PAPER 91-1896] p 727 A91-44048
Neural network based expert system for compressor stall monitoring
[AIAA PAPER 91-2500] p 781 A91-44266
ROTOR AERODYNAMICS
A novel implementation of an implicit k-epsilon turbulence model coupled with an explicit Navier-Stokes solver p 703 A91-40796
Periodic blade loads of a high speed propeller at small angle of attack
[AIAA PAPER 91-2250] p 705 A91-41735
New capabilities for aeromechanical testing and evaluation of aircraft turbine engines
[AIAA PAPER 91-2498] p 747 A91-41801
Unified treatment for dealing with auxiliary conditions in blade dynamics p 770 A91-42294
Navier-Stokes correlation of a swept helicopter rotor tip at high alpha
[AIAA PAPER 91-1752] p 711 A91-42574
On the estimation of sound produced by complex fluid-structure interactions, with application to a vortex interacting with a shrouded rotor p 784 A91-43514
Concepts for reduction of turbine rotor inertia
[AIAA PAPER 91-2031] p 752 A91-44098
Unsteady hot streak simulation through a 1-1/2 stage turbine engine
[AIAA PAPER 91-3382] p 775 A91-44321
Dynamic analysis of advanced tip rotors including three-dimensional aerodynamics p 731 N91-25111
Dynamics of elastic bending and torsion of hingeless rotors with dynamic stall
[AD-A234775] p 741 N91-26134
ROTOR BLADES
Estimating the period length of periodic signals
p 770 A91-41846
Investigation of the tip shape influence on the flowfield around hovering rotor blades
[AIAA PAPER 91-1754] p 711 A91-42576
Prediction of helicopter rotor rotational noise
p 784 A91-43503
Computer modelling of implanted component faults in a gas turbine engine
[AIAA PAPER 91-1912] p 750 A91-44053
ROTOR BLADES (TURBOMACHINERY)
Grid generation for three-dimensional turbomachinery geometries including tip clearance
[AIAA PAPER 91-2360] p 753 A91-44209
Prediction of unsteady aerodynamic loads in cascades using the linearized Euler equations on deforming grids
[AIAA PAPER 91-3378] p 730 A91-44318
An efficient method in predicting rotor/stator interaction
[AIAA PAPER 91-3380] p 730 A91-44320
The design/analysis of flows through turbomachinery: A viscous/inviscid approach
[NASA-TM-104447] p 755 N91-25148
Investigation of hot streak migration and film cooling effects on the heat transfer in rotor/stator interacting flows
[AD-A235420] p 756 N91-26145
ROTOR BODY INTERACTIONS
Interaction between a vortex dominated wake and a separated flowfield
[AIAA PAPER 91-1819] p 727 A91-43658
An efficient method in predicting rotor/stator interaction
[AIAA PAPER 91-3380] p 730 A91-44320
ROTOR DYNAMICS
A method for calculating the characteristics of a rotor with allowance for shaft vibrations p 768 A91-41155
The effects of bearing misalignment on the non-linear vibration of aero-engine rotor-damper assemblies
p 744 A91-41536
An efficient method in predicting rotor/stator interaction
[AIAA PAPER 91-3380] p 730 A91-44320
ROTOR SPEED
Estimating the period length of periodic signals
p 770 A91-41846
Dynamics of elastic bending and torsion of hingeless rotors with dynamic stall
[AD-A234775] p 741 N91-26134
ROTORCRAFT AIRCRAFT
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1906] p 769 A91-41648
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1909] p 769 A91-41650
High-speed rotorcraft propulsion
[AIAA PAPER 91-2147] p 746 A91-41709
Summary of technology needs for high speed rotorcraft study
[AIAA PAPER 91-2148] p 693 A91-41710
Conclusions from high-speed rotorcraft studies
[AIAA PAPER 91-2149] p 693 A91-41711
High speed rotorcraft propulsion system studies
[AIAA PAPER 91-2150] p 752 A91-44135
ROTORS
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
Dynamic analysis of advanced tip rotors including three-dimensional aerodynamics p 731 N91-25111
Dynamic tester for rotor seals and bearings
[NASA-CASE-MFS-28493-1] p 763 N91-25155
ROUTES
Constraint management requirements for on-line aircraft route planning p 737 N91-25126
RUNGE-KUTTA METHOD
A Runge-Kutta discontinuous finite element method for high speed flows
[AIAA PAPER 91-1575] p 699 A91-40749
Multigrid solution of hypersonic flows using rational Runge-Kutta scheme
[AIAA PAPER 91-1703] p 722 A91-43602

RUNWAYS
Airport capacity and delay analyses
[DOT/FAA/CT-TN91/18] p 762 N91-25152
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153

S

SAFETY FACTORS
Effect of shock waves upon seat mounted sensors in escape systems p 738 A91-41543
SANDWICH STRUCTURES
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422
SATELLITE COMMUNICATION
Low profile Satcom aircraft antenna development p 736 A91-42781
SATELLITE NAVIGATION SYSTEMS
Combined satellite navigation systems could lead to more reliable and more precise air navigation p 736 A91-42780
SCALE MODELS
Scale model test results of several STOVL ventral nozzle concepts
[AIAA PAPER 91-2134] p 752 A91-44134
Low-speed, powered ground effects of a generic, hypersonic configuration
[NASA-TP-3092] p 730 N91-25103
SCENE ANALYSIS
Creating a scene p 775 A91-44342
SCHEDULES
An optimal pole placement gain scheduling algorithm using output feedback p 782 N91-25643
SCHEDULING
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100
An optimal pole placement gain scheduling algorithm using output feedback p 782 N91-25643
SCHLIEREN PHOTOGRAPHY
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821
Vortex breakdown in a supersonic jet
[AIAA PAPER 91-1815] p 726 A91-43656
SEALS (STOPPERS)
The wear mechanisms occurring in abradable seals of gas turbines p 768 A91-41508
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799
Failure detection of liquid cooled electronics in sealed packages — in airborne information management system
[AIAA PAPER 91-1423] p 742 A91-43482
Simple leakage flow model for brush seals
[AIAA PAPER 91-1913] p 773 A91-44054
SEATS
Seeking crashworthy seats p 740 A91-44345
Pivoting seat for fighter aircraft
[AD-D014822] p 733 N91-25120
SECONDARY FLOW
Improved methods of characterizing ejector pumping performance p 749 A91-42815
Flowfield analysis of a backswept centrifugal impeller
[AIAA PAPER 91-2470] p 774 A91-44255
Unsteady hot streak simulation through a 1-1/2 stage turbine engine
[AIAA PAPER 91-3382] p 775 A91-44321
SELF OSCILLATION
The level of self-oscillations of aerodynamic control surfaces under nonseparating transonic gas flow p 703 A91-41218
SENSORY FEEDBACK
FCS skewed sensors array - Practical considerations p 742 A91-43082
SEPARATED FLOW
Viscous airfoil computations using Richardson extrapolation
[AIAA PAPER 91-1559] p 698 A91-40733
Comment on 'Critique of turbulence models for shock-induced flow separation' p 707 A91-42307
Low-dimensional description of the dynamics in separated flow past thick airfoils
[AIAA PAPER 91-1622] p 707 A91-42534
On three-dimensional flow separation criteria
[AIAA PAPER 91-1740] p 710 A91-42571
Navier-Stokes calculations for attached and separated flows using different turbulence models
[AIAA PAPER 91-1791] p 712 A91-42594
Numerical investigation of the effect of leading edge geometry on dynamic stall of airfoils
[AIAA PAPER 91-1798] p 712 A91-42597
Asymmetric separated flows over slender bodies at supersonic speeds p 714 A91-42730
Visualization measurements of vortex flows p 716 A91-43309
A study of flow separation on an aspect ratio three flap at Mach number 2.4
[AIAA PAPER 91-1620] p 718 A91-43554
Flow field structure and development near the root of a straight wing pitching at constant rate
[AIAA PAPER 91-1793] p 725 A91-43646
Theoretical study of supersonic flow separation over a rearward facing step
[AIAA PAPER 91-2161] p 753 A91-44139
Comparative analysis of turbofan effective thrust with mixed and separated flows engines
[AIAA PAPER 91-2376] p 754 A91-44216
SERVICE LIFE
Advanced Rotorcraft Transmission (ART) program-Boeing helicopters status report
[NASA-TM-104474] p 778 N91-25412
Ceramic technology for advanced heat engines project
[DE91-010451] p 766 N91-26384
SERVOCONTROL
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113
SHAFTS (MACHINE ELEMENTS)
A method for calculating the characteristics of a rotor with allowance for shaft vibrations p 768 A91-41155
Dynamic tester for rotor seals and bearings
[NASA-CASE-MFS-28493-1] p 763 N91-25155
SHAPE CONTROL
Aerodynamic shape optimization using sensitivity analysis on third-order Euler equations
[AIAA PAPER 91-1577] p 699 A91-40751
Unstructured meshes and surface fidelity for complex shapes
[AIAA PAPER 91-1591] p 701 A91-40765
SHARP LEADING EDGES
Laser velocimetry measurements of supersonic vortex flows on a simple razor-edged delta wing
[AIAA PAPER 91-1684] p 709 A91-42553
SHEAR LAYERS
CFD computations for aero-optical analysis of supersonic shear layers
[AIAA PAPER 91-1659] p 720 A91-43574
On the convection velocity of turbulent structures in supersonic shear layers
[AIAA PAPER 91-1724] p 723 A91-43614
Numerical simulation of the unsteady vortex structure over a delta wing
[AIAA PAPER 91-1811] p 726 A91-43653
SHEAR STRENGTH
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422
SHEAR STRESS
Modification of the van Driest damping function to include the effects of surface roughness p 770 A91-42282
SHELL STABILITY
Analysis of structural damping of titanium alloy shell structures as compared with that of aluminium alloy structures p 765 A91-41606
SHOCK DISCONTINUITY
On the validity of linearized unsteady Euler equations with shock capturing
[AIAA PAPER 91-1598] p 702 A91-40771
SHOCK LAYERS
Wave processes occurring in supersonic motion of blunted body through dust layer p 695 A91-40656
An approximate viscous shock layer approach to calculating hypersonic flows about blunt-nosed bodies
[AIAA PAPER 91-1348] p 717 A91-43417
SHOCK TUBES
A new vertical shock tube for Rayleigh-Taylor instability measurements p 759 A91-40637
An experimental evaluation of thermochromic liquid crystals for surface temperature and heat flux measurements in shock tube flows p 767 A91-40645
SHOCK TUNNELS
A compression ignition driver for a free piston shock tunnel p 759 A91-40638
New generation of free-piston shock tunnels p 760 A91-40640
Application of shock tunnel at pressure and heat transfer experiments on turbine blade p 760 A91-40649
An investigation of hypersonic shock tunnel testing at an equilibrium interface condition of 4100 K - Theory and experiment
[AIAA PAPER 91-1707] p 761 A91-42560
Planar laser-induced fluorescence imaging of underexpanded free jet flow in a shock tunnel facility
[AIAA PAPER 91-1687] p 761 A91-43592
A numerical study of the flow establishment time in hypersonic shock tunnels
[AIAA PAPER 91-1706] p 722 A91-43604
SHOCK WAVE INTERACTION
Some aspects of shock-wave boundary layer interaction at hypersonic speeds p 695 A91-40578
Experimental investigation of the shock wave and turbulent boundary layer interaction induced by a cylindrical protuberance p 695 A91-40604
Wave processes occurring in supersonic motion of blunted body through dust layer p 695 A91-40656
The peak surface pressure in fin-generated shock-wave boundary-layer interactions p 696 A91-40672
Comment on 'Critique of turbulence models for shock-induced flow separation' p 707 A91-42307
Correlative behaviours of shock/boundary layer interaction induced by sharp fin and semicone
[AIAA PAPER 91-1756] p 711 A91-42577
Hypersonic shock/boundary-layer interaction database
[AIAA PAPER 91-1763] p 711 A91-42581
A physical model of the swept shock wave/boundary-layer interaction flowfield
[AIAA PAPER 91-1768] p 712 A91-42582
Numerical simulation of a three-dimensional shock wave-turbulent boundary layer interaction generated by a sharp fin at Mach 4 p 714 A91-42726
Hypersonic rarefied flow about a compression corner - DSMC simulation and experiment
[AIAA PAPER 91-1313] p 716 A91-43385
Combusting flow simulations of detonation and shock-induced combustion waves for ram accelerator configurations with viscous effect
[AIAA PAPER 91-1674] p 721 A91-43584
Detailed measurements on unsteady properties in three-dimensional show wave/turbulent boundary layer interaction induced by blunt fin at Mach number 4
[AIAA PAPER 91-1755] p 723 A91-43629
3-D Navier-Stokes analysis of crossing, glancing shocks/turbulent boundary layer interactions
[AIAA PAPER 91-1758] p 723 A91-43631
On the quasi-conical flowfield structure of the swept shock wave-turbulent boundary layer interaction
[AIAA PAPER 91-1759] p 724 A91-43632
An experimental/computational study of heat transfer in sharp fin induced turbulent interactions at Mach 5
[AIAA PAPER 91-1764] p 724 A91-43633
Studies of shock/shock interaction on smooth and transpiration-cooled hemispherical nosetips in hypersonic flow
[AIAA PAPER 91-1765] p 724 A91-43634
Numerical investigation on shock wave/boundary-layer interactions in a constant area diffuser at Mach 3
[AIAA PAPER 91-1766] p 724 A91-43635
SHOCK WAVES
Surface heat transfer change induced by unsteady shock reflections and numerical simulations on shock reflection p 695 A91-40647
Finite element simulation of compressible flows with shocks
[AIAA PAPER 91-1551] p 767 A91-40725
Effect of shock waves upon seat mounted sensors in escape systems p 738 A91-41543
An investigation of hypersonic shock tunnel testing at an equilibrium interface condition of 4100 K - Theory and experiment
[AIAA PAPER 91-1707] p 761 A91-42560
A demonstration of mode transition in a scramjet combustor
[AIAA PAPER 91-2395] p 754 A91-44225
Application of sweep to improve efficiency of a transonic fan. II - Performance and laser test results
[AIAA PAPER 91-2544] p 730 A91-44287
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124
SHORT TAKEOFF AIRCRAFT
Estimation of the aeroelastic characteristics from flight test data of the STOL research aircraft ASKA
[NAL-TR-1083] p 740 N91-25145
SHROUDED PROPELLERS
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fab simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106
SHUTDOWNS
An approach to modeling continuous turbine engine operation from startup to shutdown
[AIAA PAPER 91-2373] p 747 A91-41764
SIGNAL PROCESSING
Estimating the period length of periodic signals p 770 A91-41846
Intelligent radar data processing p 770 A91-41849
Digital signal conditioning for flight test, volume 19
[AGARD-AG-160-VOL-19] p 778 N91-26432

SILANES
Instantaneous planar visualization of reacting supersonic flows using silane seeding
[AIAA PAPER 91-1690] p 772 A91-43593
SILICON CARBIDES
Spherical particle impact damage behaviour of a SiC fibre-reinforced chemical vapour infiltrated SiC composite p 765 A91-43752
SIMULATORS
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fab simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106
CFD calibration and application to the design of flow tailoring devices for simulating forebody influences on fighter aircraft inlet flows p 776 N91-25339
SINGLE STAGE TO ORBIT VEHICLES
HOTOL space transport for the twenty-first century p 763 A91-41537
SKIN FRICTION
An application of topological method to analysing the three-dimensional flow in cascades. II - Topological analysis on the vector field patterns of skin-frictions and section streamlines p 694 A91-40569
SLENDER BODIES
Effect of nose bluntness on flowfield over slender bodies in hypersonic flows p 707 A91-42256
Application of indicial theory to the prediction of unsteady separation
[AIAA PAPER 91-1742] p 710 A91-42572
Sources of high alpha vortex asymmetry at zero sideslip
[AIAA PAPER 91-1810] p 713 A91-42604
Asymmetric separated flows over slender bodies at supersonic speeds p 714 A91-42730
Self-propelled slender axisymmetric body flows: Errors in the Poisson equation field calculation p 731 N91-25110
SLENDER WINGS
An approximate computation method to compute low-speed aerodynamic characteristics of wing with separation p 718 A91-43510
SMOOTHING
Upwind implicit residual smoothing method for multi-stage schemes
[AIAA PAPER 91-1533] p 696 A91-40708
SOFTWARE ENGINEERING
Detection and avoidance of errors in computer software p 783 N91-25937
Autonomous aircraft initiative study
[NASA-CR-186013] p 742 N91-26140
SOFTWARE TOOLS
Turbofan engine bird ingestion testing
[AIAA PAPER 91-2380] p 754 A91-44218
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100
A neural network for the analysis of aircraft test data p 781 N91-25133
SOLID SURFACES
Unstructured meshes and surface fidelity for complex shapes
[AIAA PAPER 91-1591] p 701 A91-40765
Analysis of external burning on inclined surfaces in supersonic flow
[AIAA PAPER 91-2390] p 747 A91-41767
SONIC BOOMS
CFD prediction of the near-field sonic boom environment for two low boom HSCT configurations --- High Speed Civil Transport
[AIAA PAPER 91-1631] p 784 A91-43560
SOUND GENERATORS
The reduction of cavity noise at subsonic speeds
[NAL-TR-1081] p 784 N91-25815
SOUND PRESSURE
A study of aeroacoustic performance of a contra-rotating axial flow compressor stage p 706 A91-42248
SOUND TRANSMISSION
The design and commissioning of an acoustic liner for propeller noise testing in the ARA transonic wind tunnel p 783 A91-41540
SOUND WAVES
Computation of broadband mixing noise from turbomachinery
[AD-A233991] p 784 N91-26878
SOUNDING ROCKETS
Optimal control problems with switching points p 782 N91-25694
SPACE COMMERCIALIZATION
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046
SPACE EXPLORATION
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046
SPACE FLIGHT
Langley aerospace test highlights, 1990
[NASA-TM-104090] p 786 N91-26112
SPACE PERCEPTION
Format and basic geometry of a perspective display of air traffic for the cockpit
[NASA-TM-86680] p 743 N91-26142
SPACE PROGRAMS
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124
SPACE SHUTTLE MAIN ENGINE
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319
SPACE SHUTTLES
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046
SPACE TRANSPORTATION SYSTEM
HOTOL space transport for the twenty-first century p 763 A91-41537
SPACECRAFT DESIGN
HOTOL space transport for the twenty-first century p 763 A91-41537
SPACECRAFT REENTRY
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124
SPATIAL RESOLUTION
A vertex-centroid scheme for improved finite-volume solution of the Navier-Stokes equations
[AIAA PAPER 91-1540] p 697 A91-40715
SPECIFIC HEAT
Thermodynamic analysis of gas turbine engines and plants at high air pressure levels p 743 A91-41171
SPECIFICATIONS
Survey of current aircraft engine conditions
[AD-A235143] p 756 N91-26144
Structured representation for requirements and specifications
[NASA-CR-187522] p 783 N91-26797
SPLITTING
Flutter control of incompressible flow turbomachine blade rows by splitter blades
[AIAA PAPER 91-1900] p 704 A91-41645
SPRAY CHARACTERISTICS
Visualization of airblast atomized spray structure under varying air pressure conditions
[AIAA PAPER 91-2199] p 769 A91-41726
SPRAYED COATINGS
Flight service evalulation of thermal barrier coatings by physical vapor deposition at 5200 h p 764 A91-41511
STABLE OSCILLATIONS
Theoretical studies of the kinematics, dynamics, stability, and control of unsteady/vortical flows
[AD-A235190] p 779 N91-26477
STAGNATION POINT
On the convection velocity of turbulent structures in supersonic shear layers
[AIAA PAPER 91-1724] p 723 A91-43614
STAGNATION PRESSURE
Performance implications of gas-turbine pressure-gain combustors
[AIAA PAPER 91-1879] p 744 A91-41641
STAINLESS STEELS
Limiting thermal loads in porous structures p 768 A91-41159
STANDARDIZATION
What fuels our future?
[AD-A233674] p 767 N91-26387
STATIC AERODYNAMIC CHARACTERISTICS
Static aeroelastic analysis of a three-dimensional oblique wing p 714 A91-42711
STATIC PRESSURE
Aerodynamic free-jet nozzle performance augmentation using an exhaust diffuser
[AIAA PAPER 91-2270] p 705 A91-41740
In-flight measurement of static pressures and boundary-layer state with integrated sensors p 742 A91-43306
Dynamic tester for rotor seals and bearings
[NASA-CASE-MFS-28493-1] p 763 N91-25155
STATIC TESTS
Static performance of a multiaxis thrust vectoring cruciform nozzle
[AIAA PAPER 91-2137] p 745 A91-41707
Static performance tests of a flight-type STOVL ejector
[AIAA PAPER 91-1902] p 750 A91-44050
STATISTICAL ANALYSIS
Manual on the flight of flexible aircraft in turbulence
[AGARD-AG-317] p 758 N91-26150
STATOR BLADES
The vortex interaction in a propeller/stator flow field
[AIAA PAPER 91-1818] p 726 A91-43657
Investigation of hot streak migration and film cooling effects on the heat transfer in rotor/stator interacting flows
[AD-A235420] p 756 N91-26145
STEADY FLOW
Higher order accuracy for upwind methods by using the compatibility equations
[AIAA PAPER 91-1543] p 697 A91-40718
A new Lagrangian random choice method for steady two-dimensional supersonic/hypersonic flow
[AIAA PAPER 91-1546] p 697 A91-40721
Second-order Godunov methods and self-similar steady supersonic three-dimensional flowfields
[AIAA PAPER 91-1653] p 708 A91-42544
Vortex topology for rectangular wings in pictures, sketches and conjectures
[AIAA PAPER 91-1824] p 713 A91-42611
An efficient method for estimating neighboring steady-state numerical solutions to the Euler equations
[AIAA PAPER 91-1680] p 722 A91-43589
STEADY STATE
Accelerated convergence to steady state by gradual far-field damping
[AIAA PAPER 91-1604] p 702 A91-40776
STEERING
A look at digital nose wheel steering
[AD-A233944] p 741 N91-26131
STIFFNESS
Computational aspects of chemically reacting flows
[AIAA PAPER 91-1574] p 699 A91-40748
STOCHASTIC PROCESSES
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319
STOVL AIRCRAFT
A powered lift experiment for CFD validation
[AIAA PAPER 91-1731] p 723 A91-43619
Scale model test results of several STOVL ventral nozzle concepts
[AIAA PAPER 91-2134] p 752 A91-44134
STRAPDOWN INERTIAL GUIDANCE
Specification of an inertial navigation system for experimental SAR p 735 A91-41829
STRATOSPHERE
Science requirements and feasibility/design studies of a very-high-altitude aircraft for atmospheric research p 740 N91-25481
STREAMLINED BODIES
An application of topological method to analysing the three-dimensional flow in cascades. II - Topological analysis on the vector field patterns of skin-frictions and section streamlines p 694 A91-40569
STRESS ANALYSIS
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113
STRESS MEASUREMENT
Using implicit displacement expressions for obtaining a solution in the transition zone of a hybrid computation scheme p 768 A91-41168
STRESS-STRAIN RELATIONSHIPS
Determination of the stress-strain state of a soft lifting system --- Single-Shell Parachute Airfoil p 704 A91-41320
STRUCTURAL ANALYSIS
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799
Thermostructural concepts for hypervelocity vehicles p 764 A91-43311
Dynamic analysis of advanced tip rotors including three-dimensional aerodynamics p 731 N91-25111
Acoustical analysis of gear housing vibration
[NASA-TM-103691] p 777 N91-25411
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422
STRUCTURAL DESIGN
Gust design procedures p 759 N91-26155
STRUCTURAL RELIABILITY
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799
Failure analysis of structural systems p 739 A91-43512
STRUCTURAL STABILITY
Structural mechanics research in the DLR p 771 A91-43334
Failure analysis of structural systems p 739 A91-43512
STRUCTURAL VIBRATION
A method for calculating the characteristics of a rotor with allowance for shaft vibrations p 768 A91-41155
Gasdynamic interaction of flow with an oscillating shell p 703 A91-41157

A theoretical study on the vibration damping of aircraft gearbox gears
[AIAA PAPER 91-2558] p 738 A91-41813
Unified treatment for dealing with auxiliary conditions in blade dynamics p 770 A91-42294

STRUCTURAL WEIGHT
Summary of technology needs for high speed rotorcraft study
[AIAA PAPER 91-2148] p 693 A91-41710
Structural mechanics research in the DLR p 771 A91-43334

SUBSONIC FLOW
A numerical analysis of the flow passing through a cascade with tip clearance - Subsonic flow through a linear cascade composed of flat plates p 695 A91-40575
Determination of the stress-strain state of a soft lifting system --- Single-Shell Parachute Airfoil p 704 A91-41320
Kernel function occurring in subsonic unsteady potential flow p 707 A91-42280
A method for correcting wall pressure measurements in subsonic compressible flow p 715 A91-42957
Numerical study of juncture flows
[AIAA PAPER 91-1660] p 720 A91-43575
C.F.D. of the base flow on a plane body between a subsonic flow on one side and a supersonic flow on the other
[AIAA PAPER 91-2372] p 729 A91-44215
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116

SUBSONIC SPEED
Opportunities for applications of natural laminar flow technology at high-subsonic speeds
[AIAA PAPER 91-1773] p 724 A91-43638
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fab simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106
The reduction of cavity noise at subsonic speeds
[NAL-TR-1081] p 784 N91-25815

SUCTION
Secondary instability of high-speed flows and the influence of wall cooling and suction
[AIAA PAPER 91-1647] p 720 A91-43572

SUPERCOMPUTERS
Introduction to the LaRC central scientific computing complex
[NASA-TM-104092] p 782 N91-25623

SUPERHIGH FREQUENCIES
Experimental X-band synthetic aperture radar in aircraft p 735 A91-41825

SUPERSONIC AIRCRAFT
Computational fluid dynamics in the design of the YF-23 ATF prototype
[AIAA PAPER 91-1627] p 719 A91-43558
A numerical study of compressible viscous flow in a novel exhaust system
[AIAA PAPER 91-1728] p 723 A91-43617
On the use of CFD in HSCT inlet and nozzle design --- High Speed Civil Transport
[AIAA PAPER 91-2255] p 728 A91-44173
Optimal control problems with switching points p 782 N91-25694

SUPERSONIC BOUNDARY LAYERS
LU implicit TVD scheme for the solution of viscous two dimensional high speed flows
[AIAA PAPER 91-1573] p 699 A91-40747
Numerical simulation of a three-dimensional shock wave-turbulent boundary layer interaction generated by a sharp fin at Mach 4 p 714 A91-42726
A parametric study of the leading edge attachment line for the F-16XL
[AIAA PAPER 91-1621] p 718 A91-43555
Waves produced from a harmonic point source in a supersonic boundary layer
[AIAA PAPER 91-1646] p 720 A91-43571
Secondary instability of high-speed flows and the influence of wall cooling and suction
[AIAA PAPER 91-1647] p 720 A91-43572
An experimental/computational study of heat transfer in sharp fin induced turbulent interactions at Mach 5
[AIAA PAPER 91-1764] p 724 A91-43633

SUPERSONIC COMBUSTION
A numerical study on wind tunnel interference effects in external burning test at M = 1.5
[AIAA PAPER 91-1675] p 749 A91-43585
Instantaneous planar visualization of reacting supersonic flows using silane seeding
[AIAA PAPER 91-1690] p 772 A91-43593
Mixing enhancement of reacting parallel fuel jets in a supersonic combustor
[AIAA PAPER 91-1914] p 750 A91-44055
Navier-Stokes simulation of the supersonic combustion flowfield in a ram accelerator
[AIAA PAPER 91-1916] p 773 A91-44057
Analysis of losses in supersonic mixing and reacting flows
[AIAA PAPER 91-2266] p 774 A91-44180

SUPERSONIC COMBUSTION RAMJET ENGINES
CFD analysis of a hydrogen fueled ramjet engine at Mach 3.44
[AIAA PAPER 91-1919] p 745 A91-41653
Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41768
Computational and experimental aftbody flow fields for hypersonic, airbreathing configurations with scramjet exhaust flow simulation
[AIAA PAPER 91-1709] p 709 A91-42561
Parametric study of airframe-integrated scramjet cooling requirement p 749 A91-42817
Rapid methodology for design and performance prediction of integrated supersonic combustion ramjet engine p 739 A91-42818
A study of supersonic aerodynamic mixing in the scramjet combustor p 771 A91-43000
Numerical analysis of scramjet flows in a dump combustor
[AIAA PAPER 91-1676] p 749 A91-43586
Optimized scramjet integration on a waverider
[AIAA PAPER 91-1693] p 739 A91-43594
Performance evaluation of semi-freejet tests of the Generic High Speed Engine
[AIAA PAPER 91-2163] p 753 A91-44141
A demonstration of mode transition in a scramjet combustor
[AIAA PAPER 91-2395] p 754 A91-44225
Experiments on hypersonic ramjet propulsion cycles using a ram accelerator
[AIAA PAPER 91-2489] p 762 A91-44264
Enhanced capability of the Combustion-Heated Scramjet Test Facility
[AIAA PAPER 91-2502] p 762 A91-44267
CFD code validation for nozzle flowfields
[AIAA PAPER 91-2565] p 775 A91-44295

SUPERSONIC COMPRESSORS
A new concept on compressor and turbine for aerospace propulsion
[AIAA PAPER 91-2591] p 755 A91-44303

SUPERSONIC DIFFUSERS
Numerical investigation on shock wave/boundary-layer interactions in a constant area diffuser at Mach 3
[AIAA PAPER 91-1766] p 724 A91-43635
Supersonic wind tunnel diffuser performance with high model blockage at moderate to low Reynolds numbers
[AIAA PAPER 91-2274] p 761 A91-44183

SUPERSONIC FLIGHT
Pareto-optimal shapes of axisymmetric bodies moving at high supersonic velocities p 707 A91-42330
Comparison of cryogenic wind tunnel, flight, and computational results for a thin, low-aspect-ratio wing
[AIAA PAPER 91-1626] p 708 A91-42536
CFD prediction of the near-field sonic boom environment for two low boom HSCT configurations --- High Speed Civil Transport
[AIAA PAPER 91-1631] p 784 A91-43560

SUPERSONIC FLOW
Dissipation additions to flux-difference splitting
[AIAA PAPER 91-1544] p 697 A91-40719
A new Lagrangian random choice method for steady two-dimensional supersonic/hypersonic flow
[AIAA PAPER 91-1546] p 697 A91-40721
Supersonic jet mixing enhancement by vortex generators
[AIAA PAPER 91-2263] p 705 A91-41738
Analysis of external burning on inclined surfaces in supersonic flow
[AIAA PAPER 91-2390] p 747 A91-41767
New mixing-length model for turbulent high-speed flows p 707 A91-42277
Multigrid and upwind viscous flow solver on three-dimensional overlapped and embedded grids p 707 A91-42284
Reliability of initially compressed uncertain laminated plates in supersonic flow p 770 A91-42292
Comment on 'Critique of turbulence models for shock-induced flow separation' p 707 A91-42307
Second-order Godunov methods and self-similar steady supersonic three-dimensional flowfields
[AIAA PAPER 91-1653] p 708 A91-42544
CFD evaluation of transonic-supersonic wave front propagation effects
[AIAA PAPER 91-1657] p 708 A91-42547
Laser velocimetry measurements of supersonic vortex flows on a simple razor-edged delta wing
[AIAA PAPER 91-1684] p 709 A91-42553
Asymmetric separated flows over slender bodies at supersonic speeds p 714 A91-42730
Influence of thickness and camber on the aeroelastic stability of supersonic throughflow fans p 715 A91-42814
Combined tangential-normal injection into a supersonic flow p 715 A91-42816
Supersonic film cooling effectiveness using air and helium for a range of injectant temperatures and Mach numbers
[AIAA PAPER 91-1416] p 772 A91-43477
Assessment of meanflow solutions for instability analysis of transitioning flows
[AIAA PAPER 91-1638] p 720 A91-43565
CFD computations for aero-optical analysis of supersonic shear layers
[AIAA PAPER 91-1659] p 720 A91-43574
Numerical study of juncture flows
[AIAA PAPER 91-1660] p 720 A91-43575
Comparisons of numerical and exact solutions for oblique detonations with structure
[AIAA PAPER 91-1677] p 721 A91-43587
An efficient method for estimating neighboring steady-state numerical solutions to the Euler equations
[AIAA PAPER 91-1680] p 722 A91-43589
Instantaneous planar visualization of reacting supersonic flows using silane seeding
[AIAA PAPER 91-1690] p 772 A91-43593
On the convection velocity of turbulent structures in supersonic shear layers
[AIAA PAPER 91-1724] p 723 A91-43614
Detailed measurements of unsteady properties in three-dimensional show wave/turbulent boundary layer interaction induced by blunt fin at Mach number 4
[AIAA PAPER 91-1755] p 723 A91-43629
Numerical investigation on shock wave/boundary-layer interactions in a constant area diffuser at Mach 3
[AIAA PAPER 91-1766] p 724 A91-43635
Application of a Reynolds Stress turbulence model to a supersonic hydrogen-air diffusion flame
[AIAA PAPER 91-1786] p 725 A91-43643
Supersonic viscous flow calculations for axisymmetric, two and three-dimensional configurations
[AIAA PAPER 91-1802] p 725 A91-43649
Mach 3.5 boundary-layer transition on a cone at angle of attack
[AIAA PAPER 91-1804] p 725 A91-43650
Theoretical study of supersonic flow separation over a rearward facing step
[AIAA PAPER 91-2161] p 753 A91-44139
Analysis of losses in supersonic mixing and reacting flows
[AIAA PAPER 91-2266] p 774 A91-44180
C.F.D. of the base flow on a plane body between a subsonic flow on one side and a supersonic flow on the other
[AIAA PAPER 91-2372] p 729 A91-44215

SUPERSONIC INLETS
Supersonic inlet flow computations using fortified Navier-Stokes approach
[AIAA PAPER 91-1730] p 710 A91-42567
Sizing supersonic freejet nozzle and inlet location for simulation of the transition phase in integral rocket ramjet p 763 A91-43084
Supersonic air-intake study aiming at future airbreathing engine
[AIAA PAPER 91-2012] p 751 A91-44092
A numerical investigation for supersonic inlet with throat cavity
[AIAA PAPER 91-2477] p 729 A91-44260
High-speed forebody-inlet code validation experience at MCAIR p 776 N91-25348

SUPERSONIC JET FLOW
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821
Sizing supersonic freejet nozzle and inlet location for simulation of the transition phase in integral rocket ramjet p 763 A91-43084
Three-dimensional upwinding Navier-Stokes code with k-epsilon model for supersonic flows
[AIAA PAPER 91-1669] p 721 A91-43580
Observations of supersonic transverse jets
[AIAA PAPER 91-1723] p 772 A91-43613
Vortex breakdown in a supersonic jet
[AIAA PAPER 91-1815] p 726 A91-43656
Prediction of jet mean flow structure in support of HSCT noise suppression concepts --- High Speed Civilian Transport
[AIAA PAPER 91-2253] p 774 A91-44171

SUPERSONIC NOZZLES
Sizing supersonic freejet nozzle and inlet location for simulation of the transition phase in integral rocket ramjet p 763 A91-43084

SUPERSONIC SPEED
Wave processes occurring in supersonic motion of blunted body through dust layer p 695 A91-40656

Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41768
SUPERSONIC TURBINES
Aerodynamic losses due to pressure side coolant ejection in a transonic turbine cascade
[AIAA PAPER 91-2032] p 745 A91-41684
SUPERSONIC WIND TUNNELS
On the acoustical performances of noise suppressors with depressive networks for jet engines test rigs and supersonic wind tunnel facilities p 784 A91-42999
Study of cluster formation and its effects on Rayleigh and Raman scattering measurements in a Mach 6 wind tunnel
[AIAA PAPER 91-1496] p 718 A91-43547
Mach 3.5 boundary-layer transition on a cone at angle of attack
[AIAA PAPER 91-1804] p 725 A91-43650
Aerodynamic characteristics of Mach-3 air-intake tested in supersonic wind tunnel
[AIAA PAPER 91-2011] p 727 A91-44091
Supersonic wind tunnel diffuser performance with high model blockage at moderate to low Reynolds numbers
[AIAA PAPER 91-2274] p 761 A91-44183
A quiet flow Ludwieg tube for study of transition in compressible boundary layers: Design and feasibility
[NASA-CR-188499] p 731 N91-25107
SUPPRESSORS
Mixer/ejector noise suppressors
[AIAA PAPER 91-2243] p 753 A91-44169
SURFACE COOLING
Investigation of hot streak migration and film cooling effects on the heat transfer in rotor/stator interacting flows
[AD-A235420] p 756 N91-26145
SURFACE PROPERTIES
Surface reconstruction from scattered data through pruning of unstructured grids
[AIAA PAPER 91-1584] p 700 A91-40758
SURFACE REACTIONS
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets
p 748 A91-42805
SURFACE ROUGHNESS
Mach 6 turbulent boundary layer characteristics on smooth and rough surfaces
[AIAA PAPER 91-1762] p 711 A91-42580
SURFACE ROUGHNESS EFFECTS
Modification of the van Driest damping function to include the effects of surface roughness
p 770 A91-42282
SURFACE TEMPERATURE
An experimental evaluation of thermochromic liquid crystals for surface temperature and heat flux measurements in shock tube flows p 767 A91-40645
Accurate airborne surface temperature measurements with chopper-stabilized radiometers p 742 A91-42142
SURFACE TO AIR MISSILES
The wild weasel development programs, one run, one hit, one error
[RAND-P-7661-RGS] p 778 N91-26431
SURGES
A numerical study of surge and rotating stall in axial compressors
[AIAA PAPER 91-1896] p 727 A91-44048
SURVEILLANCE
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153
SURVEYS
Survey of current aircraft engine conditions
[AD-A235143] p 756 N91-26144
SWEAT COOLING
Studies of shock/shock interaction on smooth and transpiration-cooled hemispherical nosetips in hypersonic flow
[AIAA PAPER 91-1765] p 724 A91-43634
SWEEP EFFECT
Application of sweep to improve efficiency of a transonic fan. II - Performance and laser test results
[AIAA PAPER 91-2544] p 730 A91-44287
SWEPT WINGS
Dynamic stall experiments on a swept three-dimensional wing in compressible flow
[AIAA PAPER 91-1795] p 712 A91-42595
In-flight measurement of static pressures and boundary-layer state with integrated sensors
p 742 A91-43306
An approximate computation method to compute low-speed aerodynamic characteristics of wing with separation p 718 A91-43510
Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel
[AIAA PAPER 91-1725] p 723 A91-43615
Opportunities for applications of natural laminar flow technology at high-subsonic speeds
[AIAA PAPER 91-1773] p 724 A91-43638
A numerical method for 3D boundary layers with a small crossflow
[AIAA PAPER 91-2473] p 775 A91-44258
SWIRLING
Dynamics of discrete phase in a gas turbine co-axial, counter-swirling, combustor dome swirl cup
[AIAA PAPER 91-2353] p 746 A91-41758
Experimental and computational investigation of isothermal swirling flow in an axisymmetric dump combustor p 749 A91-42806
SYNCHRONISM
Coordination and synchronization of loran-C and GPS to universal coordinated time
[AD-A233221] p 737 N91-25141
SYNTHETIC APERTURE RADAR
Experimental X-band synthetic aperture radar in aircraft p 735 A91-41825
Concept and results of the Azimuth Quick-Look Processor for aircraft SAR of the DLR
p 735 A91-41828
Specification of an inertial navigation system for experimental SAR p 735 A91-41829
Comparison of aircraft synthetic aperture radar and buoy spectra during the Norwegian Continental Shelf Experiment of 1988 p 779 A91-42224
SYSTEMS ENGINEERING
The pilot's associate: Exploiting the intelligent advantage p 781 N91-25122
The wild weasel development programs, one run, one hit, one error
[RAND-P-7661-RGS] p 778 N91-26431
Results of the aeronautical systems division critical process team on integrated product development
[AD-A235419] p 785 N91-26995
SYSTEMS INTEGRATION
An integrated automatic ramjet engine control system tolerant to failures of the functional components
p 780 A91-41163
A multidisciplinary approach to aeroelastic analysis
p 781 A91-42709
SYSTEMS STABILITY
Parametric investigation into the combined effects of pressure and temperature distortion on compression system stability
[AIAA PAPER 91-1895] p 773 A91-44047

T

TACTICS
The pilot's associate: Exploiting the intelligent advantage p 781 N91-25122
Mission planning systems for tactical aircraft (pre-flight and in-flight)
[AGARD-AR-296] p 783 N91-25750
TAPERING
Dynamic analysis of advanced tip rotors including three-dimensional aerodynamics p 731 N91-25111
TARGET RECOGNITION
Integrated control and avionics for air superiority: A knowledge-based decision aiding system
p 743 N91-25138
TAYLOR INSTABILITY
A new vertical shock tube for Rayleigh-Taylor instability measurements p 759 A91-40637
TECHNOLOGICAL FORECASTING
HOTOL space transport for the twenty-first century
p 763 A91-41537
Twenty-first century aero-engine design - The environmental factor p 744 A91-41539
Aircraft gas turbine performance for the year 2000
[AIAA PAPER 91-2233] p 746 A91-41733
TECHNOLOGY ASSESSMENT
Summary of technology needs for high speed rotorcraft study
[AIAA PAPER 91-2148] p 693 A91-41710
Recent advances in hypersonic technology
p 716 A91-43103
TECHNOLOGY TRANSFER
Ceramic technology for advanced heat engines project
[DE91-010451] p 766 N91-26384
TECHNOLOGY UTILIZATION
Technical evaluation report on the flight mechanics panel symposium on progress in military airlift
[AGARD-AR-300] p 733 N91-25119
Opportunities for advanced speech processing in military computer-based systems
[AD-A233724] p 778 N91-26412
TEMPERATURE CONTROL
Development of IR sensor window cooling requirements for endoatmospheric interceptors
[AIAA PAPER 91-1439] p 764 A91-44338
TEMPERATURE DISTRIBUTION
Parametric investigation into the combined effects of pressure and temperature distortion on compression system stability
[AIAA PAPER 91-1895] p 773 A91-44047
Unsteady hot streak simulation through a 1-1/2 stage turbine engine
[AIAA PAPER 91-3382] p 775 A91-44321
TEMPERATURE MEASUREMENT
Accurate airborne surface temperature measurements with chopper-stabilized radiometers p 742 A91-42142
Study of cluster formation and its effects on Rayleigh and Raman scattering measurements in a Mach 6 wind tunnel
[AIAA PAPER 91-1496] p 718 A91-43547
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150
TERMINAL GUIDANCE
Ground-based 4-D guidance of flights in strong winds
p 734 A91-41438
The European ATC system - Constraints and traffic management p 734 A91-41439
Alternative strategies for traffic flow-management in Europe p 734 A91-41442
TERRAIN
How low can an unmanned air vehicle fly?
[RAND-P-7680-RGS] p 741 N91-26138
TEST FACILITIES
Development of a vitiated air heater for engine test facilities
[AIAA PAPER 91-2501] p 761 A91-41802
On the acoustical performances of noise suppressors with depressive networks for jet engines test rigs and supersonic wind tunnel facilities p 784 A91-42999
Uncertainty analysis of turbine aerodynamic performance measurements in short duration test facilities
[AIAA PAPER 91-2131] p 761 A91-44132
Turbofan engine bird ingestion testing
[AIAA PAPER 91-2380] p 754 A91-44218
Enhanced capability of the Combustion-Heated Scramjet Test Facility
[AIAA PAPER 91-2502] p 762 A91-44267
Langley aerospace test highlights, 1990
[NASA-TM-104090] p 786 N91-26112
THERMAL ANALYSIS
Thermostructural concepts for hypervelocity vehicles
p 764 A91-43311
Thermal modeling and analysis of a cryogenic tank design exposed to extreme heating profiles
[AIAA PAPER 91-1383] p 772 A91-43447
THERMAL CONTROL COATINGS
Flight service evaluation of thermal barrier coatings by physical vapor deposition at 5200 h p 764 A91-41511
THERMAL PROTECTION
Heat management concepts for hypersonic propulsion systems
[AIAA PAPER 91-2493] p 769 A91-41798
THERMOCHROMATIC MATERIALS
An experimental evaluation of thermochromic liquid crystals for surface temperature and heat flux measurements in shock tube flows p 767 A91-40645
THERMODYNAMIC CYCLES
Compressor exit temperature analysis. II
[AIAA PAPER 91-2008] p 751 A91-44090
Combined cycle aircraft engines
[AIAA PAPER 91-2377] p 754 A91-44217
Experiments on hypersonic ramjet propulsion cycles using a ram accelerator
[AIAA PAPER 91-2489] p 762 A91-44264
THERMODYNAMIC EFFICIENCY
Uncertainty analysis of turbine aerodynamic performance measurements in short duration test facilities
[AIAA PAPER 91-2131] p 761 A91-44132
Combined cycle aircraft engines
[AIAA PAPER 91-2377] p 754 A91-44217
THERMODYNAMIC EQUILIBRIUM
Aeroacoustic and aerodynamic applications of the theory of nonequilibrium thermodynamics
[NASA-TP-3118] p 776 N91-25352
THERMODYNAMIC PROPERTIES
Thermodynamic analysis of gas turbine engines and plants at high air pressure levels p 743 A91-41171
THERMOHYDRAULICS
Limiting thermal loads in porous structures
p 768 A91-41159
Jet-wake thermal characteristics of heated turbulent jets in crossflow p 770 A91-42258
THICKNESS
Influence of thickness and camber on the aeroelastic stability of supersonic throughflow fans
p 715 A91-42814
THIN PLATES
Reliability of initially compressed uncertain laminated plates in supersonic flow p 770 A91-42292

THIN WALLED SHELLS
A new method for the vibration of thin-walled beams p 772 A91-43706
THIN WINGS
Using implicit displacement expressions for obtaining a solution in the transition zone of a hybrid computation scheme p 768 A91-41168
Comparison of cryogenic wind tunnel, flight, and computational results for a thin, low-aspect-ratio wing [AIAA PAPER 91-1626] p 708 A91-42536
THREAT EVALUATION
A new threat detection criterion for airborne collision avoidance systems p 735 A91-41447
THREE DIMENSIONAL BODIES
Multigrid solutions of the three-dimensional grid equations p 706 A91-42098
Dynamic stall experiments on a swept three-dimensional wing in compressible flow [AIAA PAPER 91-1795] p 712 A91-42595
Static aeroelastic analysis of a three-dimensional oblique wing p 714 A91-42711
THREE DIMENSIONAL BOUNDARY LAYER
A numerical method for 3D boundary layers with a small crossflow [AIAA PAPER 91-2473] p 775 A91-44258
THREE DIMENSIONAL FLOW
An application of topological method to analysing the three-dimensional flow in cascades. II - Topological analysis on the vector field patterns of skin-frictions and section streamlines p 694 A91-40569
A 3-D upwind Euler solver for unstructured meshes [AIAA PAPER 91-1548] p 697 A91-40723
Multigrid for hypersonic viscous two- and three-dimensional flows [AIAA PAPER 91-1572] p 699 A91-40746
Surface reconstruction from scattered data through pruning of unstructured grids [AIAA PAPER 91-1584] p 700 A91-40758
A three-dimensional Navier-Stokes/full-potential coupled analysis for viscous transonic flow [AIAA PAPER 91-1595] p 701 A91-40769
A numerical method for predicting transition in three-dimensional flows by spatial amplification theory [AIAA PAPER 91-1606] p 702 A91-40778
Three-dimensional Navier-Stokes calculations using solution-adaptive grids p 703 A91-40802
A block-structured solution scheme with the multigrid method for three-dimensional inviscid transonic flows p 706 A91-42096
Multigrid and upwind viscous flow solver on three-dimensional overlapped and embedded grids p 707 A91-42284
Second-order Godunov methods and self-similar steady supersonic three-dimensional flowfields [AIAA PAPER 91-1653] p 708 A91-42544
LDV measurements in the roll-up region of the tip vortex from a rectangular wing [AIAA PAPER 91-1685] p 709 A91-42554
On three-dimensional flow separation criteria [AIAA PAPER 91-1740] p 710 A91-42571
Numerical and experimental study of fountain flows produced by multijet impingement on a ground plane [AIAA PAPER 91-1806] p 771 A91-42602
Vortex topology for rectangular wings in pictures, sketches and conjectures [AIAA PAPER 91-1824] p 713 A91-42611
Numerical evaluation of vortex flow control devices [AIAA PAPER 91-1825] p 713 A91-42612
Numerical simulation of a three-dimensional shock wave-turbulent boundary layer interaction generated by a sharp fin at Mach 4 p 714 A91-42726
Euler solver for arbitrary configurations - Further applications p 716 A91-43100
A parametric study of the leading edge attachment line for the F-16XL [AIAA PAPER 91-1621] p 718 A91-43555
Assessment of meanflow solutions for instability analysis of transitioning flows [AIAA PAPER 91-1638] p 720 A91-43565
Three-dimensional upwinding Navier-Stokes code with k-epsilon model for supersonic flows [AIAA PAPER 91-1669] p 721 A91-43580
Block-structured computation of three-dimensional transonic Euler equations [AIAA PAPER 91-1679] p 721 A91-43588
3-D Navier-Stokes analysis of crossing, glancing shocks/turbulent boundary layer interactions [AIAA PAPER 91-1758] p 723 A91-43631
On the quasi-conical flowfield structure of the swept shock wave-turbulent boundary layer interaction [AIAA PAPER 91-1759] p 724 A91-43632
Design and development of a compact bifurcated turboprop inlet [AIAA PAPER 91-2017] p 727 A91-44093
Computations of three-dimensional gas turbine combustor flows [AIAA PAPER 91-2076] p 773 A91-44116
Performance comparisons of Navier-Stokes codes for simulating three-dimensional hypersonic crossflow/jet interaction [AIAA PAPER 91-2096] p 728 A91-44127
Computations of three-dimensional viscous flows in turbomachinery cascades [AIAA PAPER 91-2237] p 728 A91-44164
Three-dimensional Navier-Stokes analysis of turbine passage heat transfer [AIAA PAPER 91-2241] p 774 A91-44167
Three-dimensional jet noise computations [AIAA PAPER 91-2256] p 784 A91-44174
Dynamic analysis of advanced tip rotors including three-dimensional aerodynamics p 731 N91-25111
Viscous flow simulations of internal store carriage and separation [NASA-CR-185343] p 732 N91-26123
Methods to enhance the accuracy of finite volume schemes 2 [FFA-147] p 779 N91-26466
THREE DIMENSIONAL MODELS
Application of a solution adaptive grid scheme, SAGE, to complex three-dimensional flows [AIAA PAPER 91-1594] p 701 A91-40768
Quasi-3-D non-reflecting boundary conditions for Euler equations calculations [AIAA PAPER 91-1603] p 702 A91-40775
Prediction of internal performance for two-dimensional convergent-divergent nozzles [AIAA PAPER 91-2369] p 706 A91-41762
An efficient DSMC algorithm applied to a delta wing [AIAA PAPER 91-1316] p 717 A91-43388
Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel [AIAA PAPER 91-1725] p 723 A91-43615
Application of a multiblock/multizone code (PAB3D) for the three-dimensional Navier-Stokes equations [AIAA PAPER 91-2155] p 728 A91-44137
CFD-based 3D turbofan exhaust nozzle analysis system [AIAA PAPER 91-2478] p 754 A91-44261
THROATS
A numerical investigation for supersonic inlet with throat cavity [AIAA PAPER 91-2477] p 729 A91-44260
THROTTLING
A preliminary investigation of the use of throttles for emergency flight control [AIAA PAPER 91-2222] p 756 A91-41731
THRUST
Measured thrust losses associated with secondary air injection through nozzle walls [AIAA PAPER 91-2244] p 705 A91-41734
THRUST DISTRIBUTION
An investigation of a hovering rotor in ground effect p 704 A91-41462
Comparative analysis of turbofan effective thrust with mixed and separated flows engines [AIAA PAPER 91-2376] p 754 A91-44216
THRUST VECTOR CONTROL
Two-dimensional thrust vector control nozzle [AIAA PAPER 91-2101] p 745 A91-41696
Static performance of a multiaxis thrust vectoring cruciform nozzle [AIAA PAPER 91-2137] p 745 A91-41707
Thrust vectoring using non-axisymmetric nozzles with flexible contours [AIAA PAPER 91-2368] p 746 A91-41761
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration [AIAA PAPER 91-1689] p 748 A91-42556
TILT ROTOR AIRCRAFT
Summary of technology needs for high speed rotorcraft study [AIAA PAPER 91-2148] p 693 A91-41710
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market [NASA-CR-177576] p 734 N91-26126
TILT WING AIRCRAFT
High-speed rotorcraft propulsion [AIAA PAPER 91-2147] p 746 A91-41709
Summary of technology needs for high speed rotorcraft study [AIAA PAPER 91-2148] p 693 A91-41710
TILTING ROTORS
Conclusions from high-speed rotorcraft studies [AIAA PAPER 91-2149] p 693 A91-41711
TIME DEPENDENCE
Time dependent calculations using multigrid, with applications to unsteady flows past airfoils and wings [AIAA PAPER 91-1596] p 727 A91-43675
TIME LAG
Vortical flow solutions using a time-lagged, thin-layer, Navier-Stokes algorithm p 707 A91-42279
Airport capacity and delay analyses [DOT/FAA/CT-TN91/18] p 762 N91-25152
TIME MARCHING
A numerical investigation of turbulent baseflow p 703 A91-40799
TITANIUM ALLOYS
Analysis of structural damping of titanium alloy shell structures as compared with that of aluminium alloy structures p 765 A91-41606
Titanium alloy integrated centrifugal impeller 5 coordinate computer assisted manufacturing technology [AD-A234797] p 766 N91-26300
TOPOLOGY
An application of topological method to analysing the three-dimensional flow in cascades. II - Topological analysis on the vector field patterns of skin-frictions and section streamlines p 694 A91-40569
Vortex topology for rectangular wings in pictures, sketches and conjectures [AIAA PAPER 91-1824] p 713 A91-42611
TORSION
Applications of higher harmonic control to hingeless rotor systems [NASA-TM-103846] p 694 N91-25102
Dynamics of elastic bending and torsion of hingeless rotors with dynamic stall [AD-A234775] p 741 N91-26134
TORSIONAL VIBRATION
A new method for the vibration of thin-walled beams p 772 A91-43706
TRAILING EDGES
The effect of square trailing edges on turbine blade performance [AIAA PAPER 91-2130] p 704 A91-41704
Turbulent flow predictions for afterbody/nozzle geometries including base effects p 715 A91-42813
New airfoil design concept p 716 A91-43307
TRAINING EVALUATION
Expert systems for training purposes [AIAA PAPER 91-2508] p 780 A91-41805
TRAINING SIMULATORS
ATC simulators do not have to replicate operational systems physically p 761 A91-42789
Visual systems for ATC training p 761 A91-42792
Simulating a new species of bird p 694 A91-44340
TRAJECTORY CONTROL
Optimal control problems with switching points p 782 N91-25694
TRAJECTORY OPTIMIZATION
Combined energy management and calculus of variations approach for optimizing hypersonic vehicle trajectories p 739 A91-42738
TRANSATMOSPHERIC VEHICLES
Super/hypersonic aerodynamic characteristics for a transatmospheric vehicle concept having a minimum drag forebody [AIAA PAPER 91-1694] p 709 A91-42558
Thermal modeling and analysis of a cryogenic tank design exposed to extreme heating profiles [AIAA PAPER 91-1383] p 772 A91-43447
Aerodynamic characteristics of Mach-3 air-intake tested in supersonic wind tunnel [AIAA PAPER 91-2011] p 727 A91-44091
TRANSIENT RESPONSE
Dynamic stall experiments on a swept three-dimensional wing in compressible flow [AIAA PAPER 91-1795] p 712 A91-42595
Transient performance of fan engine with water ingestion [AIAA PAPER 91-1897] p 750 A91-44049
TRANSITION FLIGHT
Incompressible boundary layer transition flight experiments over a nonaxisymmetric fuselage forebody and comparisons with laminar boundary layer stability theory p 777 N91-25359
TRANSITION FLOW
A numerical method for predicting transition in three-dimensional flows by spatial amplification theory [AIAA PAPER 91-1606] p 702 A91-40778
Analysis of external burning on inclined surfaces in supersonic flow [AIAA PAPER 91-2390] p 747 A91-41767
Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis [AIAA PAPER 91-1635] p 719 A91-43563
Assessment of meanflow solutions for instability analysis of transitioning flows [AIAA PAPER 91-1638] p 720 A91-43565
Transition predictions using Reynolds-averaged Navier-Stokes and linear stability analysis methods [AIAA PAPER 91-1641] p 720 A91-43567

TRANSMISSIONS (MACHINE ELEMENTS)
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1906] p 769 A91-41648
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1909] p 769 A91-41650
Acoustical analysis of gear housing vibration
[NASA-TM-103691] p 777 N91-25411
Advanced Rotorcraft Transmission (ART) program-Boeing helicopters status report
[NASA-TM-104474] p 778 N91-25412

TRANSONIC COMPRESSORS
Neural network based expert system for compressor stall monitoring
[AIAA PAPER 91-2500] p 781 A91-44266
A new concept on compressor and turbine for aerospace propulsion
[AIAA PAPER 91-2591] p 755 A91-44303

TRANSONIC FLOW
A vertex-centroid scheme for improved finite-volume solution of the Navier-Stokes equations
[AIAA PAPER 91-1540] p 697 A91-40715
Diagonal implicit multigrid solution of compressible turbulent flows
[AIAA PAPER 91-1571] p 699 A91-40745
A comparison of implicit multigrid Euler solvers implemented on a multiprocessor computer
[AIAA PAPER 91-1580] p 700 A91-40754
Grid convergence for adaptive methods
[AIAA PAPER 91-1592] p 701 A91-40766
A three-dimensional Navier-Stokes/full-potential coupled analysis for viscous transonic flow
[AIAA PAPER 91-1595] p 701 A91-40769
On the validity of linearized unsteady Euler equations with shock capturing
[AIAA PAPER 91-1598] p 702 A91-40771
The level of self-oscillations of aerodynamic control surfaces under nonseparating transonic gas flow
p 703 A91-41218
Viscous/inviscid method for preliminary design of transonic cascades
[AIAA PAPER 91-2364] p 706 A91-41760
A block-structured solution scheme with the multigrid method for three-dimensional inviscid transonic flows
p 706 A91-42096
CFD evaluation of transonic-supersonic wave front propagation effects
[AIAA PAPER 91-1657] p 708 A91-42547
Effect of model cooling on periodic transonic flow
[AIAA PAPER 91-1714] p 709 A91-42562
Drag and lift in nonadiabatic transonic flow
[AIAA PAPER 91-1716] p 710 A91-42564
Automatic design of transonic airfoils to reduce the shock induced pressure drag p 716 A91-43078
Synthesis of experimental riblet studies in transonic conditions p 716 A91-43142
A primary study of Reynolds number effect in transonic flow p 718 A91-43502
Flight test and numerical simulation of transonic flow around YAV-8B Harrier II wing
[AIAA PAPER 91-1628] p 719 A91-43559
Block-structured computation of three-dimensional transonic Euler equations
[AIAA PAPER 91-1679] p 721 A91-43588
Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel
[AIAA PAPER 91-1725] p 723 A91-43615
Vortical flows about a long cylinder at M = 3.5 and alpha = 18 deg
[AIAA PAPER 91-1808] p 726 A91-43651
A Finite Volume Lambda Formulation
[AIAA PAPER 91-2258] p 728 A91-44176
Methods to enhance the accuracy of finite volume schemes 2
[FFA-147] p 779 N91-26466

TRANSONIC FLUTTER
Transonic flutter analysis of aerodynamic surfaces in the presence of structural nonlinearities
p 713 A91-42710

TRANSONIC NOZZLES
A parametric experimental study of isolated rectangular nozzles
[AIAA PAPER 91-2136] p 738 A91-41706
Use of the PARC code for generic NASP nozzles operating at off-design transonic conditions
[AIAA PAPER 91-2154] p 705 A91-41713

TRANSONIC SPEED
Application of sweep to improve efficiency of a transonic fan. II - Performance and laser test results
[AIAA PAPER 91-2544] p 730 A91-44287

TRANSONIC WIND TUNNELS
The design and commissioning of an acoustic liner for propeller noise testing in the ARA transonic wind tunnel
p 783 A91-41540
Aerodynamic losses due to pressure side coolant ejection in a transonic turbine cascade
[AIAA PAPER 91-2032] p 745 A91-41684
Asymptotic methods for the prediction of transonic wind tunnel wall interference
[AIAA PAPER 91-1712] p 762 A91-44334

TRANSPORT AIRCRAFT
Areas for future CFD development as illustrated by transport aircraft applications
[AIAA PAPER 91-1527] p 696 A91-40703
Optimization of the turbofan engine control program during the cruising flight of subsonic transport aircraft
p 743 A91-41170
Effects of nozzle lip geometry on spray atomization and emissions advanced gas turbine combustors
[AIAA PAPER 91-2201] p 753 A91-44153
A simulation evaluation of a four-engine jet transport using engine thrust modulation for flightpath control
[AIAA PAPER 91-2223] p 757 A91-44162
On the use of CFD in HSCT inlet and nozzle design --- High Speed Civil Transport
[AIAA PAPER 91-2255] p 728 A91-44173
Inlet/fan cowl design for increased angle-of-attack requirements of transport aircraft - Methodology and test results
[AIAA PAPER 91-2481] p 730 A91-44263

TRANSPORTATION NETWORKS
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126

TRANSPUTERS
With us you fly right - The influence of modern technology on the development and operation of new aircraft
p 771 A91-43326

TROPOSPHERE
Science requirements and feasibility/design studies of a very-high-altitude aircraft for atmospheric research
p 740 N91-25481

TRUNCATION ERRORS
Self-propelled slender axisymmetric body flows: Errors in the Poisson equation field calculation
p 731 N91-25110

TUNING
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319
Aircraft interior noise reduction by alternate resonance tuning
[NASA-CR-185453] p 785 N91-26889

TURBINE BLADES
Application of shock tunnel at pressure and heat transfer experiments on turbine blade p 760 A91-40649
Investigation of coatings at high temperature for use in turbomachinery p 744 A91-41507
Flutter control of incompressible flow turbomachine blade rows by splitter blades
[AIAA PAPER 91-1900] p 704 A91-41645
Aerodynamic losses due to pressure side coolant ejection in a transonic turbine cascade
[AIAA PAPER 91-2032] p 745 A91-41684
The effect of square trailing edges on turbine blade performance
[AIAA PAPER 91-2130] p 704 A91-41704
Effects of streamwise pressure gradient on the suction surface boundary layer of a turbine airfoil
[AIAA PAPER 91-2030] p 727 A91-44097
Concepts for reduction of turbine rotor inertia
[AIAA PAPER 91-2031] p 752 A91-44098
An experimental investigation into the effects turbulator profile and spacing have on heat transfer coefficients and friction factors in small cooled turbine airfoils
[AIAA PAPER 91-2033] p 773 A91-44099
Unsteady hot streak simulation through a 1-1/2 stage turbine engine
[AIAA PAPER 91-3382] p 775 A91-44321
Investigation of hot streak migration and film cooling effects on the heat transfer in rotor/stator interacting flows
[AD-A235420] p 756 N91-26145

TURBINE ENGINES
Flight service evaluation of thermal barrier coatings by physical vapor deposition at 5200 h p 764 A91-41511
An approach to modeling continuous turbine engine operation from startup to shutdown
[AIAA PAPER 91-2373] p 747 A91-41764
New capabilities for aeromechanical testing and evaluation of aircraft turbine engines
[AIAA PAPER 91-2498] p 747 A91-41801
Velocity measurements in turbine engines - New developments using the laser two-focus method
p 771 A91-43328
Advanced technology engine casing designs
[AIAA PAPER 91-1893] p 750 A91-44046
Uncertainty analysis of turbine aerodynamic performance measurements in short duration test facilities
[AIAA PAPER 91-2131] p 761 A91-44132
A comparison of the analytical and experimental performance of the solid version of a cooled radial rotor
[AIAA PAPER 91-2133] p 752 A91-44133
High speed rotorcraft propulsion system studies
[AIAA PAPER 91-2150] p 752 A91-44135
Application of an unsteady Navier-Stokes solver to transonic turbine design
[AIAA PAPER 91-2468] p 729 A91-44254
A new concept on compressor and turbine for aerospace propulsion
[AIAA PAPER 91-2591] p 755 A91-44303
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150

TURBINE PUMPS
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319

TURBINE WHEELS
A three-dimensional Navier-Stokes stage analysis of the flow through a compact radial turbine
[AIAA PAPER 91-2564] p 748 A91-41815
Concepts for reduction of turbine rotor inertia
[AIAA PAPER 91-2031] p 752 A91-44098

TURBINES
A three-dimensional Navier-Stokes stage analysis of the flow through a compact radial turbine
[AIAA PAPER 91-2564] p 748 A91-41815
Aerodynamic and heat transfer analysis of the low aspect ratio turbine using a 3D Navier-Stokes code
[AIAA PAPER 91-2240] p 774 A91-44166
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319
Unsteady hot streak simulation through a 1-1/2 stage turbine engine
[AIAA PAPER 91-3382] p 775 A91-44321

TURBOCOMPRESSORS
A study of aeroacoustic performance of a contra-rotating axial flow compressor stage p 706 A91-42248
Parametric investigation into the combined effects of pressure and temperature distortion on compression system stability
[AIAA PAPER 91-1895] p 773 A91-44047
A numerical study of surge and rotating stall in axial compressors
[AIAA PAPER 91-1896] p 727 A91-44048
Compressor exit temperature analysis. II
[AIAA PAPER 91-2008] p 751 A91-44090

TURBOFAN ENGINES
A novel implementation of an implicit k-epsilon turbulence model coupled with an explicit Navier-Stokes solver p 703 A91-40796
Optimization of the turbofan engine control program during the cruising flight of subsonic transport aircraft
p 743 A91-41170
High-speed rotorcraft propulsion
[AIAA PAPER 91-2147] p 746 A91-41709
Numerical investigation of the flow within a turbofan lobed mixer p 749 A91-42812
Transient performance of fan engine with water ingestion
[AIAA PAPER 91-1897] p 750 A91-44049
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089
Compressor exit temperature analysis. II
[AIAA PAPER 91-2008] p 751 A91-44090
Comparative analysis of turbofan effective thrust with mixed and separated flows engines
[AIAA PAPER 91-2376] p 754 A91-44216
Combined cycle aircraft engines
[AIAA PAPER 91-2377] p 754 A91-44217
Turbofan engine bird ingestion testing
[AIAA PAPER 91-2380] p 754 A91-44218
A simulation study of turbofan engine deterioration estimation using Kalman filtering techniques
[NASA-TM-104233] p 755 N91-25147

TURBOFANS
CFD-based 3D turbofan exhaust nozzle analysis system
[AIAA PAPER 91-2478] p 754 A91-44261

TURBOJET ENGINES
The PC as a generic developmental fuel control for expendable turbojet engines
[AIAA PAPER 91-3399] p 755 A91-44329

TURBOMACHINERY
An expert system for predicting flutter in turbomachines
[AIAA PAPER 91-2527] p 748 A91-41808
Computations of three-dimensional viscous flows in turbomachinery cascades
[AIAA PAPER 91-2237] p 728 A91-44164

Improved turbulence modeling for gas turbine application
[AIAA PAPER 91-2239] p 728 A91-44165
The design/analysis of flows through turbomachinery: A viscous/inviscid approach
[NASA-TM-104447] p 755 N91-25148
Computation of broadband mixing noise from turbomachinery
[AD-A233991] p 784 N91-26878

TURBOPROP AIRCRAFT
A Western engine for an Eastern aircraft - Re-engining of CSFR LET 610 turboprop transport with the GE CT7-9
[AIAA PAPER 91-1911] p 744 A91-41652
Testing a modern turboprop propulsion system
[AIAA PAPER 91-2480] p 747 A91-41791

TURBOPROP ENGINES
Design of the high reliability GMA 2100 reduction gearbox
[AIAA PAPER 91-1905] p 768 A91-41647
A Western engine for an Eastern aircraft - Re-engining of CSFR LET 610 turboprop transport with the GE CT7-9
[AIAA PAPER 91-1911] p 744 A91-41652
Periodic blade loads of a high speed propeller at small angle of attack
[AIAA PAPER 91-2250] p 705 A91-41735
Design and development of a compact bifurcated turboprop inlet
[AIAA PAPER 91-2017] p 727 A91-44093

TURBULENCE
Viscous flow simulations of internal store carriage and separation
[NASA-CR-185343] p 732 N91-26123
Improved reduction of gust loads data for gust intensity p 758 N91-26153
Gust design procedures p 759 N91-26155

TURBULENCE MODELS
Comment on 'Critique of turbulence models for shock-induced flow separation' p 707 A91-42307
Hypersonic shock/boundary-layer interaction database
[AIAA PAPER 91-1763] p 711 A91-42581
Navier-Stokes calculations for attached and separated flows using different turbulence models
[AIAA PAPER 91-1791] p 712 A91-42594
Some characteristics of and dynamic scaling behavior in strong vortex flows
[AIAA PAPER 91-1821] p 713 A91-42609
Progress in hypersonic turbulence modeling
[AIAA PAPER 91-1785] p 724 A91-43642
Application of a Reynolds Stress turbulence model to a supersonic hydrogen-air diffusion flame
[AIAA PAPER 91-1786] p 725 A91-43643
High angle of attack aerodynamics of a glide vehicle
[AIAA PAPER 91-1813] p 726 A91-43654
Computations of three-dimensional gas turbine combustor flows
[AIAA PAPER 91-2076] p 773 A91-44116
Application of a multiblock/multizone code (PAB3D) for the three-dimensional Navier-Stokes equations
[AIAA PAPER 91-2155] p 728 A91-44137
Improved turbulence modeling for gas turbine application
[AIAA PAPER 91-2239] p 728 A91-44165
Prediction of jet mean flow structure in support of HSCT noise suppression concepts --- High Speed Civilian Transport
[AIAA PAPER 91-2253] p 774 A91-44171
Navier-Stokes simulations of flows about complex configurations using domain decomposition techniques
p 777 N91-25362

TURBULENT BOUNDARY LAYER
Some aspects of shock-wave boundary layer interaction at hypersonic speeds p 695 A91-40578
Experimental investigation of the shock wave and turbulent boundary layer interaction induced by a cylindrical protuberance p 695 A91-40604
Direct numerical simulation of transition and turbulence in a spatially evolving boundary layer
[AIAA PAPER 91-1607] p 702 A91-40779
Correlative behaviours of shock/boundary layer interaction induced by sharp fin and semicone
[AIAA PAPER 91-1756] p 711 A91-42577
Mach 6 turbulent boundary layer characteristics on smooth and rough surfaces
[AIAA PAPER 91-1762] p 711 A91-42580
Hypersonic shock/boundary-layer interaction database
[AIAA PAPER 91-1763] p 711 A91-42581
A physical model of the swept shock wave/boundary-layer interaction flowfield
[AIAA PAPER 91-1768] p 712 A91-42582
Numerical simulation of a three-dimensional shock wave-turbulent boundary layer interaction generated by a sharp fin at Mach 4 p 714 A91-42726
Synthesis of experimental riblet studies in transonic conditions p 716 A91-43142
Detailed measurements on unsteady properties in three-dimensional show wave/turbulent boundary layer interaction induced by blunt fin at Mach number 4
[AIAA PAPER 91-1755] p 723 A91-43629
3-D Navier-Stokes analysis of crossing, glancing shocks/turbulent boundary layer interactions
[AIAA PAPER 91-1758] p 723 A91-43631
On the quasi-conical flowfield structure of the swept shock wave-turbulent boundary layer interaction
[AIAA PAPER 91-1759] p 724 A91-43632
An experimental/computational study of heat transfer in sharp fin induced turbulent interactions at Mach 5
[AIAA PAPER 91-1764] p 724 A91-43633
Numerical investigation on shock wave/boundary-layer interactions in a constant area diffuser at Mach 3
[AIAA PAPER 91-1766] p 724 A91-43635
A numerical method for 3D boundary layers with a small crossflow
[AIAA PAPER 91-2473] p 775 A91-44258
The delay of turbulent boundary layer separation by oscillatory active control
[ITN-91-85104] p 779 N91-26482

TURBULENT FLOW
Diagonal implicit multigrid solution of compressible turbulent flows
[AIAA PAPER 91-1571] p 699 A91-40745
Computation of unsteady viscous flow using an efficient algorithm
[AIAA PAPER 91-1597] p 701 A91-40770
A numerical investigation of turbulent baseflow
p 703 A91-40799
Inlet turbulence distortion and viscous flow development in a controlled-diffusion compressor cascade at very high incidence
[AIAA PAPER 91-2004] p 704 A91-41673
New mixing-length model for turbulent high-speed flows p 707 A91-42277
Modification of the van Driest damping function to include the effects of surface roughness
p 770 A91-42282
Navier-Stokes solution of complete turbulent flow past finite axisymmetric bodies p 707 A91-42298
Turbulent flow predictions for afterbody/nozzle geometries including base effects p 715 A91-42813
An analytical comparison of convective heat transfer correlations in supercritical hydrogen
[AIAA PAPER 91-1382] p 771 A91-43446
A study of flow separation on an aspect ratio three flap at Mach number 2.4
[AIAA PAPER 91-1620] p 718 A91-43554
Numerical study of juncture flows
[AIAA PAPER 91-1660] p 720 A91-43575
On the convection velocity of turbulent structures in supersonic shear layers
[AIAA PAPER 91-1724] p 723 A91-43614

TURBULENT HEAT TRANSFER
An experimental/computational study of heat transfer in sharp fin induced turbulent interactions at Mach 5
[AIAA PAPER 91-1764] p 724 A91-43633

TURBULENT JETS
Jet-wake thermal characteristics of heated turbulent jets in crossflow p 770 A91-42258
Numerical and experimental study of fountain flows produced by multijet impingement on a ground plane
[AIAA PAPER 91-1806] p 771 A91-42602

TURBULENT MIXING
A new vertical shock tube for Rayleigh-Taylor instability measurements p 759 A91-40637
A study of supersonic aerodynamic mixing in the scramjet combustor p 771 A91-43000
Numerical analysis of scramjet flows in a dump combustor
[AIAA PAPER 91-1676] p 749 A91-43586

TURBULENT WAKES
Jet-wake thermal characteristics of heated turbulent jets in crossflow p 770 A91-42258
Experimental investigation of the near wake structure of a helicopter rotor in forward flight
[AIAA PAPER 91-1753] p 711 A91-42575

TVD SCHEMES
LU implicit TVD scheme for the solution of viscous two dimensional high speed flows
[AIAA PAPER 91-1573] p 699 A91-40747
A study of supersonic aerodynamic mixing in the scramjet combustor p 771 A91-43000
A numerical study of the flow establishment time in hypersonic shock tunnels
[AIAA PAPER 91-1706] p 722 A91-43604
Navier-Stokes simulation of the supersonic combustion flowfield in a ram accelerator
[AIAA PAPER 91-1916] p 773 A91-44057

TWO DIMENSIONAL BODIES
Prediction of internal performance for two-dimensional convergent-divergent nozzles
[AIAA PAPER 91-2369] p 706 A91-41762

TWO DIMENSIONAL BOUNDARY LAYER
Transition predictions using Reynolds-averaged Navier-Stokes and linear stability analysis methods
[AIAA PAPER 91-1641] p 720 A91-43567

TWO DIMENSIONAL FLOW
A new Lagrangian random choice method for steady two-dimensional supersonic/hypersonic flow
[AIAA PAPER 91-1546] p 697 A91-40721
Finite element simulation of compressible flows with shocks
[AIAA PAPER 91-1551] p 767 A91-40725
LU implicit TVD scheme for the solution of viscous two dimensional high speed flows
[AIAA PAPER 91-1573] p 699 A91-40747
A comparison of implicit multigrid Euler solvers implemented on a multiprocessor computer
[AIAA PAPER 91-1580] p 700 A91-40754
Measured thrust losses associated with secondary air injection through nozzle walls
[AIAA PAPER 91-2244] p 705 A91-41734
Supersonic inlet flow computations using fortified Navier-Stokes approach
[AIAA PAPER 91-1730] p 710 A91-42567
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116

TWO DIMENSIONAL JETS
Two-dimensional thrust vector control nozzle
[AIAA PAPER 91-2101] p 745 A91-41696

TWO DIMENSIONAL MODELS
Thrust vectoring using non-axisymmetric nozzles with flexible contours
[AIAA PAPER 91-2368] p 746 A91-41761

U

UH-1 HELICOPTER
Prediction of helicopter rotor rotational noise
p 784 A91-43503

UNDERWATER PROPULSION
Unsteady fluid dynamic model for propeller induced flow fields
[AIAA PAPER 91-1664] p 709 A91-42550

UNIVERSAL TIME
Coordination and synchronization of loran-C and GPS to universal coordinated time
[AD-A233221] p 737 N91-25141

UNSTEADY AERODYNAMICS
Wave processes occurring in supersonic motion of blunted body through dust layer p 695 A91-40656
Computation of unsteady viscous flow using an efficient algorithm
[AIAA PAPER 91-1597] p 701 A91-40770
On the validity of linearized unsteady Euler equations with shock capturing
[AIAA PAPER 91-1598] p 702 A91-40771
High resolution nonoscillatory schemes for unsteady gas dynamics p 702 A91-40795
Application of indicial theory to the prediction of unsteady separation
[AIAA PAPER 91-1742] p 710 A91-42572
Numerical investigation of the effect of leading edge geometry on dynamic stall of airfoils
[AIAA PAPER 91-1798] p 712 A91-42597
Influence of thickness and camber on the aeroelastic stability of supersonic throughflow fans
p 715 A91-42814
Effect of thickness on the unsteady aerodynamics of closely coupled oscillating airfoils p 716 A91-43308
Time dependent calculations using multigrid, with applications to unsteady flows past airfoils and wings
[AIAA PAPER 91-1596] p 727 A91-43675
Prediction of unsteady aerodynamic loads in cascades using the linearized Euler equations on deforming grids
[AIAA PAPER 91-3378] p 730 A91-44318
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
State space models for aeroelastic and viscoelastic systems
[AD-A234730] p 732 N91-26117
Viscous flow simulations of internal store carriage and separation
[NASA-CR-185343] p 732 N91-26123
Gust design procedures p 759 N91-26155

UNSTEADY FLOW
Kernel function occurring in subsonic unsteady potential flow p 707 A91-42280
Low-dimensional description of the dynamics in separated flow past thick airfoils
[AIAA PAPER 91-1622] p 707 A91-42534

Unsteady fluid dynamic model for propeller induced flow fields
[AIAA PAPER 91-1664] p 709 A91-42550
Steady and unsteady solutions of the Navier-Stokes equations for flows about airfoils at low speeds
[AIAA PAPER 91-1733] p 710 A91-42568
Navier-Stokes solutions for an oscillating double-delta wing
[AIAA PAPER 91-1624] p 718 A91-43556
A quantitative study of unsteady compressible flow on an oscillating airfoil
[AIAA PAPER 91-1683] p 722 A91-43590
Effects of leading-edge flap oscillation on unsteady delta wing flow and rock control
[AIAA PAPER 91-1796] p 725 A91-43647
Numerical simulation of the unsteady vortex structure over a delta wing
[AIAA PAPER 91-1811] p 726 A91-43653
Time dependent calculations using multigrid, with applications to unsteady flows past airfoils and wings
[AIAA PAPER 91-1596] p 727 A91-43675
Prediction of unsteady aerodynamic loads in cascades using the linearized Euler equations on deforming grids
[AIAA PAPER 91-3378] p 730 A91-44318

UNSWEPT WINGS
Opportunities for applications of natural laminar flow technology at high-subsonic speeds
[AIAA PAPER 91-1773] p 724 A91-43638

UPWASH
Numerical and experimental study of fountain flows produced by multijet impingement on a ground plane
[AIAA PAPER 91-1806] p 771 A91-42602

V

V-22 AIRCRAFT
Simulating a new species of bird p 694 A91-44340

V/STOL AIRCRAFT
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration
[AIAA PAPER 91-1689] p 748 A91-42556
Static performance tests of a flight-type STOVL ejector
[AIAA PAPER 91-1902] p 750 A91-44050

VANES
Flight service evalulation of thermal barrier coatings by physical vapor deposition at 5200 h p 764 A91-41511

VAPOR DEPOSITION
Flight service evalulation of thermal barrier coatings by physical vapor deposition at 5200 h p 764 A91-41511

VAPORIZING
Fuel-rich, catalytic reaction experimental results --- fuel development for high-speed civil transport aircraft
[AIAA PAPER 91-2463] p 754 A91-44250

VELOCITY DISTRIBUTION
The delay of turbulent boundary layer separation by oscillatory active control
[ITN-91-85104] p 779 N91-26482

VELOCITY MEASUREMENT
Velocity measurements in turbine engines - New developments using the laser two-focus method
p 771 A91-43328
Velocity measurements inside the leading edge vortex formed on a delta wing
[NAL-TR-1087] p 732 N91-25115

VERTICAL LANDING
Static performance tests of a flight-type STOVL ejector
[AIAA PAPER 91-1902] p 750 A91-44050

VERY LARGE SCALE INTEGRATION
VHSIC electronics and the cost of Air Force avionics in the 1990s
[RAND-R-3843-AF] p 743 N91-26143

VERY LOW FREQUENCIES
An Omega/VLF radio compass p 734 A91-41437

VHSIC (CIRCUITS)
VHSIC electronics and the cost of Air Force avionics in the 1990s
[RAND-R-3843-AF] p 743 N91-26143

VIBRATION
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
Dynamic tester for rotor seals and bearings
[NASA-CASE-MFS-28493-1] p 763 N91-25155
The delay of turbulent boundary layer separation by oscillatory active control
[ITN-91-85104] p 779 N91-26482

VIBRATION DAMPING
A method for calculating the characteristics of a rotor with allowance for shaft vibrations p 768 A91-41155
The effects of bearing misalignment on the non-linear vibration of aero-engine rotor-damper assemblies
p 744 A91-41536
Analysis of structural damping of titanium alloy shell structures as compared with that of aluminium alloy structures p 765 A91-41606
A theoretical study on the vibration damping of aircraft gearbox gears
[AIAA PAPER 91-2558] p 738 A91-41813
Dynamic tester for rotor seals and bearings
[NASA-CASE-MFS-28493-1] p 763 N91-25155
Establishment of a remotely piloted helicopter test flight program for higher harmonic control research
[AD-A234978] p 741 N91-26135

VIBRATION ISOLATORS
The effects of bearing misalignment on the non-linear vibration of aero-engine rotor-damper assemblies
p 744 A91-41536

VIBRATION MODE
Acoustical analysis of gear housing vibration
[NASA-TM-103691] p 777 N91-25411

VIBRATION TESTS
A study on the stiffness simulation calculation method of flutter models of after body and horizontal tail of a new type aeroplane p 739 A91-43511

VIBRATORY LOADS
An efficient method in predicting rotor/stator interaction
[AIAA PAPER 91-3380] p 730 A91-44320
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102

VISCOELASTICITY
State space models for aeroelastic and viscoelastic systems
[AD-A234730] p 732 N91-26117

VISCOSITY
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124

VISCOUS DAMPING
Modification of the van Driest damping function to include the effects of surface roughness
p 770 A91-42282

VISCOUS DRAG
Incompressible boundary layer transition flight experiments over a nonaxisymmetric fuselage forebody and comparisons with laminar boundary layer stability theory p 777 N91-25359

VISCOUS FLOW
Viscous airfoil computations using Richardson extrapolation
[AIAA PAPER 91-1559] p 698 A91-40733
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740
Approximate analysis and sensitivity analysis methods for viscous flow involving variation of geometric shape
[AIAA PAPER 91-1569] p 767 A91-40743
Multigrid for hypersonic viscous two- and three-dimensional flows
[AIAA PAPER 91-1572] p 699 A91-40746
LU implicit TVD scheme for the solution of viscous two dimensional high speed flows
[AIAA PAPER 91-1573] p 699 A91-40747
Asynchronous, macrotasked relaxation strategies for the solution of viscous, hypersonic flows
[AIAA PAPER 91-1579] p 700 A91-40753
Collar grids for intersecting geometric components within the Chimera overlapped grid scheme
[AIAA PAPER 91-1587] p 700 A91-40761
A three-dimensional Navier-Stokes/full-potential coupled analysis for viscous transonic flow
[AIAA PAPER 91-1595] p 701 A91-40769
Computation of unsteady viscous flow using an efficient algorithm
[AIAA PAPER 91-1597] p 701 A91-40770
Inlet turbulence distortion and viscous flow development in a controlled-diffusion compressor cascade at very high incidence
[AIAA PAPER 91-2004] p 704 A91-41673
Multigrid and upwind viscous flow solver on three-dimensional overlapped and embedded grids
p 707 A91-42284
Low-dimensional description of the dynamics in separated flow past thick airfoils
[AIAA PAPER 91-1622] p 707 A91-42534
Steady and unsteady solutions of the Navier-Stokes equations for flows about airfoils at low speeds
[AIAA PAPER 91-1733] p 710 A91-42568
On three-dimensional flow separation criteria
[AIAA PAPER 91-1740] p 710 A91-42571
Application of indicial theory to the prediction of unsteady separation
[AIAA PAPER 91-1742] p 710 A91-42572
Hopf bifurcation in viscous flows about airfoils at low speeds
[AIAA PAPER 91-1807] p 712 A91-42603
An approximate viscous shock layer approach to calculating hypersonic flows about blunt-nosed bodies
[AIAA PAPER 91-1348] p 717 A91-43417
Viscous equilibrium computations using program LAURA
[AIAA PAPER 91-1389] p 717 A91-43452
Numerical simulation of hypersonic viscous flow for the design of H-II orbiting plane (HOPE). II
[AIAA PAPER 91-1390] p 717 A91-43453
A numerical study of compressible viscous flow in a novel exhaust system
[AIAA PAPER 91-1728] p 723 A91-43617
3-D Navier-Stokes analysis of crossing, glancing shocks/turbulent boundary layer interactions
[AIAA PAPER 91-1758] p 723 A91-43631
Supersonic viscous flow calculations for axisymmetric, two and three-dimensional configurations
[AIAA PAPER 91-1802] p 725 A91-43649
Computations of three-dimensional viscous flows in turbomachinery cascades
[AIAA PAPER 91-2237] p 728 A91-44164
Grid generation for three-dimensional turbomachinery geometries including tip clearance
[AIAA PAPER 91-2360] p 753 A91-44209
The design/analysis of flows through turbomachinery: A viscous/inviscid approach
[NASA-TM-104447] p 755 N91-25148
Aeroacoustic and aerodynamic applications of the theory of nonequilibrium thermodynamics
[NASA-TP-3118] p 776 N91-25352
Viscous flow simulations of internal store carriage and separation
[NASA-CR-185343] p 732 N91-26123

VOICE COMMUNICATION
Opportunities for advanced speech processing in military computer-based systems
[AD-A233724] p 778 N91-26412

VOICE DATA PROCESSING
Opportunities for advanced speech processing in military computer-based systems
[AD-A233724] p 778 N91-26412

VORTEX AVOIDANCE
Airport capacity and delay analyses
[DOT/FAA/CT-TN91/18] p 762 N91-25152

VORTEX BREAKDOWN
Navier-Stokes solutions for an oscillating double-delta wing
[AIAA PAPER 91-1624] p 718 A91-43556
Numerical simulation of vortex breakdown over a delta wing
[AIAA PAPER 91-1814] p 726 A91-43655
Vortex breakdown in a supersonic jet
[AIAA PAPER 91-1815] p 726 A91-43656

VORTEX FILAMENTS
The vortex interaction in a propeller/stator flow field
[AIAA PAPER 91-1818] p 726 A91-43657

VORTEX GENERATORS
Supersonic jet mixing enhancement by vortex generators
[AIAA PAPER 91-2263] p 705 A91-41738
The laminar horseshoe vortex system formed at a cylinder/plate juncture
[AIAA PAPER 91-1826] p 727 A91-43659
An experimental investigation into the effects turbulator profile and spacing have on heat transfer coefficients and friction factors in small cooled turbine airfoils
[AIAA PAPER 91-2033] p 773 A91-44099
A design strategy for the use of vortex generators to manage inlet-engine distortion using computational fluid dynamics
[AIAA PAPER 91-2474] p 729 A91-44259

VORTEX SHEDDING
Low-dimensional description of the dynamics in separated flow past thick airfoils
[AIAA PAPER 91-1622] p 707 A91-42534
On the estimation of sound produced by complex fluid-structure interactions, with application to a vortex interacting with a shrouded rotor p 784 A91-43514

VORTICES
Control of vortex structure on a delta wing by small amplitude perturbations of angle-of-attack
p 706 A91-42094
Vortical flow solutions using a time-lagged, thin-layer, Navier-Stokes algorithm p 707 A91-42279
Laser velocimetry measurements of supersonic vortex flows on a simple razor-edged delta wing
[AIAA PAPER 91-1684] p 709 A91-42553
On three-dimensional flow separation criteria
[AIAA PAPER 91-1740] p 710 A91-42571
Investigation of the tip shape influence on the flowfield around hovering rotor blades
[AIAA PAPER 91-1754] p 711 A91-42576
The vortex kinematics associated with an oscillating delta wing
[AIAA PAPER 91-1797] p 712 A91-42596

Sources of high alpha vortex asymmetry at zero sideslip
[AIAA PAPER 91-1810] p 713 A91-42604
Chine forebody vortex manipulation by mechanical and pneumatic techniques on a delta wing configuration
[AIAA PAPER 91-1812] p 713 A91-42605
Vortex topology for rectangular wings in pictures, sketches and conjectures
[AIAA PAPER 91-1824] p 713 A91-42611
Numerical evaluation of vortex flow control devices
[AIAA PAPER 91-1825] p 713 A91-42612
Computation and visualization of leading edge vortex flows p 714 A91-42721
Visualization measurements of vortex flows
p 716 A91-43309
Numerical simulation of the unsteady vortex structure over a delta wing
[AIAA PAPER 91-1811] p 726 A91-43653
Interaction between a vortex dominated wake and a separated flowfield
[AIAA PAPER 91-1819] p 727 A91-43658
Velocity measurements inside the leading edge vortex formed on a delta wing
[NAL-TR-1087] p 732 N91-25115
Airport capacity and delay analyses
[DOT/FAA/CT-TN91/18] p 762 N91-25152
Theoretical studies of the kinematics, dynamics, stability, and control of unsteady/vortical flows
[AD-A235190] p 779 N91-26477

VORTICITY
The effect of artificial vorticity on the discrete solution of Euler equations
[AIAA PAPER 91-1553] p 698 A91-40727
Comment on 'Critique of turbulence models for shock-induced flow separation' p 707 A91-42307
Some characteristics of and dynamic scaling behavior in strong vortex flows
[AIAA PAPER 91-1821] p 713 A91-42609
Compressible stability of growing boundary layers using parabolized stability equations
[AIAA PAPER 91-1636] p 720 A91-43564
Vortical flows about a long cylinder at M = 3.5 and alpha = 18 deg
[AIAA PAPER 91-1808] p 726 A91-43651
Self-propelled slender axisymmetric body flows: Errors in the Poisson equation field calculation
p 731 N91-25110

W

WAFERS
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799

WAKES
Airport capacity and delay analyses
[DOT/FAA/CT-TN91/18] p 762 N91-25152

WALL FLOW
Analysis of external burning on inclined surfaces in supersonic flow
[AIAA PAPER 91-2390] p 747 A91-41767
Modification of the van Driest damping function to include the effects of surface roughness
p 770 A91-42282
Secondary instability of high-speed flows and the influence of wall cooling and suction
[AIAA PAPER 91-1647] p 720 A91-43572
Asymptotic methods for the prediction of transonic wind tunnel wall interference
[AIAA PAPER 91-1712] p 762 A91-44334

WALL JETS
Numerical and experimental study of fountain flows produced by multijet impingement on a ground plane
[AIAA PAPER 91-1806] p 771 A91-42602

WALL PRESSURE
An investigation of hypersonic shock tunnel testing at an equilibrium interface condition of 4100 K - Theory and experiment
[AIAA PAPER 91-1707] p 761 A91-42560
A method for correcting wall pressure measurements in subsonic compressible flow p 715 A91-42957

WALL TEMPERATURE
Effect of model cooling on periodic transonic flow
[AIAA PAPER 91-1714] p 709 A91-42562
Parametric study of airframe-integrated scramjet cooling requirement p 749 A91-42817

WALLS
Aircraft interior noise reduction by alternate resonance tuning
[NASA-CR-185453] p 785 N91-26889

WARFARE
Stealth aircraft and technology from World War II to the Gulf. I - History and background p 743 A91-43772

WARNING SYSTEMS
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153
KC-135 ground collision avoidance system questionnaire
[AD-A234385] p 733 N91-26125
Evaluation of the C/EC/KC-135 Ground Collision Avoidance System (GCAS), study 1
[AD-A235301] p 737 N91-26130

WATER
Prediffuser-combustor model studies under conditions of water ingestion in engines
[AIAA PAPER 91-1965] p 751 A91-44077

WATER INJECTION
Jet-wake thermal characteristics of heated turbulent jets in crossflow p 770 A91-42258

WATER TUNNEL TESTS
Static and dynamic water tunnel flow visualization studies of a canard-configured X-31A-like fighter aircraft model
[AIAA PAPER 91-1629] p 708 A91-42537

WAVE FRONTS
CFD evaluation of transonic-supersonic wave front propagation effects
[AIAA PAPER 91-1657] p 708 A91-42547

WAVE GENERATION
Waves produced from a harmonic point source in a supersonic boundary layer
[AIAA PAPER 91-1646] p 720 A91-43571

WAVE PROPAGATION
CFD evaluation of transonic-supersonic wave front propagation effects
[AIAA PAPER 91-1657] p 708 A91-42547

WAVE REFLECTION
Surface heat transfer change induced by unsteady shock reflections and numerical simulations on shock reflection
p 695 A91-40647
Accelerated convergence to steady state by gradual far-field damping
[AIAA PAPER 91-1604] p 702 A91-40776

WAVERIDERS
Direct simulation of waveriders in hypersonic rarefied flow
[AIAA PAPER 91-1317] p 717 A91-43389
Optimized scramjet integration on a waverider
[AIAA PAPER 91-1693] p 739 A91-43594
Hypersonic waverider analysis - A comparison of numerical and experimental results
[AIAA PAPER 91-1696] p 739 A91-43596
Interactive design of hypersonic waverider geometries
[AIAA PAPER 91-1697] p 740 A91-43597

WEAPON SYSTEMS
The wild weasel development programs, one run, one hit, one error
[RAND-P-7661-RGS] p 778 N91-26431

WEAR RESISTANCE
The wear mechanisms occurring in abradable seals of gas turbines p 768 A91-41508

WEATHER STATIONS
TABS - An automated pre-flight planning system
p 733 A91-42783

WEIBULL DENSITY FUNCTIONS
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799

WEIGHT REDUCTION
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1909] p 769 A91-41650
Thermostructural concepts for hypervelocity vehicles
p 764 A91-43311
Application of aluminum-lithium alloys to fighter aircraft
p 766 A91-43916

WELDABILITY
Aluminium-lithium weldable alloy 1420 - Alloying system Al-Li-Mg-Zr p 765 A91-43891

WIND PROFILES
Guide to measurement of winds with instrumented aircraft
[NASA-CR-188601] p 780 N91-25553

WIND TUNNEL DRIVES
Combustion-driven blowdown facilities for chemical laser research
[AIAA PAPER 91-1455] p 772 A91-43528

WIND TUNNEL MODELS
Supersonic wind tunnel diffuser performance with high model blockage at moderate to low Reynolds numbers
[AIAA PAPER 91-2274] p 761 A91-44183

WIND TUNNEL NOZZLES
Goertler instability and hypersonic quiet nozzle design
[AIAA PAPER 91-1648] p 708 A91-42542
Supersonic wind tunnel diffuser performance with high model blockage at moderate to low Reynolds numbers
[AIAA PAPER 91-2274] p 761 A91-44183
A quiet flow Ludwieg tube for study of transition in compressible boundary layers: Design and feasibility
[NASA-CR-188499] p 731 N91-25107

WIND TUNNEL TESTS
A parametric experimental study of isolated rectangular nozzles
[AIAA PAPER 91-2136] p 738 A91-41706
Experimental investigation of the near wake structure of a helicopter rotor in forward flight
[AIAA PAPER 91-1753] p 711 A91-42575
Synthesis of experimental riblet studies in transonic conditions p 716 A91-43142
An efficient DSMC algorithm applied to a delta wing
[AIAA PAPER 91-1316] p 717 A91-43388
Study of cluster formation and its effects on Rayleigh and Raman scattering measurements in a Mach 6 wind tunnel
[AIAA PAPER 91-1496] p 718 A91-43547
A numerical study on wind tunnel interference effects in external burning test at M = 1.5
[AIAA PAPER 91-1675] p 749 A91-43585
Planar laser-induced fluorescence imaging of underexpanded free jet flow in a shock tunnel facility
[AIAA PAPER 91-1687] p 761 A91-43592
Hypersonic waverider analysis - A comparison of numerical and experimental results
[AIAA PAPER 91-1696] p 739 A91-43596
Mixing enhancement in compressible mixing layers - An experimental study
[AIAA PAPER 91-1721] p 723 A91-43612
Observations of supersonic transverse jets
[AIAA PAPER 91-1723] p 772 A91-43613
Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel
[AIAA PAPER 91-1725] p 723 A91-43615
A powered lift experiment for CFD validation
[AIAA PAPER 91-1731] p 723 A91-43619
Effects of streamwise pressure gradient on the suction surface boundary layer of a turbine airfoil
[AIAA PAPER 91-2030] p 727 A91-44097
Supersonic wind tunnel diffuser performance with high model blockage at moderate to low Reynolds numbers
[AIAA PAPER 91-2274] p 761 A91-44183
Low-speed, powered ground effects of a generic, hypersonic configuration
[NASA-TP-3092] p 730 N91-25103
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116
Performance optimization of helicopter rotor blades
[NASA-TM-104054] p 741 N91-26137
The delay of turbulent boundary layer separation by oscillatory active control
[ITN-91-85104] p 779 N91-26482

WIND VELOCITY
Ground-based 4-D guidance of flights in strong winds
p 734 A91-41438

WING LOADING
Fuzzy logic for control of roll and moment for a flexible wing aircraft p 757 A91-43932

WING OSCILLATIONS
The vortex kinematics associated with an oscillating delta wing
[AIAA PAPER 91-1797] p 712 A91-42596
Navier-Stokes solutions for an oscillating double-delta wing
[AIAA PAPER 91-1624] p 718 A91-43556
Effects of leading-edge flap oscillation on unsteady delta wing flow and rock control
[AIAA PAPER 91-1796] p 725 A91-43647

WING PROFILES
Using implicit displacement expressions for obtaining a solution in the transition zone of a hybrid computation scheme p 768 A91-41168
Multigrid solutions of the three-dimensional grid equations p 706 A91-42098
Reduction of the RCS of the leading edge of a conducting wing-shaped structure by means of lossless dielectric material p 770 A91-42241
Chine forebody vortex manipulation by mechanical and pneumatic techniques on a delta wing configuration
[AIAA PAPER 91-1812] p 713 A91-42605
Flow field structure and development near the root of a straight wing pitching at constant rate
[AIAA PAPER 91-1793] p 725 A91-43646

WING TIP VORTICES
LDV measurements in the roll-up region of the tip vortex from a rectangular wing
[AIAA PAPER 91-1685] p 709 A91-42554
Navier-Stokes correlation of a swept helicopter rotor tip at high alpha
[AIAA PAPER 91-1752] p 711 A91-42574

WING TIPS
Navier-Stokes correlation of a swept helicopter rotor tip at high alpha
[AIAA PAPER 91-1752] p 711 A91-42574

WINGS
On three-dimensional flow separation criteria
[AIAA PAPER 91-1740] p 710 A91-42571
Observation of laminar boundary layer transition on light monoplane wing surface
[NAL-TR-1077] p 777 N91-25366
Calculated aerodynamics of wings in severe maneuver
[AD-A235241] p 732 N91-26120

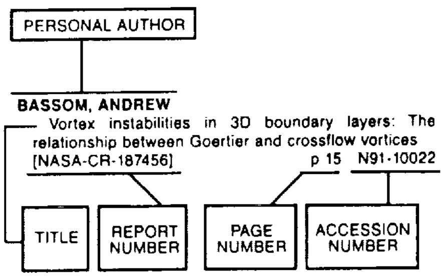
WORKING FLUIDS
An ejector performance correlation factor
[AIAA PAPER 91-2545] p 748 A91-41810
Uncertainty analysis of turbine aerodynamic performance measurements in short duration test facilities
[AIAA PAPER 91-2131] p 761 A91-44132

X

X-30 VEHICLE
Recent advances in hypersonic technology
p 716 A91-43103

PERSONAL AUTHOR INDEX

Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence.

A

ABDOL-HAMID, KHALED S.
Prediction of internal performance for two-dimensional convergent-divergent nozzles
[AIAA PAPER 91-2369] p 706 A91-41762
Three-dimensional upwinding Navier-Stokes code with k-epsilon model for supersonic flows
[AIAA PAPER 91-1669] p 721 A91-43580
Application of a multiblock/multizone code (PAB3D) for the three-dimensional Navier-Stokes equations
[AIAA PAPER 91-2155] p 728 A91-44137

ABOUELKHEIR, M.
A row-by-row off-design performance calculation method for turbines
[AIAA PAPER 91-2132] p 745 A91-41705

ADAMS, J. C.
CFD calibration and application to the design of flow tailoring devices for simulating forebody influences on fighter aircraft inlet flows p 776 N91-25339

ADDINGTON, GREGORY A.
Flow field structure and development near the root of a straight wing pitching at constant rate
[AIAA PAPER 91-1793] p 725 A91-43646

AGAMI, D.
FCS skewed sensors array - Practical considerations p 742 A91-43082

AHMED, S.
Laser velocimetry measurements of oscillating airfoil dynamic stall flow field
[AIAA PAPER 91-1799] p 725 A91-43648

AHMED, S. A.
Experimental and computational investigation of isothermal swirling flow in an axisymmetric dump combustor p 749 A91-42806

AJMANI, KUMUD
Generalized conjugate-gradient methods for the Navier-Stokes equations
[AIAA PAPER 91-1556] p 698 A91-40730

AKIBA, T.
Spherical particle impact damage behaviour of a SiC fibre-reinforced chemical vapour infiltrated SiC composite p 765 A91-43752

AKIMUNE, Y.
Spherical particle impact damage behaviour of a SiC fibre-reinforced chemical vapour infiltrated SiC composite p 765 A91-43752

ALEXANDER, H.
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126

ALLEGRE, J.
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124

ALLEN, JAMES G.
A knowledge-based system design/information tool for aircraft flight control systems p 757 N91-25139

ALLMARAS, STEVEN R.
Navier-Stokes calculations for attached and separated flows using different turbulence models
[AIAA PAPER 91-1791] p 712 A91-42594

ALTHOFF, SUSAN L.
Computational rotorcraft flowfield research at the U.S. Army AeroStructures Directorate p 703 A91-41148

ALVI, F. S.
A physical model of the swept shock wave/boundary-layer interaction flowfield
[AIAA PAPER 91-1768] p 712 A91-42582

AMERI, ALI A.
Three-dimensional Navier-Stokes analysis of turbine passage heat transfer
[AIAA PAPER 91-2241] p 774 A91-44167

AMOS, D. H.
Coordination and synchronization of loran-C and GPS to universal coordinated time
[AD-A233221] p 737 N91-25141

ANDERSON, BERNHARD H.
A design strategy for the use of vortex generators to manage inlet-engine distortion using computational fluid dynamics
[AIAA PAPER 91-2474] p 729 A91-44259

ANDERSON, BIANCA
A parametric study of the leading edge attachment line for the F-16XL
[AIAA PAPER 91-1621] p 718 A91-43555

ANDERSON, W. K.
Grid convergence for adaptive methods
[AIAA PAPER 91-1592] p 701 A91-40766

ANDO, YASUNORI
A study of supersonic aerodynamic mixing in the scramjet combustor p 771 A91-43000

ANDREEV, S. P.
Comparative analysis of turbofan effective thrust with mixed and separated flows engines
[AIAA PAPER 91-2376] p 754 A91-44216

ANDREOPOULOS, J.
Experimental investigation of the near wake structure of a helicopter rotor in forward flight
[AIAA PAPER 91-1753] p 711 A91-42575

ANDREW, T. L.
Inlet/fan cowl design for increased angle-of-attack requirements of transport aircraft - Methodology and test results
[AIAA PAPER 91-2481] p 730 A91-44263

ANDREWS, EARL H.
Enhanced capability of the Combustion-Heated Scramjet Test Facility
[AIAA PAPER 91-2502] p 762 A91-44267

ANFIMOV, N. A.
Multi-cascade compression - Effective means to obtain high temperature dense gas in piston gas dynamic units (PGU) p 760 A91-40641

ANTOLINE, S.
Concepts for reduction of turbine rotor inertia
[AIAA PAPER 91-2031] p 752 A91-44098

ARNONE, ANDREA
Three-dimensional Navier-Stokes analysis of turbine passage heat transfer
[AIAA PAPER 91-2241] p 774 A91-44167

ASBURY, SCOTT C.
Static performance of a multiaxis thrust vectoring cruciform nozzle
[AIAA PAPER 91-2137] p 745 A91-41707

ASHBY, DALE L.
Unsteady fluid dynamic model for propeller induced flow fields
[AIAA PAPER 91-1664] p 709 A91-42550

ASO, SHIGERU
Surface heat transfer change induced by unsteady shock reflections and numerical simulations on shock reflection p 695 A91-40647
Detailed measurements on unsteady properties in three-dimensional show wave/turbulent boundary layer interaction induced by blunt fin at Mach number 4
[AIAA PAPER 91-1755] p 723 A91-43629

ASTILLERO, RICARDO
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153

AYOUB, PETER
Effect of shock waves upon seat mounted sensors in escape systems p 738 A91-41543

AZEVEDO, DAVID
Measured thrust losses associated with secondary air injection through nozzle walls
[AIAA PAPER 91-2244] p 705 A91-41734

B

BAART, DOUGLAS
Airport capacity and delay analyses
[DOT/FAA/CT-TN91/18] p 762 N91-25152

BABBITT, R. R.
Advanced high bypass mixed-flow exhaust system design study
[AIAA PAPER 91-2242] p 753 A91-44168

BADEKAS, DIAS
On the quasi-conical flowfield structure of the swept shock wave-turbulent boundary layer interaction
[AIAA PAPER 91-1759] p 724 A91-43632

BAGANOFF, D.
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821

BAKER, TIMOTHY J.
Unstructured meshes and surface fidelity for complex shapes
[AIAA PAPER 91-1591] p 701 A91-40765

BALAKUMAR, P.
Waves produced from a harmonic point source in a supersonic boundary layer
[AIAA PAPER 91-1646] p 720 A91-43571

BANGERT, L. S.
A parametric experimental study of isolated rectangular nozzles
[AIAA PAPER 91-2136] p 736 A91-41706

BAO, YOULIN
Titanium alloy integrated centrifugal impeller 5 coordinate computer assisted manufacturing technology
[AD-A234797] p 766 N91-26300

BARANKIEWICZ, WENDY S.
Static performance tests of a flight-type STOVL ejector
[AIAA PAPER 91-1902] p 750 A91-44050

BARATA, J. M. M.
Numerical and experimental study of fountain flows produced by multijet impingement on a ground plane
[AIAA PAPER 91-1806] p 771 A91-42602

BARBAUX, Y.
Properties of commercially available Al-Li alloys' possible use on civil aircraft p 766 A91-43920

BARE, E. A.
The impact of LO-configured forebodies on inlet approach flowfields
[AIAA PAPER 91-2599] p 730 A91-44304

BARNES, TERENCE J.
Certification procedures and requirements p 759 N91-26154

BARON, JUDSON R.
Direct simulation of waveriders in hypersonic rarefied flow
[AIAA PAPER 91-1317] p 717 A91-43389

BARTA, A. B.
Design and development of a compact bifurcated turboprop inlet
[AIAA PAPER 91-2017] p 727 A91-44093
BARTH, TIMOTHY J.
A 3-D upwind Euler solver for unstructured meshes
[AIAA PAPER 91-1548] p 697 A91-40723
BARTIE, K. M.
Technology needs for high-speed rotorcraft, volume 1
[NASA-CR-177585] p 742 N91-26139
BARTLETT, C. R.
Aerodynamic free-jet nozzle performance augmentation using an exhaust diffuser
[AIAA PAPER 91-2270] p 705 A91-41740
BARWEY, DINESH
Dynamics of elastic bending and torsion of hingeless rotors with dynamic stall
[AD-A234775] p 741 N91-26134
BASSON, A. H.
Grid generation for three-dimensional turbomachinery geometries including tip clearance
[AIAA PAPER 91-2360] p 753 A91-44209
BATZER, H.-J.
A radar-data communication network for ATC in the Benelux nations and northern Germany
p 736 A91-41853
BAUER, S. X. S.
Hypersonic waverider analysis - A comparison of numerical and experimental results
[AIAA PAPER 91-1696] p 739 A91-43596
BAYNE, FRANCES M.
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100
BAYSAL, OKTAY
Aerodynamic shape optimization using sensitivity analysis on third-order Euler equations
[AIAA PAPER 91-1577] p 699 A91-40751
Multigrid and upwind viscous flow solver on three-dimensional overlapped and embedded grids
p 707 A91-42284
Viscous flow simulations of internal store carriage and separation
[NASA-CR-185343] p 732 N91-26123
BEALE, D. K.
CFD calibration and application to the design of flow tailoring devices for simulating forebody influences on fighter aircraft inlet flows p 776 N91-25339
BECKER, GREGORY M.
Testing a modern turboprop propulsion system
[AIAA PAPER 91-2480] p 747 A91-41791
BECKER, T. M.
Computation and visualization of leading edge vortex flows p 714 A91-42721
BECKWITH, IVAN E.
Goertler instability and hypersonic quiet nozzle design
[AIAA PAPER 91-1648] p 708 A91-42542
BEEVERS, C. J.
The fatigue response of the aluminium-lithium alloy, 8090 p 765 A91-43857
BEIGELMAN, Z.
A simulation model of a single rotor helicopter
p 739 A91-43080
BELCHER, P. J.
Combined energy management and calculus of variations approach for optimizing hypersonic vehicle trajectories p 739 A91-42738
BELK, DAVE M.
Vortical flow solutions using a time-lagged, thin-layer, Navier-Stokes algorithm p 707 A91-42279
BELKIN, BRENDA L.
Systematic methods for knowledge acquisition and expert system development p 781 A91-43926
BELOUSOV, V. L.
Wave processes occurring in supersonic motion of blunted body through dust layer p 695 A91-40656
BEMENT, DAVID A.
Performance evaluation of semi-freejet tests of the Generic High Speed Engine
[AIAA PAPER 91-2163] p 753 A91-44141
BENNETT, W. A.
Design and development of a compact bifurcated turboprop inlet
[AIAA PAPER 91-2017] p 727 A91-44093
BENOIT, ANDRE
Ground-based 4-D guidance of flights in strong winds
p 734 A91-41438
BERAN, PHILIP S.
Steady and unsteady solutions of the Navier-Stokes equations for flows about airfoils at low speeds
[AIAA PAPER 91-1733] p 710 A91-42568
Hopf bifurcation in viscous flows about airfoils at low speeds
[AIAA PAPER 91-1807] p 712 A91-42603
BERMAN, C.
Three-dimensional jet noise computations
[AIAA PAPER 91-2256] p 784 A91-44174
BERNARD, J. J.
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124
BERRY, D.
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126
BERRY, JOHN D.
Computational rotorcraft flowfield research at the U.S. Army AeroStructures Directorate p 703 A91-41148
BERTOLOTTI, F. P.
Compressible boundary layer stability analyzed with the PSE equations
[AIAA PAPER 91-1637] p 708 A91-42539
BERTON, E.
Investigation of the tip shape influence on the flowfield around hovering rotor blades
[AIAA PAPER 91-1754] p 711 A91-42576
BERTSCH, REMI
Aerodynamic losses due to pressure side coolant ejection in a transonic turbine cascade
[AIAA PAPER 91-2032] p 745 A91-41684
BESHEARS, D. L.
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150
BETIN, PIERRE
Reflections on the spaceplane p 785 A91-41548
BETTNER, J. L.
High speed rotorcraft propulsion system studies
[AIAA PAPER 91-2150] p 752 A91-44135
BEVER, G. A.
Digital signal conditioning for flight test, volume 19
[AGARD-AG-160-VOL-19] p 778 N91-26432
BEY, KIM S.
A Runge-Kutta discontinuous finite element method for high speed flows
[AIAA PAPER 91-1575] p 699 A91-40749
BHARADVAJ, BALA K.
A three-dimensional Navier-Stokes/full-potential coupled analysis for viscous transonic flow
[AIAA PAPER 91-1595] p 701 A91-40769
BIEDRON, R. T.
A generalized patched-grid algorithm with application to the F-18 forebody with actuated control strake
p 715 A91-42736
BILLIG, F. S.
Analysis of external burning on inclined surfaces in supersonic flow
[AIAA PAPER 91-2390] p 747 A91-41767
Combined tangential-normal injection into a supersonic flow p 715 A91-42816
BINGAMAN, DONALD C.
The impact of LO-configured forebodies on inlet approach flowfields
[AIAA PAPER 91-2599] p 730 A91-44304
BIRCH, T. J.
Vortical flows about a long cylinder at M = 3.5 and alpha = 18 deg
[AIAA PAPER 91-1808] p 726 A91-43651
BIRD, G. A.
An efficient DSMC algorithm applied to a delta wing
[AIAA PAPER 91-1316] p 717 A91-43388
BIRT, M. J.
The fatigue response of the aluminium-lithium alloy, 8090 p 765 A91-43857
BISMARCK-NASR, MAHER N.
Kernel function occurring in subsonic unsteady potential flow p 707 A91-42280
BLACK, J. D.
Design of the high reliability GMA 2100 reduction gearbox
[AIAA PAPER 91-1905] p 768 A91-41647
BLAIR, A. B.
Study of cluster formation and its effects on Rayleigh and Raman scattering measurements in a Mach 6 wind tunnel
[AIAA PAPER 91-1496] p 718 A91-43547
BLAZEK, J.
Upwind implicit residual smoothing method for multi-stage schemes
[AIAA PAPER 91-1533] p 696 A91-40708
BLISS, DONALD B.
Aircraft interior noise reduction by alternate resonance tuning
[NASA-CR-185453] p 785 N91-26889
BLOCK, JOACHIM
Structural mechanics research in the DLR
p 771 A91-43334
BOBBA, CHOUDARY R.
A numerical study of compressible viscous flow in a novel exhaust system
[AIAA PAPER 91-1728] p 723 A91-43617
BOBER, L. J.
Large-scale advanced propeller blade pressure distributions - Prediction and data p 715 A91-42820
BOGARD, D. C.
Effects of streamwise pressure gradient on the suction surface boundary layer of a turbine airfoil
[AIAA PAPER 91-2030] p 727 A91-44097
BOLDMAN, D. R.
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fan simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106
BOLLING, COREY
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100
BOOYSEN, A. J.
Reduction of the RCS of the leading edge of a conducting wing-shaped structure by means of lossless dielectric material p 770 A91-42241
BOPPE, CHARLES W.
Computational simulations for fighter and hypersonic vehicle inlet-forebody interactions p 776 N91-25347
BOREL, M. O.
The wear mechanisms occurring in abradable seals of gas turbines p 768 A91-41506
BORLAND, C. J.
A multidisciplinary approach to aeroelastic analysis
p 781 A91-42709
BOSSLER, ROBERT
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1906] p 769 A91-41648
BOWMAN, H. L.
Reduced pressure oscillations in a dump combustor with tapered corrugations
[AIAA PAPER 91-2354] p 753 A91-44208
BOZZOLA, R.
Advanced high work turbine technology
[AIAA PAPER 91-2028] p 752 A91-44096
BRAITHWAITE, W. W.
Integrated computer systems in aircraft design and manufacture difficulties and implications
p 781 A91-43079
BRASZ, JOOST J.
Flowfield analysis of a backswept centrifugal impeller
[AIAA PAPER 91-2470] p 774 A91-44255
BREER, MARLIN D.
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies
p 771 A91-43310
BRENNEIS, A.
Navier-Stokes results for hypersonic inlet flows
[AIAA PAPER 91-2472] p 729 A91-44257
BRENNER, M. J.
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113
BRIASSULIS, G.
Experimental investigation of the near wake structure of a helicopter rotor in forward flight
[AIAA PAPER 91-1753] p 711 A91-42575
BROADBENT, E. G.
Intakes and boundary layer crossflows for hypersonic vehicles
[AIAA PAPER 91-2160] p 728 A91-44138
BROCK, N. J.
A quantitative study of unsteady compressible flow on an oscillating airfoil
[AIAA PAPER 91-1683] p 722 A91-43590
BRODERSEN, O.
Transition predictions using Reynolds-averaged Navier-Stokes and linear stability analysis methods
[AIAA PAPER 91-1641] p 720 A91-43567
BROOKER, PETER
The European ATC system - Constraints and traffic management p 734 A91-41439
BROWN, GEORGE E., JR.
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046
BROWN, JEFFREY J.
On the use of CFD in HSCT inlet and nozzle design
[AIAA PAPER 91-2255] p 728 A91-44173
BROZENA, JOHN M.
GPS and airborne gravimetry - Recent progress and future plans p 742 A91-43315
BRUCKER, D.
The effect of artificial vorticity on the discrete solution of Euler equations
[AIAA PAPER 91-1553] p 698 A91-40727
BRUCKNER, A. P.
Experiments on hypersonic ramjet propulsion cycles using a ram accelerator
[AIAA PAPER 91-2489] p 762 A91-44264

BUCK, F.
Functional baseline specification for ATC data link service implementation in the host computer system
[DOT/FAA/CT-91/12] p 779 N91-26433
BUCKREUSS, STEFAN
Specification of an inertial navigation system for experimental SAR p 735 A91-41829
BUNDICK, W. THOMAS
Development of an adaptive failure detection and identification system for detecting aircraft control element failures
[NASA-TP-3051] p 758 N91-25151
BUNING, PIETER G.
Collar grids for intersecting geometric components within the Chimera overlapped grid scheme
[AIAA PAPER 91-1587] p 700 A91-40761
BURCHAM, F. W., JR.
A preliminary investigation of the use of throttles for emergency flight control
[AIAA PAPER 91-2222] p 756 A91-41731
BURCHAM, FRANK W., JR.
A simulation evaluation of a four-engine jet transport using engine thrust modulation for flightpath control
[AIAA PAPER 91-2223] p 757 A91-44162
BURGREEN, GREG W.
Aerodynamic shape optimization using sensitivity analysis on third-order Euler equations
[AIAA PAPER 91-1577] p 699 A91-40751
BURNHAM, E. A.
Experiments on hypersonic ramjet propulsion cycles using a ram accelerator
[AIAA PAPER 91-2489] p 762 A91-44264
BURNS, B. R. A.
HOTOL space transport for the twenty-first century p 763 A91-41537
BUSCH, RICHARD J., JR.
Computational fluid dynamics in the design of the YF-23 ATF prototype
[AIAA PAPER 91-1627] p 719 A91-43558
BUSSICHELLA, J. K.
Concepts for reduction of turbine rotor inertia
[AIAA PAPER 91-2031] p 752 A91-44098
BUTTERWORTH-HAYES, PHILIP
Sub-contractors play new strategic roles p 694 A91-43273
BUYUKATAMAN, KAYAALP
A theoretical study on the vibration damping of aircraft gearbox gears
[AIAA PAPER 91-2558] p 738 A91-41813
BYINGTON, C. S.
Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41768

C

CAIN, T. M.
A compression ignition driver for a free piston shock tunnel p 759 A91-40638
CAN, ALI D.
Block-structured computation of three-dimensional transonic Euler equations
[AIAA PAPER 91-1679] p 721 A91-43588
CAPRIOTTI, D. P.
Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41768
CARD, VICTOR
Certification procedures and requirements p 759 N91-26154
CARISTIA, S.
Supersonic wind tunnel diffuser performance with high model blockage at moderate to low Reynolds numbers
[AIAA PAPER 91-2274] p 761 A91-44183
CARLSON, JOHN R.
Prediction of internal performance for two-dimensional convergent-divergent nozzles
[AIAA PAPER 91-2369] p 706 A91-41762
CARPENTER, D. A.
A demonstration of mode transition in a scramjet combustor
[AIAA PAPER 91-2395] p 754 A91-44225
CARR, L. W.
A quantitative study of unsteady compressible flow on an oscillating airfoil
[AIAA PAPER 91-1683] p 722 A91-43590
CARSON, G. T., JR.
A parametric experimental study of isolated rectangular nozzles
[AIAA PAPER 91-2136] p 738 A91-41706
CARTA, FRANKLIN O.
Dynamic stall experiments on a swept three-dimensional wing in compressible flow
[AIAA PAPER 91-1795] p 712 A91-42595
CASALINI, F.
A Finite Volume Lambda Formulation
[AIAA PAPER 91-2258] p 728 A91-44176
CASPER, JAY
An extension of essentially nonoscillatory shock-capturing schemes to multidimensional systems of conservation laws p 776 N91-25355
CATLIN, J. D.
Coordination and synchronization of loran-C and GPS to universal coordinated time
[AD-A233221] p 737 N91-25141
CATON, J. L.
Two-dimensional thrust vector control nozzle
[AIAA PAPER 91-2101] p 745 A91-41696
CAUGHEY, D. A.
Diagonal implicit multigrid solution of compressible turbulent flows
[AIAA PAPER 91-1571] p 699 A91-40745
CAUGHEY, DAVID
Parallel block multigrid solution of the compressible Navier-Stokes equations p 702 A91-40792
CAVAILLER, C.
A new vertical shock tube for Rayleigh-Taylor instability measurements p 759 A91-40637
CAVALLERI, ROBERT
CFD evaluation of transonic-supersonic wave front propagation effects
[AIAA PAPER 91-1657] p 708 A91-42547
CEBECI, TUNCER
A numerical method for predicting transition in three-dimensional flows by spatial amplification theory
[AIAA PAPER 91-1606] p 702 A91-40778
CELENLIGIL, M. C.
Hypersonic rarefied flow about a delta wing - Direct simulation and comparison with experiment
[AIAA PAPER 91-1315] p 716 A91-43387
CENKO, A.
Potential flow applications to complex configurations
[AIAA PAPER 91-1634] p 719 A91-43562
CENTER, K. B.
Interactive design of hypersonic waverider geometries
[AIAA PAPER 91-1697] p 740 A91-43597
CHAKRAVARTHY, S. R.
Computational aerodynamics methodology for the Aerospace Plane p 714 A91-42728
CHAN, K. W.
Condition monitoring of aircraft high lift systems p 738 A91-41535
CHAN, STEPHEN C.
CFD computations for aero-optical analysis of supersonic shear layers
[AIAA PAPER 91-1659] p 720 A91-43574
CHAN, WILLIAM M.
Collar grids for intersecting geometric components within the Chimera overlapped grid scheme
[AIAA PAPER 91-1587] p 700 A91-40761
CHAND, SUJEET
Fuzzy logic for control of roll and moment for a flexible wing aircraft p 757 A91-43932
CHANDRASEKHAR, R.
Application of a Reynolds Stress turbulence model to a supersonic hydrogen-air diffusion flame
[AIAA PAPER 91-1786] p 725 A91-43643
CHANDRASEKHARA, M. S.
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821
A quantitative study of unsteady compressible flow on an oscillating airfoil
[AIAA PAPER 91-1683] p 722 A91-43590
Laser velocimetry measurements of oscillating airfoil dynamic stall flow field
[AIAA PAPER 91-1799] p 725 A91-43648
CHANG, CHAU-LYAN
Compressible stability of growing boundary layers using parabolized stability equations
[AIAA PAPER 91-1636] p 720 A91-43564
CHAPMAN, GARY T.
A study of flow separation on an aspect ratio three flap at Mach number 2.4
[AIAA PAPER 91-1620] p 718 A91-43554
CHAPPELL, M. A.
An approach to modeling continuous turbine engine operation from startup to shutdown
[AIAA PAPER 91-2373] p 747 A91-41764
CHARGIN, M. K.
Static aeroelastic analysis of a three-dimensional oblique wing p 714 A91-42711
CHAUDHARY, ASHWANI
Fuzzy logic for control of roll and moment for a flexible wing aircraft p 757 A91-43932
CHAUDHRY, K. K.
A study of aeroacoustic performance of a contra-rotating axial flow compressor stage p 706 A91-42248
CHAUSSEE, DENNY S.
A numerical investigation of turbulent baseflow p 703 A91-40799
CHEATWOOD, F. MCN.
An approximate viscous shock layer approach to calculating hypersonic flows about blunt-nosed bodies
[AIAA PAPER 91-1348] p 717 A91-43417
CHEN, CHING JEN
Navier-Stokes solution of complete turbulent flow past finite axisymmetric bodies p 707 A91-42298
CHEN, CHUNG-LUNG
Numerical study of juncture flows
[AIAA PAPER 91-1660] p 720 A91-43575
CHEN, FANG-JENQ
Goertler instability and hypersonic quiet nozzle design
[AIAA PAPER 91-1648] p 708 A91-42542
CHEN, HSUN H.
A numerical method for predicting transition in three-dimensional flows by spatial amplification theory
[AIAA PAPER 91-1606] p 702 A91-40778
CHEN, S. H.
An efficient method in predicting rotor/stator interaction
[AIAA PAPER 91-3380] p 730 A91-44320
CHEN, SUHUAN
A new method for the vibration of thin-walled beams p 772 A91-43706
CHEN, YEN-SEN
CFD analysis of baffle flame stabilization
[AIAA PAPER 91-1967] p 773 A91-44078
CHENG, KEMING
A primary study of Reynolds number effect in transonic flow p 718 A91-43502
CHENG, R. M. H.
Design optimization of an electronic fuel control unit featuring two digital actuators
[AIAA PAPER 91-2003] p 745 A91-41672
CHERNISS, S. C.
NASA/Ames Research Center DC-8 data system p 782 N91-25458
CHEW, G.
Experiments on hypersonic ramjet propulsion cycles using a ram accelerator
[AIAA PAPER 91-2489] p 762 A91-44264
CHIANG, HSIAO-WEI D.
Flutter control of incompressible flow turbomachine blade rows by splitter blades
[AIAA PAPER 91-1900] p 704 A91-41645
CHINZEI, NOBUO
Parametric study of airframe-integrated scramjet cooling requirement p 749 A91-42817
CHISHOLM, J. D.
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089
CHIU, STEPHEN
Fuzzy logic for control of roll and moment for a flexible wing aircraft p 757 A91-43932
CHOI, D.
Improved turbulence modeling for gas turbine application
[AIAA PAPER 91-2239] p 728 A91-44165
Aerodynamic and heat transfer analysis of the low aspect ratio turbine using a 3D Navier-Stokes code
[AIAA PAPER 91-2240] p 774 A91-44166
CHOI, SEOK KI
Navier-Stokes solution of complete turbulent flow past finite axisymmetric bodies p 707 A91-42298
CHOKANI, NDAONA
Comparison of cryogenic wind tunnel, flight, and computational results for a thin, low-aspect-ratio wing
[AIAA PAPER 91-1626] p 708 A91-42536
Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel
[AIAA PAPER 91-1725] p 723 A91-43615
CHOPRA, INDERJIT
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
CHOW, CHUEN-YEN
Flight test and numerical simulation of transonic flow around YAV-8B Harrier II wing
[AIAA PAPER 91-1628] p 719 A91-43559
Theoretical studies of the kinematics, dynamics, stability, and control of unsteady/vortical flows
[AD-A235190] p 779 N91-26477
CHOW, REUBEN R.
Navier-Stokes solution for high-lift multielement airfoil system with flap separation
[AIAA PAPER 91-1623] p 707 A91-42535
CHPOUN, A.
Leading edge effect on rarefied hypersonic flow over a flat plate
[AIAA PAPER 91-1749] p 710 A91-42573
CHU, JULIO
Comparison of cryogenic wind tunnel, flight, and computational results for a thin, low-aspect-ratio wing
[AIAA PAPER 91-1626] p 708 A91-42536

Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel
[AIAA PAPER 91-1725] p 723 A91-43615

CHU, KING-WAI
Navier-Stokes solution for high-lift multielement airfoil system with flap separation
[AIAA PAPER 91-1623] p 707 A91-42535

CHUCK, C.
Combusting flow simulations of detonation and shock-induced combustion waves for ram accelerator configurations with viscous effect
[AIAA PAPER 91-1674] p 721 A91-43584

CHUN, CH.-H.
Hypersonic rarefied flow about a compression corner - DSMC simulation and experiment
[AIAA PAPER 91-1313] p 716 A91-43385

CHUPP, RAYMOND E.
Simple leakage flow model for brush seals
[AIAA PAPER 91-1913] p 773 A91-44054

CHYU, WEI J.
Flight test and numerical simulation of transonic flow around YAV-8B Harrier II wing
[AIAA PAPER 91-1628] p 719 A91-43559

CLARK, CYNTHIA C.
On the use of CFD in HSCT inlet and nozzle design
[AIAA PAPER 91-2255] p 728 A91-44173

CLARK, WILLIAM S.
Prediction of unsteady aerodynamic loads in cascades using the linearized Euler equations on deforming grids
[AIAA PAPER 91-3378] p 730 A91-44318

CLEVER, WILLARD C.
Numerical study of the X-31 high angle-of-attack flow characteristics
[AIAA PAPER 91-1630] p 708 A91-42538

CLOOS, B.
The development of 'Radar data quality control and Radar Analysis Support System RDQC/RASS'
p 735 A91-41834

COHEN, GERALD C.
Structured representation for requirements and specifications
[NASA-CR-187522] p 783 N91-26797

COHN, J. A.
Advanced high bypass mixed-flow exhaust system design study
[AIAA PAPER 91-2242] p 753 A91-44168

COHRS, B.
Uncertainty analysis of turbine aerodynamic performance measurements in short duration test facilities
[AIAA PAPER 91-2131] p 761 A91-44132

COIRIER, WILLIAM J.
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740

COLE, J. D.
Asymptotic methods for the prediction of transonic wind tunnel wall interference
[AIAA PAPER 91-1712] p 762 A91-44334

COLEMAN, RODERICK M.
Numerical evaluation of vortex flow control devices
[AIAA PAPER 91-1825] p 713 A91-42612

COLLIE, J. C.
The effect of square trailing edges on turbine blade performance
[AIAA PAPER 91-2130] p 704 A91-41704

COLLIER, F. S., JR.
Opportunities for applications of natural laminar flow technology at high-subsonic speeds
[AIAA PAPER 91-1773] p 724 A91-43638

COLLIER, M. S.
CFD calibration and application to the design of flow tailoring devices for simulating forebody influences on fighter aircraft inlet flows p 776 N91-25339

CONLEY, JOSEPH L.
A simulation evaluation of a four-engine jet transport using engine thrust modulation for flightpath control
[AIAA PAPER 91-2223] p 757 A91-44162

CONTER, T.
SEAN: A navigation aid expert system for combat aircraft p 737 N91-25137

CONWAY, SCOTT
Conclusions from high-speed rotorcraft studies
[AIAA PAPER 91-2149] p 693 A91-41711

COON, MICHAEL D.
A study of flow separation on an aspect ratio three flap at Mach number 2.4
[AIAA PAPER 91-1620] p 718 A91-43554

COPP, P. D.
Failure analysis and damage initiation in carbon-carbon composite materials under three-point bending
p 764 A91-41569

COSGROVE, B. A.
Aging fleet - Maintaining airworthiness
p 693 A91-43077

COSNER, R. R.
High-speed forebody-inlet code validation experience at MCAIR p 776 N91-25348

COSNER, RAYMOND R.
Aeropropulsion analysis of tactical aircraft - Status and plans
[AIAA PAPER 91-1528] p 740 A91-43673

COUPRY, GABRIEL
Improved reduction of gust loads data for gust intensity p 758 N91-26153

COUSTOLS, E.
Synthesis of experimental riblet studies in transonic conditions p 716 A91-43142

COVINO, ALFRED F., JR.
Dynamic stall experiments on a swept three-dimensional wing in compressible flow
[AIAA PAPER 91-1795] p 712 A91-42595

CRATCH, P.
Functional baseline specification for ATC data link service implementation in the host computer system
[DOT/FAA/CT-91/12] p 779 N91-26433

CRAWFORD, M. E.
Effects of streamwise pressure gradient on the suction surface boundary layer of a turbine airfoil
[AIAA PAPER 91-2030] p 727 A91-44097

CROMER, T. W.
New capabilities for aeromechanical testing and evaluation of aircraft turbine engines
[AIAA PAPER 91-2498] p 747 A91-41801

CRUMP, JAMES RAYMOND
A drag analysis of the early stages of large-scale high-altitude free balloon ascents p 731 N91-25108

CRUZ, CHRISTOPHER I.
Super/hypersonic aerodynamic characteristics for a transatmospheric vehicle concept having a minimum drag forebody
[AIAA PAPER 91-1694] p 709 A91-42558
Enhancements to the high speed convective heating and viscous drag prediction techniques of the Aerodynamic Preliminary Analysis System (APAS)
[AIAA PAPER 91-1435] p 717 A91-43494

CULLUM, GAIL H.
Ceramic composites for aircraft gas turbine engines
[AIAA PAPER 91-1892] p 750 A91-44045

CUTLER, ANDREW D.
Vortex breakdown in a supersonic jet
[AIAA PAPER 91-1815] p 726 A91-43656

D

DA COSTA, J. L.
A multidomain Euler code applied to hypersonic flows
[AIAA PAPER 91-1699] p 722 A91-43598

DADONE, A.
A Finite Volume Lambda Formulation
[AIAA PAPER 91-2258] p 728 A91-44176

DANNENHOFFER, JOHN F., III
Computer-aided block-structuring through the use of optimization and expert system techniques
[AIAA PAPER 91-1585] p 700 A91-40759

DARDEN, C. M.
CFD prediction of the near-field sonic boom environment for two low boom HSCT configurations
[AIAA PAPER 91-1631] p 784 A91-43560

DARMOFAL, D.
Computation and visualization of leading edge vortex flows p 714 A91-42721

DASH, S. M.
Prediction of jet mean flow structure in support of HSCT noise suppression concepts
[AIAA PAPER 91-2253] p 774 A91-44171

DAVIES, CAROL B.
Application of a solution adaptive grid scheme, SAGE, to complex three-dimensional flows
[AIAA PAPER 91-1594] p 701 A91-40768

DAVIS, M. W., JR.
Parametric investigation into the combined effects of pressure and temperature distortion on compression system stability
[AIAA PAPER 91-1895] p 773 A91-44047

DAVIS, ROGER L.
Investigation of hot streak migration and film cooling effects on the heat transfer in rotor/stator interacting flows
[AD-A235420] p 756 N91-26145

DE HUGUES, P. P.
Investigation of the tip shape influence on the flowfield around hovering rotor blades
[AIAA PAPER 91-1754] p 711 A91-42576

DE ZEEUW, DARREN
An adaptively-refined Cartesian mesh solver for the Euler equations
[AIAA PAPER 91-1542] p 697 A91-40717

DEAN, WILLIAM E.
How low can an unmanned air vehicle fly?
[RAND-P-7680-RGS] p 741 N91-26138

DEANE, ANIL E.
Low-dimensional description of the dynamics in separated flow past thick airfoils
[AIAA PAPER 91-1622] p 707 A91-42534

DECREMIERS, M.
SEAN: A navigation aid expert system for combat aircraft p 737 N91-25137

DEJARNETTE, F. R.
An approximate viscous shock layer approach to calculating hypersonic flows about blunt-nosed bodies
[AIAA PAPER 91-1348] p 717 A91-43417

DEJONGE, J. B.
Acquisition of statistical gust load data by commercial airplanes p 758 N91-26152

DEMEIS, RICHARD
Seeking crashworthy seats p 740 A91-44345

DEMPSEY, BARRY J.
Guidelines for design, construction, and evaluation of airport pavement drainage
[DOT/FAA/RD-90/31] p 763 N91-26161

DEN, SUQING
Application of shock tunnel at pressure and heat transfer experiments on turbine blade p 760 A91-40649

DENDIS, J. C.
Failure analysis and damage initiation in carbon-carbon composite materials under three-point bending
p 764 A91-41569

DENG, XUE-YING
Correlative behaviours of shock/boundary layer interaction induced by sharp fin and semicone
[AIAA PAPER 91-1756] p 711 A91-42577

DER, JOE, JR.
Improved methods of characterizing ejector pumping performance p 749 A91-42815

DIETRICH, D. A.
CFD-based 3D turbofan exhaust nozzle analysis system
[AIAA PAPER 91-2478] p 754 A91-44261

DIGIOVANNI, R. A.
Upgraded T55 engine for Special Forces MH-47E aircraft
[AIAA PAPER 91-2024] p 752 A91-44094

DIGIROLAMO, ROBERT D.
Flight control law synthesis using neural network theory
[AD-A234990] p 758 N91-26149

DIMOTAKIS, PAUL E.
On the convection velocity of turbulent structures in supersonic shear layers
[AIAA PAPER 91-1724] p 723 A91-43614

DISIMILE, P. J.
Mach 6 turbulent boundary layer characteristics on smooth and rough surfaces
[AIAA PAPER 91-1762] p 711 A91-42580

DNEPROV, I. V.
Determination of the stress-strain state of a soft lifting system p 704 A91-41320

DOBRODEEV, V. P.
Thermodynamic analysis of gas turbine engines and plants at high air pressure levels p 743 A91-41171

DODSON, L. J.
Hypersonic shock/boundary-layer interaction database
[AIAA PAPER 91-1763] p 711 A91-42581

DOHRMANN, ULRICH
Drag and lift in nonadiabatic transonic flow
[AIAA PAPER 91-1716] p 710 A91-42564

DOLLING, D. S.
An experimental/computational study of heat transfer in sharp fin induced turbulent interactions at Mach 5
[AIAA PAPER 91-1764] p 724 A91-43633

DONLEY, SHAWN T.
Flight control law synthesis using neural network theory
[AD-A234990] p 758 N91-26149

DORNEY, DANIEL J.
Flowfield analysis of a backswept centrifugal impeller
[AIAA PAPER 91-2470] p 774 A91-44255
Investigation of hot streak migration and film cooling effects on the heat transfer in rotor/stator interacting flows
[AD-A235420] p 756 N91-26145

DOUGHERTY, F. C.
Hypersonic waverider analysis - A comparison of numerical and experimental results
[AIAA PAPER 91-1696] p 739 A91-43596
Interactive design of hypersonic waverider geometries
[AIAA PAPER 91-1697] p 740 A91-43597

DOWLER, CONSTANCE A.
Simple leakage flow model for brush seals
[AIAA PAPER 91-1913] p 773 A91-44054
Compressor exit temperature analysis. II
[AIAA PAPER 91-2008] p 751 A91-44090

DOWNEY, DAWN M.
Compressor exit temperature analysis. II
[AIAA PAPER 91-2008] p 751 A91-44090
DRELA, MARK
Viscous/inviscid method for preliminary design of transonic cascades
[AIAA PAPER 91-2364] p 706 A91-41760
DRUMMOND, J. P.
Mixing enhancement of reacting parallel fuel jets in a supersonic combustor
[AIAA PAPER 91-1914] p 750 A91-44055
DRUZHININ, L. N.
Comparative analysis of turbofan effective thrust with mixed and separated flows engines
[AIAA PAPER 91-2376] p 754 A91-44216
Combined cycle aircraft engines
[AIAA PAPER 91-2377] p 754 A91-44217
DUCRUET, C.
A method for correcting wall pressure measurements in subsonic compressible flow p 715 A91-42957
DUDAS, CHARLES
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153
DUFFIN, J.
New generation of free-piston shock tunnels p 760 A91-40640
DUNCAN, BEVERLY
CFD analysis of a hydrogen fueled ramjet engine at Mach 3.44
[AIAA PAPER 91-1919] p 745 A91-41653
DUNN, M. G.
Uncertainty analysis of turbine aerodynamic performance measurements in short duration test facilities
[AIAA PAPER 91-2131] p 761 A91-44132
DWOYER, DOUGLAS L.
Recent advances in hypersonic technology p 716 A91-43103
DZIEDZIC, WILLIAM M.
An analytical comparison of convective heat transfer correlations in supercritical hydrogen
[AIAA PAPER 91-1382] p 771 A91-43446

E

EASTLAND, A. H.
An efficient method in predicting rotor/stator interaction
[AIAA PAPER 91-3380] p 730 A91-44320
EBERHARDT, S.
Combusting flow simulations of detonation and shock-induced combustion waves for ram accelerator configurations with viscous effect
[AIAA PAPER 91-1674] p 721 A91-43584
ECER, AKIN
Block-structured computation of three-dimensional transonic Euler equations
[AIAA PAPER 91-1679] p 721 A91-43588
EDWARDS, BRIAN
The progressive improvement of European flow-management p 734 A91-41440
EDWARDS, T. A.
Sensitivity of inlet performance predictions to CFD numerical and physical modeling p 776 N91-25345
EFANOV, V. N.
An integrated automatic ramjet engine control system tolerant to failures of the functional components p 780 A91-41163
EGGERS, JAMES M.
Enhanced capability of the Combustion-Heated Scramjet Test Facility
[AIAA PAPER 91-2502] p 762 A91-44267
EKATERINARIS, JOHN A.
Numerical investigation of the effect of leading edge geometry on dynamic stall of airfoils
[AIAA PAPER 91-1798] p 712 A91-42597
Navier-Stokes solutions for an oscillating double-delta wing
[AIAA PAPER 91-1624] p 718 A91-43556
EL-HADY, NABIL M.
Secondary instability of high-speed flows and the influence of wall cooling and suction
[AIAA PAPER 91-1647] p 720 A91-43572
EL-SAYED, M. A.
Size dependence of gaseous cluster reactivity and evaporation dynamics as a mechanistic probe
[AD-A233811] p 766 N91-26249
ELANGOVAN, R.
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies p 771 A91-43310
ELESHAKY, MOHAMED E.
Aerodynamic shape optimization using sensitivity analysis on third-order Euler equations
[AIAA PAPER 91-1577] p 699 A91-40751
ELIASSON, PETER
Navier-Stokes computations of hypersonic flow past a blunt edge delta wing at several angles of attack
[AIAA PAPER 91-1698] p 709 A91-42559
ELLIS, S. L.
Effects of streamwise pressure gradient on the suction surface boundary layer of a turbine airfoil
[AIAA PAPER 91-2030] p 727 A91-44097
ELLIS, STEPHEN R.
Format and basic geometry of a perspective display of air traffic for the cockpit
[NASA-TM-86680] p 743 N91-26142
ENGELUND, WALTER C.
Enhancements to the high speed convective heating and viscous drag prediction techniques of the Aerodynamic Preliminary Analysis System (APAS)
[AIAA PAPER 91-1435] p 717 A91-43494
EPSTEIN, B.
Euler solver for arbitrary configurations - Further applications p 716 A91-43100
ERICSSON, L. E.
Sources of high alpha vortex asymmetry at zero sideslip
[AIAA PAPER 91-1810] p 713 A91-42604
ERLEBACHER, GORDON
Compressible stability of growing boundary layers using parabolized stability equations
[AIAA PAPER 91-1636] p 720 A91-43564
EVDOKIMOV, S. A.
An integrated automatic ramjet engine control system tolerant to failures of the functional components p 780 A91-41163
EVERSMAN, W.
Effect of thickness on the unsteady aerodynamics of closely coupled oscillating airfoils p 716 A91-43308
EXTON, R. J.
Study of cluster formation and its effects on Rayleigh and Raman scattering measurements in a Mach 6 wind tunnel
[AIAA PAPER 91-1496] p 718 A91-43547

F

FARMER, RICHARD C.
CFD analysis of baffle flame stabilization
[AIAA PAPER 91-1967] p 773 A91-44078
FAROKHI, SAEED
Analysis of pressure distribution on hypersonic vehicles with power effects
[AIAA PAPER 91-2491] p 738 A91-41796
FAVALORO, S. C.
Experimental and computational investigation of isothermal swirling flow in an axisymmetric dump combustor p 749 A91-42806
FAVIER, D.
Investigation of the tip shape influence on the flowfield around hovering rotor blades
[AIAA PAPER 91-1754] p 711 A91-42576
FAVIN, S.
Analysis of external burning on inclined surfaces in supersonic flow
[AIAA PAPER 91-2390] p 747 A91-41767
FENG, LIANG
Application of transformational ideas to automatic flight control design
[AD-A234758] p 758 N91-26148
FERNANDEZ, G.
Finite element simulation of compressible flows with shocks
[AIAA PAPER 91-1551] p 767 A91-40725
FERNANDO, E. M.
Mixing enhancement in compressible mixing layers - An experimental study
[AIAA PAPER 91-1721] p 723 A91-43612
FERRARO, P. J.
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration
[AIAA PAPER 91-1689] p 748 A91-42556
FINDLAY, D.
Numerical investigation of the effects of blowing on high angle of attack flow over delta wings
[AIAA PAPER 91-1809] p 726 A91-43652
FINFROCK, G. P.
MACGS - A zonal grid generation system for complex aero-propulsion configurations
[AIAA PAPER 91-2156] p 738 A91-41714
FINLAYSON, IAN
Creating a scene p 775 A91-44342
FISHER, GENE
Structured representation for requirements and specifications
[NASA-CR-187522] p 783 N91-26797
FISHER, P.
The PC as a generic developmental fuel control for expendable turbojet engines
[AIAA PAPER 91-3399] p 755 A91-44329
FITZPATRICK, ROBERT E.
High-speed rotorcraft propulsion
[AIAA PAPER 91-2147] p 746 A91-41709
FLEETER, SANFORD
Active unsteady aerodynamic suppression of rotating stall in an incompressible flow centrifugal compressor with vaned diffuser
[AIAA PAPER 91-1898] p 704 A91-41644
Flutter control of incompressible flow turbomachine blade rows by splitter blades
[AIAA PAPER 91-1900] p 704 A91-41645
FLEMING, DAVID P.
Magnetic bearings-state of the art
[NASA-TM-104465] p 778 N91-25413
FLEMING, K. J.
Advanced high bypass mixed-flow exhaust system design study
[AIAA PAPER 91-2242] p 753 A91-44168
FLOOD, J. D.
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration
[AIAA PAPER 91-1689] p 748 A91-42556
FLORES, JOLEN
A parametric study of the leading edge attachment line for the F-16XL
[AIAA PAPER 91-1621] p 718 A91-43555
FOERSTER, WOLFGANG
Velocity measurements in turbine engines - New developments using the laser two-focus method p 771 A91-43328
FORD, R. L.
A new threat detection criterion for airborne collision avoidance systems p 735 A91-41447
FORDYCE, STEPHEN C.
Thrust vectoring using non-axisymmetric nozzles with flexible contours
[AIAA PAPER 91-2368] p 746 A91-41761
FOULADI-SEMNANI, KAMRAN
Navier-Stokes simulations of flows about complex configurations using domain decomposition techniques p 777 N91-25362
FOULADI, KAMRAN
Multigrid and upwind viscous flow solver on three-dimensional overlapped and embedded grids p 707 A91-42284
FRANKE, M. E.
Two-dimensional thrust vector control nozzle
[AIAA PAPER 91-2101] p 745 A91-41696
FRANKLIN, J. E.
Lightweight ceramic components for propulsion applications
[AIAA PAPER 91-2217] p 774 A91-44159
FREUND, GEORGE A., JR.
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies p 771 A91-43310
FREYMUTH, PETER
Vortex topology for rectangular wings in pictures, sketches and conjectures
[AIAA PAPER 91-1824] p 713 A91-42611
FRIDLIANDER, I. N.
Aluminium-lithium weldable alloy 1420 - Alloying system Al-Li-Mg-Zr p 765 A91-43891
FRINCKE, DEBORAH
Structured representation for requirements and specifications
[NASA-CR-187522] p 783 N91-26797
FRISCH, BRUCE
Simulating a new species of bird p 694 A91-44340
FROST, WALTER
Guide to measurement of winds with instrumented aircraft
[NASA-CR-188601] p 780 N91-25553
FUJIEDA, HIROTOSHI
Velocity measurements inside the leading edge vortex formed on a delta wing
[NAL-TR-1087] p 732 N91-25115
FUJII, KOZO
Unified zonal method based on the fortified Navier-Stokes concept
[AIAA PAPER 91-1558] p 698 A91-40732
Supersonic inlet flow computations using fortified Navier-Stokes approach
[AIAA PAPER 91-1730] p 710 A91-42567
FUJII, SHOUICHI
The reduction of cavity noise at subsonic speeds
[NAL-TR-1081] p 784 N91-25815

FUJIMORI, TOSHIRO
A study of supersonic aerodynamic mixing in the scramjet combustor p 771 A91-43000
FUJITA, TOSHIMI
Velocity measurements inside the leading edge vortex formed on a delta wing
[NAL-TR-1087] p 732 N91-25115
FULLER, E. J.
Mixing studies of helium in air at Mach 6
[AIAA PAPER 91-2268] p 705 A91-41739
FULLERTON, C. G.
A preliminary investigation of the use of throttles for emergency flight control
[AIAA PAPER 91-2222] p 756 A91-41731

G

GABRIELI, H.
Functional baseline specification for ATC data link service implementation in the host computer system
[DOT/FAA/CT-91/12] p 779 N91-26433
GAI, S. L.
Laminar heat transfer to spherically blunted cones in high enthalpy hyper velocity flows p 695 A91-40646
GALOTTI, VINCENT P., JR.
ATC simulators do not have to replicate operational systems physically p 761 A91-42789
GANY, A.
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets
p 748 A91-42805
GANY, ALON
Burning and flameholding characteristics of a miniature solid fuel ramjet combustor p 749 A91-42807
GAO, ZHENG
Prediction of helicopter rotor rotational noise
p 784 A91-43503
GAONKAR, GOPAL H.
Dynamics of elastic bending and torsion of hingeless rotors with dynamic stall
[AD-A234775] p 741 N91-26134
GARNER, P. L.
Areas for future CFD development as illustrated by transport aircraft applications
[AIAA PAPER 91-1527] p 696 A91-40703
GARRIS, C. A.
A new concept for a hubless rotary jet
[AIAA PAPER 91-1903] p 750 A91-44051
GATLIN, BOYD
Adaptive EAGLE - Solution-adaptive and quality-enhancing multi-block grids for arbitrary domains
[AIAA PAPER 91-1593] p 701 A91-40767
GATLIN, GREGORY M.
Low-speed, powered ground effects of a generic, hypersonic configuration
[NASA-TP-3092] p 730 N91-25103
GATZKE, T. D.
MACGS - A zonal grid generation system for complex aero-propulsion configurations
[AIAA PAPER 91-2156] p 738 A91-41714
GEA, LIE-MINE
Flight test and numerical simulation of transonic flow around YAV-8B Harrier II wing
[AIAA PAPER 91-1628] p 719 A91-43559
GELHAAR, BERND
With us you fly right - The influence of modern technology on the development and operation of new aircraft
p 771 A91-43326
GENBACH, A. A.
Limiting thermal loads in porous structures
p 768 A91-41159
GEORGANTAS, A. I.
Design optimization of an electronic fuel control unit featuring two digital actuators
[AIAA PAPER 91-2003] p 745 A91-41672
GEORGE, MICHAEL W.
Numerical study of the X-31 high angle-of-attack flow characteristics
[AIAA PAPER 91-1630] p 708 A91-42538
GEYER, W. H.
Hot-surface ignition and fire-suppression tests in an aircraft engine bay
[AIAA PAPER 91-2382] p 754 A91-44219
GIL'MAN, O. A.
Pareto-optimal shapes of axisymmetric bodies moving at high supersonic velocities p 707 A91-42330
GILES, MICHAEL B.
On the validity of linearized unsteady Euler equations with shock capturing
[AIAA PAPER 91-1598] p 702 A91-40771
Quasi-3-D non-reflecting boundary conditions for Euler equations calculations
[AIAA PAPER 91-1603] p 702 A91-40775
GILYARD, G. B.
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089
GILYARD, GLENN B.
A preliminary investigation of the use of throttles for emergency flight control
[AIAA PAPER 91-2222] p 756 A91-41731
A simulation evaluation of a four-engine jet transport using engine thrust modulation for flightpath control
[AIAA PAPER 91-2223] p 757 A91-44162
GLASER, JOHN
Analysis by the statistical discrete gust method
p 759 N91-26156
GLAZ, HARLAND M.
Second-order Godunov methods and self-similar steady supersonic three-dimensional flowfields
[AIAA PAPER 91-1653] p 708 A91-42544
GNOFFO, PETER A.
Asynchronous, macrotasked relaxation strategies for the solution of viscous, hypersonic flows
[AIAA PAPER 91-1579] p 700 A91-40753
GODDARD, K.
Re-engining - The sound case for aircraft noise reduction
[AIAA PAPER 91-2144] p 783 A91-41708
GODDARD, R. B.
Coordination and synchronization of loran-C and GPS to universal coordinated time
[AD-A233221] p 737 N91-25141
GOETZ, G.
Heat management concepts for hypersonic propulsion systems
[AIAA PAPER 91-2493] p 769 A91-41798
GOLDEN, J. B.
A neural network for the analysis of aircraft test data
p 781 N91-25133
GOORJIAN, PETER M.
Higher order accuracy for upwind methods by using the compatibility equations
[AIAA PAPER 91-1543] p 697 A91-40718
GORDNIER, RAYMOND E.
Numerical simulation of the unsteady vortex structure over a delta wing
[AIAA PAPER 91-1811] p 726 A91-43653
GORDON, G.
Three-dimensional jet noise computations
[AIAA PAPER 91-2256] p 784 A91-44174
GOSWAMI, AVIJIT
Grid restructuring for moving boundaries
[AIAA PAPER 91-1589] p 700 A91-40763
GOTTESDIENER, L.
Leading edge effect on rarefied hypersonic flow over a flat plate
[AIAA PAPER 91-1749] p 710 A91-42573
GOTTWALD, JAMES A.
Aircraft interior noise reduction by alternate resonance tuning
[NASA-CR-185453] p 785 N91-26889
GOULD, DANA C.
An analytical comparison of convective heat transfer correlations in supercritical hydrogen
[AIAA PAPER 91-1382] p 771 A91-43446
GOWADIA, NOSHIR S.
Thrust vectoring using non-axisymmetric nozzles with flexible contours
[AIAA PAPER 91-2368] p 746 A91-41761
GRAAGE, K.
Transition predictions using Reynolds-averaged Navier-Stokes and linear stability analysis methods
[AIAA PAPER 91-1641] p 720 A91-43567
GRABER, A.
An investigation of a hovering rotor in ground effect
p 704 A91-41462
GRANDHI, R. V.
Combined energy management and calculus of variations approach for optimizing hypersonic vehicle trajectories p 739 A91-42738
GRASSO, FRANCESCO
LU implicit TVD scheme for the solution of viscous two dimensional high speed flows
[AIAA PAPER 91-1573] p 699 A91-40747
GREENBERG, I.
Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41768
Sizing supersonic freejet nozzle and inlet location for simulation of the transition phase in integral rocket ramjet p 763 A91-43084
GREENE, FRANCIS A.
Viscous equilibrium computations using program LAURA
[AIAA PAPER 91-1389] p 717 A91-43452
GREFF, E.
In-flight measurement of static pressures and boundary-layer state with integrated sensors
p 742 A91-43306
GREGG, ROBERT D., III
New airfoil design concept p 716 A91-43307
GREGORY, BRENT A.
Aerodynamic losses due to pressure side coolant ejection in a transonic turbine cascade
[AIAA PAPER 91-2032] p 745 A91-41684
GREY, R. E.
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration
[AIAA PAPER 91-1689] p 748 A91-42556
GRIFFIN, MICHAEL J.
Numerical evaluation of vortex flow control devices
[AIAA PAPER 91-1825] p 713 A91-42612
GRIGOR'EV, S. B.
Optimization of the turbofan engine control program during the cruising flight of subsonic transport aircraft
p 743 A91-41170
GRISMER, MATTHEW J.
Comparisons of numerical and exact solutions for oblique detonations with structure
[AIAA PAPER 91-1677] p 721 A91-43587
GROHSMEYER, STEVEN P.
Numerical investigation of the effect of leading edge geometry on dynamic stall of airfoils
[AIAA PAPER 91-1798] p 712 A91-42597
GROSSMAN, B.
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles
[AIAA PAPER 91-2273] p 760 A91-41741
Transonic flutter analysis of aerodynamic surfaces in the presence of structural nonlinearities
p 713 A91-42710
GUILLEN, PH.
A multidomain Euler code applied to hypersonic flows
[AIAA PAPER 91-1699] p 722 A91-43598
GUPTA, K. K.
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113
GUPTA, S. K.
Flight service evaluation of thermal barrier coatings by physical vapor deposition at 5200 h p 764 A91-41511
GUSEV, IU. M.
An integrated automatic ramjet engine control system tolerant to failures of the functional components
p 780 A91-41163
GUTMARK, E.
Reduced pressure oscillations in a dump combustor with tapered corrugations
[AIAA PAPER 91-2354] p 753 A91-44208

H

HAAS, J. F.
A new vertical shock tube for Rayleigh-Taylor instability measurements p 759 A91-40637
HACHEMIN, J. V.
A multidomain Euler code applied to hypersonic flows
[AIAA PAPER 91-1699] p 722 A91-43598
HADDAD, RAYMOND C.
The impact of LO-configured forebodies on inlet approach flowfields
[AIAA PAPER 91-2599] p 730 A91-44304
HADDER, J. L.
Concepts for reduction of turbine rotor inertia
[AIAA PAPER 91-2031] p 752 A91-44098
HAFEZ, M.
Finite element simulation of compressible flows with shocks
[AIAA PAPER 91-1551] p 767 A91-40725
The effect of artificial vorticity on the discrete solution of Euler equations
[AIAA PAPER 91-1553] p 698 A91-40727
HAGENMAIER, M.
Supersonic viscous flow calculations for axisymmetric, two and three-dimensional configurations
[AIAA PAPER 91-1802] p 725 A91-43649
HALDEMAN, C. W., JR.
Uncertainty analysis of turbine aerodynamic performance measurements in short duration test facilities
[AIAA PAPER 91-2131] p 761 A91-44132
HALL, JEFFERY L.
An experimental investigation of structure, mixing, and combustion in compressible turbulent shear layers
[AD-A235278] p 766 N91-26281
HALL, KENNETH C.
Prediction of unsteady aerodynamic loads in cascades using the linearized Euler equations on deforming grids
[AIAA PAPER 91-3378] p 730 A91-44318

HALL, M. G.
A vertex-centroid scheme for improved finite-volume solution of the Navier-Stokes equations
[AIAA PAPER 91-1540] p 697 A91-40715

HALL, RALPH M.
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046

HALLORAN, SCOTT D.
A numerical study on wind tunnel interference effects in external burning test at M = 1.5
[AIAA PAPER 91-1675] p 749 A91-43585

HALSKI, DONALD J.
Integrated control and avionics for air superiority: A knowledge-based decision aiding system
p 743 N91-25138

HANKEY, W. L.
Combined energy management and calculus of variations approach for optimizing hypersonic vehicle trajectories p 739 A91-42738

HANNA, GREGORY J.
Thermal modeling and analysis of a cryogenic tank design exposed to extreme heating profiles
[AIAA PAPER 91-1383] p 772 A91-43447

HANNIGAN, TODD E.
Wind tunnel results of counter rotation prop-fans designed with lifting line and Euler code methods
[AIAA PAPER 91-2499] p 755 A91-44265

HANSON, R. K.
Planar laser-induced fluorescence imaging of underexpanded free jet flow in a shock tunnel facility
[AIAA PAPER 91-1687] p 761 A91-43592

HANUS, G. J.
Supersonic wind tunnel diffuser performance with high model blockage at moderate to low Reynolds numbers
[AIAA PAPER 91-2274] p 761 A91-44183

HARTMAN, RANDOLPH
Combined satellite navigation systems could lead to more reliable and more precise air navigation
p 736 A91-42780

HASHIMOTO, MASAKATA
A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114

HASHIMOTO, T.
Development of a vitiated air heater for engine test facilities
[AIAA PAPER 91-2501] p 761 A91-41802

HASSOUN, JOHN A.
KC-135 ground collision avoidance system questionnaire
[AD-A234385] p 733 N91-26125
Evaluation of the C/EC/KC-135 Ground Collision Avoidance System (GCAS), study 1
[AD-A235301] p 737 N91-26130

HAYASHI, MASANORI
Surface heat transfer change induced by unsteady shock reflections and numerical simulations on shock reflection
p 695 A91-40647
Detailed measurements on unsteady properties in three-dimensional show wave/turbulent boundary layer interaction induced by blunt fin at Mach number 4
[AIAA PAPER 91-1755] p 723 A91-43629

HEATH, GREGORY
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1906] p 769 A91-41648

HEBBAR, SHESHAGIRI K.
Static and dynamic water tunnel flow visualization studies of a canard-configured X-31A-like fighter aircraft model
[AIAA PAPER 91-1629] p 708 A91-42537

HEFFNER, K. S.
Leading edge effect on rarefied hypersonic flow over a flat plate
[AIAA PAPER 91-1749] p 710 A91-42573

HEIDMANN, JAMES D.
A three-dimensional Navier-Stokes stage analysis of the flow through a compact radial turbine
[AIAA PAPER 91-2564] p 748 A91-41815

HELDT, R. W.
Coordination and synchronization of loran-C and GPS to universal coordinated time
[AD-A233221] p 737 N91-25141

HENNE, PRESTON A.
New airfoil design concept p 716 A91-43307

HERDMAN, T. L.
State space models for aeroelastic and viscoelastic systems
[AD-A234730] p 732 N91-26117

HERTZBERG, A.
Experiments on hypersonic ramjet propulsion cycles using a ram accelerator
[AIAA PAPER 91-2489] p 762 A91-44264

HEWETT, MARLE D.
Autonomous aircraft initiative study
[NASA-CR-186013] p 742 N91-26140

HILLARD, M. E.
Study of cluster formation and its effects on Rayleigh and Raman scattering measurements in a Mach 6 wind tunnel
[AIAA PAPER 91-1496] p 718 A91-43547

HIROSAKI, N.
Spherical particle impact damage behaviour of a SiC fibre-reinforced chemical vapour infiltrated SiC composite p 765 A91-43752

HIROSE, NAOKI
A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114

HO, PENG YIP
Self-propelled slender axisymmetric body flows: Errors in the Poisson equation field calculation
p 731 N91-25110

HO, Y. H.
Computation of unsteady viscous flow using an efficient algorithm
[AIAA PAPER 91-1597] p 701 A91-40770

HOADLEY, A. W.
Failure detection of liquid cooled electronics in sealed packages
[AIAA PAPER 91-1423] p 742 A91-43482

HOBSON, G. V.
Inlet turbulence distortion and viscous flow development in a controlled-diffusion compressor cascade at very high incidence
[AIAA PAPER 91-2004] p 704 A91-41673

HOFF, S. M.
Concepts for reduction of turbine rotor inertia
[AIAA PAPER 91-2031] p 752 A91-44098

HOFFMANN, K. A.
Effect of the grid system on heat transfer computations for high speed flows
[DE91-010874] p 777 N91-25375

HOLDEMAN, J. D.
A CFD study of jet mixing in reduced flow areas for lower combustor emissions
[AIAA PAPER 91-2460] p 747 A91-41788
CFD analysis of jet mixing in low NOx flametube combustors
[NASA-TM-104466] p 756 N91-26146

HOLDEN, M. S.
Studies of shock/shock interaction on smooth and transpiration-cooled hemispherical nosetips in hypersonic flow
[AIAA PAPER 91-1765] p 724 A91-43634

HOLLE, GLENN F.
Simple leakage flow model for brush seals
[AIAA PAPER 91-1913] p 773 A91-44054

HOLMES, DOUGLAS I.
The pilot's associate: Exploiting the intelligent advantage p 781 N91-25122

HOLMES, R.
The effects of bearing misalignment on the non-linear vibration of aero-engine rotor-damper assemblies
p 744 A91-41536

HOLZBAUR, ULRICH D.
Intelligent radar data processing p 770 A91-41849

HONAMI, S.
Aerodynamic characteristics of Mach-3 air-intake tested in supersonic wind tunnel
[AIAA PAPER 91-2011] p 727 A91-44091
Supersonic air-intake study aiming at future airbreathing engine
[AIAA PAPER 91-2012] p 751 A91-44092

HORN, RALF
Experimental X-band synthetic aperture radar in aircraft p 735 A91-41825

HORNE, W. CLIFTON
Aeroacoustic and aerodynamic applications of the theory of nonequilibrium thermodynamics
[NASA-TP-3118] p 776 N91-25352

HOU, GENE W.
Approximate analysis and sensitivity analysis methods for viscous flow involving variation of geometric shape
[AIAA PAPER 91-1569] p 767 A91-40743
An efficient method for estimating neighboring steady-state numerical solutions to the Euler equations
[AIAA PAPER 91-1680] p 722 A91-43589

HOUBOLT, JOHN C.
Manual on the flight of flexible aircraft in turbulence
[AGARD-AG-317] p 758 N91-26150

HOWARD, W. D.
Turbofan engine bird ingestion testing
[AIAA PAPER 91-2380] p 754 A91-44218

HOWE, M. S.
On the estimation of sound produced by complex fluid-structure interactions, with application to a vortex interacting with a shrouded rotor p 784 A91-43514

HOYING, D. A.
Application of sweep to improve efficiency of a transonic fan. II - Performance and laser test results
[AIAA PAPER 91-2544] p 730 A91-44287

HSIEH, T.
Vortical flows about a long cylinder at M = 3.5 and alpha = 18 deg
[AIAA PAPER 91-1808] p 726 A91-43651

HSIEH, W. H.
Theoretical study of supersonic flow separation over a rearward facing step
[AIAA PAPER 91-2161] p 753 A91-44139

HSU, C. A.
High resolution nonoscillatory schemes for unsteady gas dynamics p 702 A91-40795

HSU, YANN-FU
A numerical study on wind tunnel interference effects in external burning test at M = 1.5
[AIAA PAPER 91-1675] p 749 A91-43585

HU, JINMING
Application of shock tunnel at pressure and heat transfer experiments on turbine blade p 760 A91-40649

HUANG, W. C.
Three-dimensional Navier-Stokes calculations using solution-adaptive grids p 703 A91-40802

HUBBARD, DENNIS G.
Observations of supersonic transverse jets
[AIAA PAPER 91-1723] p 772 A91-43613

HUDSON, CAMILLE T.
Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions
[CPIA-PUBL-551] p 775 N91-25336

HUEBNER, LAWRENCE D.
Computational and experimental aftbody flow fields for hypersonic, airbreathing configurations with scramjet exhaust flow simulation
[AIAA PAPER 91-1709] p 709 A91-42561

HUI, W. H.
A new Lagrangian random choice method for steady two-dimensional supersonic/hypersonic flow
[AIAA PAPER 91-1546] p 697 A91-40721

HUME, COLIN
The airline's perception of air traffic management
p 734 A91-41441

HUNG, CHING-MAO
Comment on 'Critique of turbulence models for shock-induced flow separation' p 707 A91-42307
Numerical study of juncture flows
[AIAA PAPER 91-1660] p 720 A91-43575

HUNT, M. L.
Supersonic film cooling effectiveness using air and helium for a range of injectant temperatures and Mach numbers
[AIAA PAPER 91-1416] p 772 A91-43477

HUREAU, J.
A general method for practical conformal mapping of aerodynamic shapes p 715 A91-42902

HUSSAINI, M. Y.
Compressible stability of growing boundary layers using parabolized stability equations
[AIAA PAPER 91-1636] p 720 A91-43564

HUYER, STEPHEN A.
The vortex kinematics associated with an oscillating delta wing
[AIAA PAPER 91-1797] p 712 A91-42596

HWANG, D. P.
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fab simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106

I

IDAN, MOSHE
An identification algorithm based on smoothing
p 782 N91-25642

IEK, C.
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fab simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106

IKAWA, HIDEO
Rapid methodology for design and performance prediction of integrated supersonic combustion ramjet engine p 739 A91-42818

IKEDA, HIDETO
A study of supersonic aerodynamic mixing in the scramjet combustor p 771 A91-43000

IKELS, KENNETH G.
Refurbishing AV-8 on-board oxygen generation system beds
[AD-A235083] p 741 N91-26136

ISHIDA, YOJI
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116

ISHII, H.
A numerical study of surge and rotating stall in axial compressors
[AIAA PAPER 91-1896] p 727 A91-44048
ISHIKAWA, MASAYUKI
A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114
ISLER, N. J.
A Western engine for an Eastern aircraft - Re-engining of CSFR LET 610 turboprop transport with the GE CT7-9
[AIAA PAPER 91-1911] p 744 A91-41652
IWASAKI, AKIHITO
Velocity measurements inside the leading edge vortex formed on a delta wing
[NAL-TR-1087] p 732 N91-25115
IYER, VENKIT
Assessment of meanflow solutions for instability analysis of transitioning flows
[AIAA PAPER 91-1638] p 720 A91-43565
IZADI, M. J.
C.F.D. of the base flow on a plane body between a subsonic flow on one side and a supersonic flow on the other
[AIAA PAPER 91-2372] p 729 A91-44215

J

JACKSON, E. D.
An efficient method in predicting rotor/stator interaction
[AIAA PAPER 91-3380] p 730 A91-44320
JACKSON, RAYMOND H.
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422
JAFROUDI, H.
Asymptotic methods for the prediction of transonic wind tunnel wall interference
[AIAA PAPER 91-1712] p 762 A91-44334
JAMESON, ANTONY
Automatic design of transonic airfoils to reduce the shock induced pressure drag p 716 A91-43078
Airfoils admitting non-unique solutions of the Euler equations
[AIAA PAPER 91-1625] p 719 A91-43557
Time dependent calculations using multigrid, with applications to unsteady flows past airfoils and wings
[AIAA PAPER 91-1596] p 727 A91-43675
JAMIESON, J. B.
Twenty-first century aero-engine design - The environmental factor p 744 A91-41539
JARVAISE, JEANNE M.
VHSIC electronics and the cost of Air Force avionics in the 1990s
[RAND-R-3843-AF] p 743 N91-26143
JARVIS, ROBERT L.
What fuels our future?
[AD-A233674] p 767 N91-26387
JASUJA, A. K.
Visualization of airblast atomized spray structure under varying air pressure conditions
[AIAA PAPER 91-2199] p 769 A91-41726
JENNIONS, IAN K.
A novel implementation of an implicit k-epsilon turbulence model coupled with an explicit Navier-Stokes solver p 703 A91-40796
JENTINK, THOMAS N.
CFD code validation for nozzle flowfields
[AIAA PAPER 91-2565] p 775 A91-44295
JERACKI, R. J.
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fab simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106
JOE, W.
Laminar heat transfer to spherically blunted cones in high enthalpy hyper velocity flows p 695 A91-40646
JOHNSON, J. A.
MACGS - A zonal grid generation system for complex aero-propulsion configurations
[AIAA PAPER 91-2156] p 738 A91-41714
JOHNSON, L. R.
The potential role of maglev in short-haul airline operations
[DE91-010813] p 777 N91-25408
JOHNSON, PAUL D.
Application of an unsteady Navier-Stokes solver to transonic turbine design
[AIAA PAPER 91-2468] p 729 A91-44254
JOHNSTON, R. T.
The vortex interaction in a propeller/stator flow field
[AIAA PAPER 91-1818] p 726 A91-43657
JONES, K. D.
Hypersonic waverider analysis - A comparison of numerical and experimental results
[AIAA PAPER 91-1696] p 739 A91-43596
JONES, R. A.
Experimental investigation of a unique airbreathing pulsed laser propulsion concept
[AIAA PAPER 91-1922] p 751 A91-44059
JONES, STUART C.
An analytical comparison of convective heat transfer correlations in supercritical hydrogen
[AIAA PAPER 91-1382] p 771 A91-43446
JUHANY, K. A.
Supersonic film cooling effectiveness using air and helium for a range of injectant temperatures and Mach numbers
[AIAA PAPER 91-1416] p 772 A91-43477

K

KAMATA, YUKIO
Observation of laminar boundary layer transition on light monoplane wing surface
[NAL-TR-1077] p 777 N91-25366
KAMIYA, NOBUHIKO
Observation of laminar boundary layer transition on light monoplane wing surface
[NAL-TR-1077] p 777 N91-25366
KANAZAWA, ISAO
A numerical analysis of the flow passing through a cascade with tip clearance - Subsonic flow through a linear cascade composed of flat plates p 695 A91-40575
KANDA, HIROSHI
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116
KANDA, TAKESHI
Parametric study of airframe-integrated scramjet cooling requirement p 749 A91-42817
KANDIL, OSAMA A.
Effects of leading-edge flap oscillation on unsteady delta wing flow and rock control
[AIAA PAPER 91-1796] p 725 A91-43647
KANG, SHUN
An application of topological method to analysing the three-dimensional flow in cascades. II - Topological analysis on the vector field patterns of skin-frictions and section streamlines p 694 A91-40569
KANMURI, AKIO
Parametric study of airframe-integrated scramjet cooling requirement p 749 A91-42817
KAPANIA, R. K.
Transonic flutter analysis of aerodynamic surfaces in the presence of structural nonlinearities p 713 A91-42710
KARADIMITRIS, A.
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets p 748 A91-42805
KARAMCHETI, KRISHNAMURTY
Aeroacoustic and aerodynamic applications of the theory of nonequilibrium thermodynamics
[NASA-TP-3118] p 776 N91-25352
KARNI, SMADAR
Accelerated convergence to steady state by gradual far-field damping
[AIAA PAPER 91-1604] p 702 A91-40776
KARNIADAKIS, G.
Three-dimensional jet noise computations
[AIAA PAPER 91-2256] p 784 A91-44174
KASATKIN, M. IU.
Thermodynamic analysis of gas turbine engines and plants at high air pressure levels p 743 A91-41171
KASHIWABARA, Y.
A numerical study of surge and rotating stall in axial compressors
[AIAA PAPER 91-1896] p 727 A91-44048
KATZ, JOSEPH
Unsteady fluid dynamic model for propeller induced flow fields
[AIAA PAPER 91-1664] p 709 A91-42550
KAUS, C.
Concepts for reduction of turbine rotor inertia
[AIAA PAPER 91-2031] p 752 A91-44098
KAUTZ, FREDERICK A., II
Direct simulation of waveriders in hypersonic rarefied flow
[AIAA PAPER 91-1317] p 717 A91-43389
KAWAI, MASAFUMI
A study of supersonic aerodynamic mixing in the scramjet combustor p 771 A91-43000
KEDDY, M.
Heat pipe radiation cooling of advanced hypersonic propulsion system components
[AIAA PAPER 91-2358] p 746 A91-41759
KEITH, B. D.
CFD-based 3D turbofan exhaust nozzle analysis system
[AIAA PAPER 91-2478] p 754 A91-44261
KEMP, JOHN F.
An Omega/VLF radio compass p 734 A91-41437
KENTFIELD, J. A. C.
Performance implications of gas-turbine pressure-gain combustors
[AIAA PAPER 91-1879] p 744 A91-41641
KERN, S.
Numerical investigation of the effects of blowing on high angle of attack flow over delta wings
[AIAA PAPER 91-1809] p 726 A91-43652
KERR, L. J.
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089
KHOSLA, P. K.
Pressure-based flux vector splitting for blunt geometries p 703 A91-40797
Supersonic viscous flow calculations for axisymmetric, two and three-dimensional configurations
[AIAA PAPER 91-1802] p 725 A91-43649
KHRISTICH, V. A.
Characteristics of the working cycle of a low-pressure pneumatic nozzle with a sector structure of the fuel jet p 744 A91-41174
KILLINGSWORTH, PAUL S.
VHSIC electronics and the cost of Air Force avionics in the 1990s
[RAND-R-3843-AF] p 743 N91-26143
KIM, J.-M.
Interaction between a vortex dominated wake and a separated flowfield
[AIAA PAPER 91-1819] p 727 A91-43658
KIM, KI CHUNG
Dynamic analysis of advanced tip rotors including three-dimensional aerodynamics p 731 N91-25111
KING, P. S.
Combined tangential-normal injection into a supersonic flow p 715 A91-42816
KING, RUDOLPH A.
Mach 3.5 boundary-layer transition on a cone at angle of attack
[AIAA PAPER 91-1804] p 725 A91-43650
KINSLER, LES
Detection and avoidance of errors in computer software p 783 N91-25937
KISH, JULES
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1909] p 769 A91-41650
KISLYKH, V. V.
Multi-cascade compression - Effective means to obtain high temperature dense gas in piston gas dynamic units (PGU) p 760 A91-40641
KISS, T.
The effect of square trailing edges on turbine blade performance
[AIAA PAPER 91-2130] p 704 A91-41704
KISS, TIBOR
Aerodynamic losses due to pressure side coolant ejection in a transonic turbine cascade
[AIAA PAPER 91-2032] p 745 A91-41684
KNIGHT, C. J.
Improved turbulence modeling for gas turbine application
[AIAA PAPER 91-2239] p 728 A91-44165
Aerodynamic and heat transfer analysis of the low aspect ratio turbine using a 3D Navier-Stokes code
[AIAA PAPER 91-2240] p 774 A91-44166
KNIGHT, D. D.
Numerical simulation of a three-dimensional shock wave-turbulent boundary layer interaction generated by a sharp fin at Mach 4 p 714 A91-42726
KNIGHT, DOYLE D.
On the quasi-conical flowfield structure of the swept shock wave-turbulent boundary layer interaction
[AIAA PAPER 91-1759] p 724 A91-43632
An experimental/computational study of heat transfer in sharp fin induced turbulent interactions at Mach 5
[AIAA PAPER 91-1764] p 724 A91-43633
KNOWLEN, C.
Experiments on hypersonic ramjet propulsion cycles using a ram accelerator
[AIAA PAPER 91-2489] p 762 A91-44264
KO, WILLIAM L.
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422

KOCHER, JAMES A.
Integrated control and avionics for air superiority: A knowledge-based decision aiding system
p 743 N91-25138

KOFF, S. G.
Application of sweep to improve efficiency of a transonic fan. II - Performance and laser test results
[AIAA PAPER 91-2544] p 730 A91-44287

KOIFMAN, M.
Estimation of aircraft attitude by angular rate measurements p 757 A91-43095

KOMERATH, N. M.
Interaction between a vortex dominated wake and a separated flowfield
[AIAA PAPER 91-1819] p 727 A91-43658

KONTINOS, D. A.
An explicit, rotated upwind algorithm for solution of the Euler/Navier-Stokes equations
[AIAA PAPER 91-1531] p 696 A91-40706

KORIVI, VAMSHI M.
Approximate analysis and sensitivity analysis methods for viscous flow involving variation of geometric shape
[AIAA PAPER 91-1569] p 767 A91-40743
An efficient method for estimating neighboring steady-state numerical solutions to the Euler equations
[AIAA PAPER 91-1680] p 722 A91-43589

KORNECKI, ANDREW
ATC simulators do not have to replicate operational systems physically p 761 A91-42789

KORTE, JOHN J.
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles
[AIAA PAPER 91-2273] p 760 A91-41741

KOUTMOS, P.
Numerical investigation of the flow within a turbofan lobed mixer p 749 A91-42812

KOZHEVNIKOV, IU. V.
Design of a language processor for aviation engine testing p 760 A91-41164

KREPEC, T.
Design optimization of an electronic fuel control unit featuring two digital actuators
[AIAA PAPER 91-2003] p 745 A91-41672

KRISHNAN, M. R.
Design and development of a compact bifurcated turboprop inlet
[AIAA PAPER 91-2017] p 727 A91-44093

KRISPIN, JACOB
Second-order Godunov methods and self-similar steady supersonic three-dimensional flowfields
[AIAA PAPER 91-1653] p 708 A91-42544

KRIST, SHERRIE
Grid convergence for adaptive methods
[AIAA PAPER 91-1592] p 701 A91-40766

KROGSTAD, PER-AGE
Modification of the van Driest damping function to include the effects of surface roughness
p 770 A91-42282

KROLL, N.
Upwind implicit residual smoothing method for multi-stage schemes
[AIAA PAPER 91-1533] p 696 A91-40708

KROTHAPALLI, A.
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821

KROUSE, CHERYL
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100

KUMAR, A.
Effect of nose bluntness on flowfield over slender bodies in hypersonic flows p 707 A91-42256

KUMAR, AJAY
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles
[AIAA PAPER 91-2273] p 760 A91-41741
A numerical study of hypersonic forebody/inlet integration problem p 732 N91-25343

KUNZ, R. F.
Grid generation for three-dimensional turbomachinery geometries including tip clearance
[AIAA PAPER 91-2360] p 753 A91-44209

KUO, CHENG-HSIUNG
Control of vortex structure on a delta wing by small amplitude perturbations of angle-of-attack
p 706 A91-42094

KUO, K. K.
Theoretical study of supersonic flow separation over a rearward facing step
[AIAA PAPER 91-2161] p 753 A91-44139

KURANAGA, SEISHI
Detailed measurements on unsteady properties in three-dimensional show wave/turbulent boundary layer interaction induced by blunt fin at Mach number 4
[AIAA PAPER 91-1755] p 723 A91-43629

KURODA, SHINICHI
Unified zonal method based on the fortified Navier-Stokes concept
[AIAA PAPER 91-1558] p 698 A91-40732
Supersonic inlet flow computations using fortified Navier-Stokes approach
[AIAA PAPER 91-1730] p 710 A91-42567

KUZ'MENKO, V. I.
Characteristics of the working cycle of a low-pressure pneumatic nozzle with a sector structure of the fuel jet
p 744 A91-41174

KWAK, DOCHAN
An implicit three-dimensional Navier-Stokes solver for compressible flow
[AIAA PAPER 91-1555] p 698 A91-40729

KWOK, F. T.
A demonstration of mode transition in a scramjet combustor
[AIAA PAPER 91-2395] p 754 A91-44225

KWON, HUI M.
Static and dynamic water tunnel flow visualization studies of a canard-configured X-31A-like fighter aircraft model
[AIAA PAPER 91-1629] p 708 A91-42537

KWON, O.
Numerical investigation of the effects of blowing on high angle of attack flow over delta wings
[AIAA PAPER 91-1809] p 726 A91-43652

L

LABOZZETTA, W. F.
MACGS - A zonal grid generation system for complex aero-propulsion configurations
[AIAA PAPER 91-2156] p 738 A91-41714

LACEY, D. W.
Some characteristics of and dynamic scaling behavior in strong vortex flows
[AIAA PAPER 91-1821] p 713 A91-42609

LAI, M. C.
CFD analysis of jet mixing in low NOx flametube combustors
[NASA-TM-104466] p 756 N91-26146

LAKSHMINARAYANA, B.
Computation of unsteady viscous flow using an efficient algorithm
[AIAA PAPER 91-1597] p 701 A91-40770
Grid generation for three-dimensional turbomachinery geometries including tip clearance
[AIAA PAPER 91-2360] p 753 A91-44209

LAMBERT, H. H.
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089

LAMBERT, HEATHER H.
A simulation study of turbofan engine deterioration estimation using Kalman filtering techniques
[NASA-TM-104233] p 755 N91-25147

LANDERS, STEPHEN
A parametric study of the leading edge attachment line for the F-16XL
[AIAA PAPER 91-1621] p 718 A91-43555

LANDY, ROBERT J.
Integrated control and avionics for air superiority: A knowledge-based decision aiding system
p 743 N91-25138

LARKIN, M.
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fab simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106

LAWING, PIERCE L.
Comparison of cryogenic wind tunnel, flight, and computational results for a thin, low-aspect-ratio wing
[AIAA PAPER 91-1626] p 708 A91-42536
Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel
[AIAA PAPER 91-1725] p 723 A91-43615

LAWLESS, PATRICK B.
Active unsteady aerodynamic suppression of rotating stall in an incompressible flow centrifugal compressor with vaned diffuser
[AIAA PAPER 91-1898] p 704 A91-41644

LAWRENCE, S. L.
Sensitivity of inlet performance predictions to CFD numerical and physical modeling p 776 N91-25345

LAWRENCE, SCOTT L.
Numerical performance estimates for a generic hypersonic forebody
[AIAA PAPER 91-1695] p 722 A91-43595

LAWRENCE, W. P.
Computer-drawn charts for EROPS flights
p 735 A91-41446

LE, JEANETTE
A simulation evaluation of a four-engine jet transport using engine thrust modulation for flightpath control
[AIAA PAPER 91-2223] p 757 A91-44162

LEAGUE, MARK
Analysis of pressure distribution on hypersonic vehicles with power effects
[AIAA PAPER 91-2491] p 738 A91-41796

LEE, CYNTHIA C.
Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis
[AIAA PAPER 91-1635] p 719 A91-43563

LEE, I.
Static aeroelastic analysis of a three-dimensional oblique wing p 714 A91-42711

LEE, J.
A numerical method for 3D boundary layers with a small crossflow
[AIAA PAPER 91-2473] p 775 A91-44258

LEE, JANG-YEON
A numerical study of the flow establishment time in hypersonic shock tunnels
[AIAA PAPER 91-1706] p 722 A91-43604

LEE, K. D.
Three-dimensional Navier-Stokes calculations using solution-adaptive grids p 703 A91-40802

LEE, R. A.
Prediction of jet mean flow structure in support of HSCT noise suppression concepts
[AIAA PAPER 91-2253] p 774 A91-44171

LEHNIG, T. R.
Inlet/fan cowl design for increased angle-of-attack requirements of transport aircraft - Methodology and test results
[AIAA PAPER 91-2481] p 730 A91-44263

LENGRAND, J. C.
Leading edge effect on rarefied hypersonic flow over a flat plate
[AIAA PAPER 91-1749] p 710 A91-42573

LENSKI, JOSEPH W., JR.
Advanced Rotorcraft Transmission (ART) program-Boeing helicopters status report
[NASA-TM-104474] p 778 N91-25412

LEONARD, CHARLES T.
How failure prediction methodology affects electronic equipment design p 768 A91-40812

LESSARD, V. R.
Periodic blade loads of a high speed propeller at small angle of attack
[AIAA PAPER 91-2250] p 705 A91-41735

LESSARD, VICTOR R.
Multigrid and upwind viscous flow solver on three-dimensional overlapped and embedded grids
p 707 A91-42284

LEVASHOV, P. D.
Using implicit displacement expressions for obtaining a solution in the transition zone of a hybrid computation scheme p 768 A91-41168

LEVCHUK, S. A.
Characteristics of the working cycle of a low-pressure pneumatic nozzle with a sector structure of the fuel jet
p 744 A91-41174

LEVEY, BRIAN S.
Vortex breakdown in a supersonic jet
[AIAA PAPER 91-1815] p 726 A91-43656

LEVY, RALPH
A design strategy for the use of vortex generators to manage inlet-engine distortion using computational fluid dynamics
[AIAA PAPER 91-2474] p 729 A91-44259

LEWIS, MARK J.
Optimized scramjet integration on a waverider
[AIAA PAPER 91-1693] p 739 A91-43594
A numerical study of the flow establishment time in hypersonic shock tunnels
[AIAA PAPER 91-1706] p 722 A91-43604

LEWIS, TOM
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046

LEWIS, W., III
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150

LI, C. P.
Computational aspects of chemically reacting flows
[AIAA PAPER 91-1574] p 699 A91-40748

LI, JINGMEI
Application of shock tunnel at pressure and heat transfer experiments on turbine blade p 760 A91-40649

LI, ZHEN
Synchronization device of digital flight controlling computer and the algorithm for system scheduling
p 742 A91-43508

LIANG, T. E.
Supersonic viscous flow calculations for axisymmetric, two and three-dimensional configurations
[AIAA PAPER 91-1802] p 725 A91-43649
LIAO, JIN-HUA
Correlative behaviours of shock/boundary layer interaction induced by sharp fin and semicone
[AIAA PAPER 91-1756] p 711 A91-42577
LIAW, D. G.
Reliability of initially compressed uncertain laminated plates in supersonic flow p 770 A91-42292
LILLEY, J. S.
The PC as a generic developmental fuel control for expendable turbojet engines
[AIAA PAPER 91-3399] p 755 A91-44329
LIN, HONG-CHIA
Dissipation additions to flux-difference splitting
[AIAA PAPER 91-1544] p 697 A91-40719
LIN, MIKE
Observations of supersonic transverse jets
[AIAA PAPER 91-1723] p 772 A91-43613
LIN, PEI
Numerical investigation on shock wave/boundary-layer interactions in a constant area diffuser at Mach 3
[AIAA PAPER 91-1766] p 724 A91-43635
LIN, WEN H.
Numerical analysis of scramjet flows in a dump combustor
[AIAA PAPER 91-1676] p 749 A91-43586
LIN, YANFANG
A new concept on compressor and turbine for aerospace propulsion
[AIAA PAPER 91-2591] p 755 A91-44303
LINDQUIST, DANA R.
On the validity of linearized unsteady Euler equations with shock capturing
[AIAA PAPER 91-1598] p 702 A91-40771
LIOU, MENG-SING
Generalized conjugate-gradient methods for the Navier-Stokes equations
[AIAA PAPER 91-1556] p 698 A91-40730
Development of a new flux splitting scheme
p 768 A91-40793
LIOU, S.-G.
Interaction between a vortex dominated wake and a separated flowfield
[AIAA PAPER 91-1819] p 727 A91-43658
LISS, A. IU.
A method for calculating the characteristics of a rotor with allowance for shaft vibrations p 768 A91-41155
LIU, DUN C.
A block-structured solution scheme with the multigrid method for three-dimensional inviscid transonic flows
p 706 A91-42096
Multigrid solutions of the three-dimensional grid equations p 706 A91-42098
LIU, WIN G.
An expert system for predicting flutter in turbomachines
[AIAA PAPER 91-2527] p 748 A91-41808
LO, CHING F.
Neural network based expert system for compressor stall monitoring
[AIAA PAPER 91-2500] p 781 A91-44266
LOELLBACH, J. M.
Three-dimensional Navier-Stokes calculations using solution-adaptive grids p 703 A91-40802
LOEWENSTEIN, MAX
Science requirements and feasibility/design studies of a very-high-altitude aircraft for atmospheric research
p 740 N91-25481
LOEWY, R. G.
Unified treatment for dealing with auxiliary conditions in blade dynamics p 770 A91-42294
LOH, C. Y.
A new Lagrangian random choice method for steady two-dimensional supersonic/hypersonic flow
[AIAA PAPER 91-1546] p 697 A91-40721
LORBER, PETER F.
Dynamic stall experiments on a swept three-dimensional wing in compressible flow
[AIAA PAPER 91-1795] p 712 A91-42595
LORENZ, DIETER
Accurate airborne surface temperature measurements with chopper-stabilized radiometers p 742 A91-42142
LOSITSKAIA, M. I.
Nonlinear oscillations of a heavy axisymmetric body in a resistant medium with drag p 784 A91-43169
LOTSOF, J.
Uncertainty analysis of turbine aerodynamic performance measurements in short duration test facilities
[AIAA PAPER 91-2131] p 761 A91-44132
LOWSON, MARTIN V.
Visualization measurements of vortex flows
p 716 A91-43309
LU, FRANK K.
The peak surface pressure in fin-generated shock-wave boundary-layer interactions p 696 A91-40672
LUKACHEV, S. V.
Release of benz(a)pyrene with the exhaust gases of gas turbine engines burning natural gas
p 764 A91-41173
LUNTZ, A. L.
Euler solver for arbitrary configurations - Further applications p 716 A91-43100
LUO, JIAQUAN
A study on the stiffness simulation calculation method of flutter models of after body and horizontal tail of a new type aeroplane p 739 A91-43511
LUONG, PHU V.
Adaptive EAGLE - Solution-adaptive and quality-enhancing multi-block grids for arbitrary domains
[AIAA PAPER 91-1593] p 701 A91-40767
LUSEBRINK, HELMUT
Gust design procedures p 759 N91-26155
LUTTGES, MARVIN W.
The vortex kinematics associated with an oscillating delta wing
[AIAA PAPER 91-1797] p 712 A91-42596
Flow field structure and development near the root of a straight wing pitching at constant rate
[AIAA PAPER 91-1793] p 725 A91-43646
LUTTON, MARK J.
Hopf bifurcation in viscous flows about airfoils at low speeds
[AIAA PAPER 91-1807] p 712 A91-42603
LUX, DAVID P.
Science requirements and feasibility/design studies of a very-high-altitude aircraft for atmospheric research
p 740 N91-25481
LYONS, P. W.
Experimental investigation of a unique airbreathing pulsed laser propulsion concept
[AIAA PAPER 91-1922] p 751 A91-44059

M

MABEY, D. G.
Effect of model cooling on periodic transonic flow
[AIAA PAPER 91-1714] p 709 A91-42562
MACARTHUR, C. D.
Uncertainty analysis of turbine aerodynamic performance measurements in short duration test facilities
[AIAA PAPER 91-2131] p 761 A91-44132
MACKALL, DALE A.
A knowledge-based system design/information tool for aircraft flight control systems p 757 N91-25139
MACLEOD, J. D.
Computer modelling of implanted component faults in a gas turbine engine
[AIAA PAPER 91-1912] p 750 A91-44053
MADAVAN, NATERI K.
Application of an unsteady Navier-Stokes solver to transonic turbine design
[AIAA PAPER 91-2468] p 729 A91-44254
MADSON, M.
Potential flow applications to complex configurations
[AIAA PAPER 91-1634] p 719 A91-43562
MAJESKI, J. A.
Development of IR sensor window cooling requirements for endoatmospheric interceptors
[AIAA PAPER 91-1439] p 764 A91-44338
MAKSYMIUK, C. M.
Surface reconstruction from scattered data through pruning of unstructured grids
[AIAA PAPER 91-1584] p 700 A91-40758
MALAEK, SEYYED MOHAMMAD B.
Development of a system of interactive computer programs for airplane conceptual design and advanced airplane analysis p 740 N91-25144
MALHERBE, J. A. G.
Reduction of the RCS of the leading edge of a conducting wing-shaped structure by means of lossless dielectric material p 770 A91-42241
MALIK, M. R.
Waves produced from a harmonic point source in a supersonic boundary layer
[AIAA PAPER 91-1646] p 720 A91-43571
MALIK, MUJEEB R.
Compressible stability of growing boundary layers using parabolized stability equations
[AIAA PAPER 91-1636] p 720 A91-43564
MALL, S.
Failure analysis and damage initiation in carbon-carbon composite materials under three-point bending
p 764 A91-41569
MALMUTH, N. D.
Asymptotic methods for the prediction of transonic wind tunnel wall interference
[AIAA PAPER 91-1712] p 762 A91-44334
MANKA, C.
Experimental investigation of a unique airbreathing pulsed laser propulsion concept
[AIAA PAPER 91-1922] p 751 A91-44059
MANZ, WOLFGANG
Determination of orientation accuracy in curved flight paths p 736 A91-41835
MARCHIONNA, N.
Computations of three-dimensional gas turbine combustor flows
[AIAA PAPER 91-2076] p 773 A91-44116
MARESCA, C.
Investigation of the tip shape influence on the flowfield around hovering rotor blades
[AIAA PAPER 91-1754] p 711 A91-42576
MARINI, MARCO
LU implicit TVD scheme for the solution of viscous two dimensional high speed flows
[AIAA PAPER 91-1573] p 699 A91-40747
MARK, H.
Heat management concepts for hypersonic propulsion systems
[AIAA PAPER 91-2493] p 769 A91-41798
MARTIN, R. A.
Heat pipe radiation cooling of advanced hypersonic propulsion system components
[AIAA PAPER 91-2358] p 746 A91-41759
MARY, F.
Technical evaluation report on the flight mechanics panel symposium on progress in military airlift
[AGARD-AR-300] p 733 N91-25119
MASUYA, GORO
Parametric study of airframe-integrated scramjet cooling requirement p 749 A91-42817
MATHEW, M. B.
Unified treatment for dealing with auxiliary conditions in blade dynamics p 770 A91-42294
MATSON, ROBERT E.
The importance of maintainability and reliability in the design process - An airline perspective
[AIAA PAPER 91-2374] p 693 A91-41765
MATSUO, YUICHI
Computations of three-dimensional viscous flows in turbomachinery cascades
[AIAA PAPER 91-2237] p 728 A91-44164
MATTERN, DUANE
Feedback linearization for control of air breathing engines
[AIAA PAPER 91-2000] p 745 A91-41671
MATTES, L. A.
A demonstration of mode transition in a scramjet combustor
[AIAA PAPER 91-2395] p 754 A91-44225
MATTHEWS, R. K.
Aerothermal test methodology for the development of structural components for hypersonic vehicles
[AIAA PAPER 91-1441] p 764 A91-43498
MAURICE, MARK S.
Laser velocimetry measurements of supersonic vortex flows on a simple razor-edged delta wing
[AIAA PAPER 91-1684] p 709 A91-42553
MAVRIPLIS, CATHERINE
Low-dimensional description of the dynamics in separated flow past thick airfoils
[AIAA PAPER 91-1622] p 707 A91-42534
MAVRIPLIS, DIMITRI J.
Implicit solvers for unstructured meshes
[AIAA PAPER 91-1537] p 696 A91-40712
MAY, A. P. H.
Condition monitoring of aircraft high lift systems
p 738 A91-41535
MAYS, R. B.
Mixing studies of helium in air at Mach 6
[AIAA PAPER 91-2268] p 705 A91-41739
MCAMIS, R. W.
Aerodynamic free-jet nozzle performance augmentation using an exhaust diffuser
[AIAA PAPER 91-2270] p 705 A91-41740
MCCLENEGHAN, SCOTT R.
Aircraft gas turbine performance for the year 2000
[AIAA PAPER 91-2233] p 746 A91-41733
MCCLINTON, C. R.
Analysis of losses in supersonic mixing and reacting flows
[AIAA PAPER 91-2266] p 774 A91-44180
MCCUNE, J. E.
Calculated aerodynamics of wings in severe maneuver
[AD-A235241] p 732 N91-26120
MCDONELL, V. G.
Dynamics of discrete phase in a gas turbine co-axial, counter-swirling, combustor dome swirl cup
[AIAA PAPER 91-2353] p 746 A91-41758

MCDONOUGH, J. M.
Performance comparisons of Navier-Stokes codes for simulating three-dimensional hypersonic crossflow/jet interaction
[AIAA PAPER 91-2096] p 728 A91-44127

MCGREEVY, MICHAEL WALLACE
Format and basic geometry of a perspective display of air traffic for the cockpit
[NASA-TM-86680] p 743 N91-26142

MCGUIRK, J. J.
Numerical investigation of the flow within a turbofan lobed mixer p 749 A91-42812

MCLACHLAN, R.
Asymptotic methods for the prediction of transonic wind tunnel wall interference
[AIAA PAPER 91-1712] p 762 A91-44334

MCLAUGHLIN, P. W.
An approach to modeling continuous turbine engine operation from startup to shutdown
[AIAA PAPER 91-2373] p 747 A91-41764

MCMILLIN, B. K.
Planar laser-induced fluorescence imaging of underexpanded free jet flow in a shock tunnel facility
[AIAA PAPER 91-1687] p 761 A91-43592

MCRAE, D. S.
An explicit, rotated upwind algorithm for solution of the Euler/Navier-Stokes equations
[AIAA PAPER 91-1531] p 696 A91-40706

MEEKCOMS, K. J.
The origins and evolution of design requirements for British military aircraft p 785 A91-41541

MENDILLO, J.
Computations of three-dimensional gas turbine combustor flows
[AIAA PAPER 91-2076] p 773 A91-44116

MENKER, LAVERN J.
Results of the aeronautical systems division critical process team on integrated product development
[AD-A235419] p 785 N91-26995

MENON, S.
Mixing enhancement in compressible mixing layers - An experimental study
[AIAA PAPER 91-1721] p 723 A91-43612

MERCIER, P.
A new vertical shock tube for Rayleigh-Taylor instability measurements p 759 A91-40637

MEREDITH, P. T.
Areas for future CFD development as illustrated by transport aircraft applications
[AIAA PAPER 91-1527] p 696 A91-40703

MERHAV, S. J.
Estimation of aircraft attitude by angular rate measurements p 757 A91-43095

MERRIAM, M. L.
Surface reconstruction from scattered data through pruning of unstructured grids
[AIAA PAPER 91-1584] p 700 A91-40758

MERRIGAN, M. A.
Heat pipe radiation cooling of advanced hypersonic propulsion system components
[AIAA PAPER 91-2358] p 746 A91-41759

MEYER, A. G.
Composite gearboxes, designing for the 90's
[AIAA PAPER 91-1910] p 769 A91-41651

MEYER, B. E.
Scale model test results of several STOVL ventral nozzle concepts
[AIAA PAPER 91-2134] p 752 A91-44134

MICHAL, T.
Hodograph solution for compressible flow past a corner and comparison with Euler numerical predictions
[AIAA PAPER 91-1547] p 697 A91-40722

MICKLOW, GERALD J.
Effects of nozzle lip geometry on spray atomization and emissions advanced gas turbine combustors
[AIAA PAPER 91-2201] p 753 A91-44153

MIETRACH, DIETMAR
AGARD handbook on advanced casting
[AGARD-AG-299] p 775 N91-25302

MIKKELSEN, K. L.
Supersonic wind tunnel diffuser performance with high model blockage at moderate to low Reynolds numbers
[AIAA PAPER 91-2274] p 761 A91-44183

MILHOLEN, WILLIAM E., II
Comparison of cryogenic wind tunnel, flight, and computational results for a thin, low-aspect-ratio wing
[AIAA PAPER 91-1626] p 708 A91-42536
Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel
[AIAA PAPER 91-1725] p 723 A91-43615

MILLER, D. P.
The design/analysis of flows through turbomachinery: A viscous/inviscid approach
[NASA-TM-104447] p 755 N91-25148

MILTON, JAMES E.
Vortical flow solutions using a time-lagged, thin-layer, Navier-Stokes algorithm p 707 A91-42279

MINSTER, T.
Prediffuser-combustor model studies under conditions of water ingestion in engines
[AIAA PAPER 91-1965] p 751 A91-44077

MINUCCI, M. A. S.
An investigation of hypersonic shock tunnel testing at an equilibrium interface condition of 4100 K - Theory and experiment
[AIAA PAPER 91-1707] p 761 A91-42560

MITCHELL, STEPHEN C.
Advanced technology engine casing designs
[AIAA PAPER 91-1893] p 750 A91-44046

MIURA, H.
Static aeroelastic analysis of a three-dimensional oblique wing p 714 A91-42711

MOHIN, W. B.
Coordination and synchronization of loran-C and GPS to universal coordinated time
[AD-A233221] p 737 N91-25141

MOIN, PARVIZ
Direct numerical simulation of transition and turbulence in a spatially evolving boundary layer
[AIAA PAPER 91-1607] p 702 A91-40779

MOLCHANOVA, M. I.
Combined cycle aircraft engines
[AIAA PAPER 91-2377] p 754 A91-44217

MONGIA, H. C.
Model for airblast atomization p 771 A91-42801
Three-dimensional analysis of gas turbine combustors p 749 A91-42819
Low NOx rich-lean combustion concept application
[AIAA PAPER 91-1962] p 751 A91-44075

MONK, HELEN
Airport capacity and delay analyses
[DOT/FAA/CT-TN91/18] p 762 N91-25152

MOORE, DOUG
Fuzzy logic for control of roll and moment for a flexible wing aircraft p 757 A91-43932

MORANDI, S. L.
A Western engine for an Eastern aircraft - Re-engining of CSFR LET 610 turboprop transport with the GE CT7-9
[AIAA PAPER 91-1911] p 744 A91-41652

MOREIRA, ALBERTO
Concept and results of the Azimuth Quick-Look Processor for aircraft SAR of the DLR p 735 A91-41828

MORILLON, D.
SEAN: A navigation aid expert system for combat aircraft p 737 N91-25137

MORINISHI, KOJI
Multigrid solution of hypersonic flows using rational Runge-Kutta scheme
[AIAA PAPER 91-1703] p 722 A91-43602

MORRIS, H. W.
Development of IR sensor window cooling requirements for endoatmospheric interceptors
[AIAA PAPER 91-1439] p 764 A91-44338

MORRISON, W. R. B.
New generation of free-piston shock tunnels p 760 A91-40640

MOSCHETTI, KEVIN G.
Navier-Stokes calculations for attached and separated flows using different turbulence models
[AIAA PAPER 91-1791] p 712 A91-42594

MOSES, H. L.
The effect of square trailing edges on turbine blade performance
[AIAA PAPER 91-2130] p 704 A91-41704

MOSES, HAL L.
Aerodynamic losses due to pressure side coolant ejection in a transonic turbine cascade
[AIAA PAPER 91-2032] p 745 A91-41684

MOSS, JAMES N.
Hypersonic rarefied flow about a compression corner - DSMC simulation and experiment
[AIAA PAPER 91-1313] p 716 A91-43385
Hypersonic rarefied flow about a delta wing - Direct simulation and comparison with experiment
[AIAA PAPER 91-1315] p 716 A91-43387

MOSTAFA, A.
Computations of three-dimensional gas turbine combustor flows
[AIAA PAPER 91-2076] p 773 A91-44116

MOUNTS, JON S.
Vortical flow solutions using a time-lagged, thin-layer, Navier-Stokes algorithm p 707 A91-42279
Flowfield analysis of a backswept centrifugal impeller
[AIAA PAPER 91-2470] p 774 A91-44255

MOUSSA, N. A.
Hot-surface ignition and fire-suppression tests in an aircraft engine bay
[AIAA PAPER 91-2382] p 754 A91-44219

MUDRY, M.
A general method for practical conformal mapping of aerodynamic shapes p 715 A91-42902

MUELLER, ANDREAS
A knowledge-based tracker for aircraft formations p 736 A91-41851

MUELLER, RICHARD N.
Thermostructural concepts for hypervelocity vehicles p 764 A91-43311

MURAKAMI, A.
Aerodynamic characteristics of Mach-3 air-intake tested in supersonic wind tunnel
[AIAA PAPER 91-2011] p 727 A91-44091

MURMAN, E. M.
Computation and visualization of leading edge vortex flows p 714 A91-42721

MURROW, HAROLD N.
Measurement of atmospheric turbulence p 780 N91-26151

MURTHY, DURBHA V.
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319

MURTHY, S. N. B.
Transient performance of fan engine with water ingestion
[AIAA PAPER 91-1897] p 750 A91-44049
Prediffuser-combustor model studies under conditions of water ingestion in engines
[AIAA PAPER 91-1965] p 751 A91-44077

MYRABO, L. N.
Experimental investigation of a unique airbreathing pulsed laser propulsion concept
[AIAA PAPER 91-1922] p 751 A91-44059

N

NACHSHON, A.
Euler solver for arbitrary configurations - Further applications p 716 A91-43100

NAGAMATSU, H. T.
An investigation of hypersonic shock tunnel testing at an equilibrium interface condition of 4100 K - Theory and experiment
[AIAA PAPER 91-1707] p 761 A91-42560
Experimental investigation of a unique airbreathing pulsed laser propulsion concept
[AIAA PAPER 91-1922] p 751 A91-44059

NAGEL, DIETER
Estimating the period length of periodic signals p 770 A91-41846

NAGESWARA RAO, B.
Post-critical behaviour of a uniform cantilever column subjected to a tip concentrated subtangential follower force with small damping p 768 A91-41584

NALLASAMY, N.
Large-scale advanced propeller blade pressure distributions - Prediction and data p 715 A91-42820

NARAIN, J. P.
High angle of attack aerodynamics of a glide vehicle
[AIAA PAPER 91-1813] p 726 A91-43654

NARAYANAN, MADHAVAN
A numerical study of compressible viscous flow in a novel exhaust system
[AIAA PAPER 91-1728] p 723 A91-43617

NARRAMORE, JIM C.
Navier-Stokes correlation of a swept helicopter rotor tip at high alpha
[AIAA PAPER 91-1752] p 711 A91-42574

NATUSHKIN, V. F.
A chart of unstable aircraft motions due to cross constraints of various origins p 756 A91-41156

NEIR, R.
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126

NEJAD, A. S.
Experimental and computational investigation of isothermal swirling flow in an axisymmetric dump combustor p 749 A91-42806

NELIUS, ANDREW E.
Guide to measurement of winds with instrumented aircraft
[NASA-CR-188601] p 780 N91-25553

NETZER, AMNON
Burning and flameholding characteristics of a miniature solid fuel ramjet combustor p 749 A91-42807

NETZER, D.
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets p 748 A91-42805

NEWMAN, D. A.
The design and commissioning of an acoustic liner for propeller noise testing in the ARA transonic wind tunnel p 783 A91-41540

NG, WING-FAI
Generalized conjugate-gradient methods for the Navier-Stokes equations
[AIAA PAPER 91-1556] p 698 A91-40730
NGUYEN, CHIEN
C-130 Automated Digital Data System (CADDS)
p 780 N91-25482
NGUYEN, H. L.
Effects of nozzle lip geometry on spray atomization and emissions advanced gas turbine combustors
[AIAA PAPER 91-2201] p 753 A91-44153
NGUYEN, KHANH
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
NI, R. H.
Unsteady hot streak simulation through a 1-1/2 stage turbine engine
[AIAA PAPER 91-3382] p 775 A91-44321
NICHOL, K. L.
New capabilities for aeromechanical testing and evaluation of aircraft turbine engines
[AIAA PAPER 91-2498] p 747 A91-41801
NICOLL, A. R.
The wear mechanisms occurring in abradable seals of gas turbines p 768 A91-41508
NIETO, J. L.
A general method for practical conformal mapping of aerodynamic shapes p 715 A91-42902
NISHIWAKI, HIDEO
The reduction of cavity noise at subsonic speeds
[NAL-TR-1081] p 784 N91-25815
NISHRI, BOAZ
The delay of turbulent boundary layer separation by oscillatory active control
[ITN-91-85104] p 779 N91-26482
NIXON, D.
Application of indicial theory to the prediction of unsteady separation
[AIAA PAPER 91-1742] p 710 A91-42572
NOEL, B. W.
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150
NONAKA, OSAMU
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116
NONWEILER, T. R. F.
Intakes and boundary layer crossflows for hypersonic vehicles
[AIAA PAPER 91-2160] p 728 A91-44138
NOOR, AHMED K.
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NORTHAM, G. B.
Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41768
Instantaneous planar visualization of reacting supersonic flows using silane seeding
[AIAA PAPER 91-1690] p 772 A91-43593
NOWACK, MARK L.
A look at digital nose wheel steering
[AD-A233944] p 741 N91-26131
NOWAK, R. J.
Studies of shock/shock interaction on smooth and transpiration-cooled hemispherical nosetips in hypersonic flow
[AIAA PAPER 91-1765] p 724 A91-43634
NOZAKI, OSAMU
A numerical analysis of the flow passing through a cascade with tip clearance - Subsonic flow through a linear cascade composed of flat plates p 695 A91-40575

O

O'CALLAHAN, J. A.
A comparison of implicit multigrid Euler solvers implemented on a multiprocessor computer
[AIAA PAPER 91-1580] p 700 A91-40754
O'CONNOR, GEORGE M.
Numerical investigation on shock wave/boundary-layer interactions in a constant area diffuser at Mach 3
[AIAA PAPER 91-1766] p 724 A91-43635
O'NEILL, MARY K. L.
Optimized scramjet integration on a waverider
[AIAA PAPER 91-1693] p 739 A91-43594
OBARA, CLIFFORD J.
Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis
[AIAA PAPER 91-1635] p 719 A91-43563
OBAYASHI, SHIGERU
Higher order accuracy for upwind methods by using the compatibility equations
[AIAA PAPER 91-1543] p 697 A91-40718
ODEN, J. T.
A Runge-Kutta discontinuous finite element method for high speed flows
[AIAA PAPER 91-1575] p 699 A91-40749
OGASAWARA, T.
Spherical particle impact damage behaviour of a SiC fibre-reinforced chemical vapour infiltrated SiC composite p 765 A91-43752
OHMORI, YASUNORI
A study of supersonic aerodynamic mixing in the scramjet combustor p 771 A91-43000
OHNUKI, TAKESHI
A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114
Observation of laminar boundary layer transition on light monoplane wing surface
[NAL-TR-1077] p 777 N91-25366
OLSEN, R. B.
Comparison of aircraft synthetic aperture radar and buoy spectra during the Norwegian Continental Shelf Experiment of 1988 p 779 A91-42224
OLSTAD, S. J.
Supersonic wind tunnel diffuser performance with high model blockage at moderate to low Reynolds numbers
[AIAA PAPER 91-2274] p 761 A91-44183
ONG, C. L.
Repair of F-104 aircraft nosedome by composite patching p 693 A91-43009
ONKEN, R.
Knowledge-based cockpit assistant for IFR operations
p 736 N91-25125
ORSZAG, S.
Three-dimensional jet noise computations
[AIAA PAPER 91-2256] p 784 A91-44174
OSWALD, FRED B.
Acoustical analysis of gear housing vibration
[NASA-TM-103691] p 777 N91-25411
OWENS, JAY
Applied high-speed imaging for the icing research program at NASA Lewis Research Center
[NASA-TM-104415] p 779 N91-26490

P

PAGAN, G.
Intakes and boundary layer crossflows for hypersonic vehicles
[AIAA PAPER 91-2160] p 728 A91-44138
PAIGE, TERRY S.
Guide to measurement of winds with instrumented aircraft
[NASA-CR-188601] p 780 N91-25553
PALKA, EDWARD
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100
PALMER, J. L.
Planar laser-induced fluorescence imaging of underexpanded free jet flow in a shock tunnel facility
[AIAA PAPER 91-1687] p 761 A91-43592
PAN, JIAZHENG
An approach to aerodynamic characteristics of low radar cross-section fuselages p 718 A91-43501
PAPADAKIS, MICHAEL
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies
p 771 A91-43310
PAPAMOSCHOU, DIMITRI
Observations of supersonic transverse jets
[AIAA PAPER 91-1723] p 772 A91-43613
PARKER, SID
Propulsion systems for upgrades of current fighter aircraft
[AIAA PAPER 91-2026] p 752 A91-44095
PARKS, STEVEN J.
Collar grids for intersecting geometric components within the Chimera overlapped grid scheme
[AIAA PAPER 91-1587] p 700 A91-40761
PARPIA, IJAZ H.
Grid restructuring for moving boundaries
[AIAA PAPER 91-1589] p 700 A91-40763
PASHKOV, A. V.
A chart of unstable aircraft motions due to cross constraints of various origins p 756 A91-41156
PAYNTER, G. C.
A numerical method for 3D boundary layers with a small crossflow
[AIAA PAPER 91-2473] p 775 A91-44258
PEACE, A. J.
Turbulent flow predictions for afterbody/nozzle geometries including base effects p 715 A91-42813
PECHT, MICHAEL
How failure prediction methodology affects electronic equipment design p 768 A91-40812
PECK, WALTER
Effect of shock waves upon seat mounted sensors in escape systems p 738 A91-41543
PENG, ZEYAN
A new concept on compressor and turbine for aerospace propulsion
[AIAA PAPER 91-2591] p 755 A91-44303
PENGELLY, S. L.
The PC as a generic developmental fuel control for expendable turbojet engines
[AIAA PAPER 91-3399] p 755 A91-44329
PERRY, BOYD, III
Calculating time-correlated gust loads using matched filter and random process theories p 739 A91-43312
PESETSKY, D. S.
High speed rotorcraft propulsion system studies
[AIAA PAPER 91-2150] p 752 A91-44135
PETLEY, DENNIS H.
An analytical comparison of convective heat transfer correlations in supercritical hydrogen
[AIAA PAPER 91-1382] p 771 A91-43446
PFAFFENBERGER, E. E.
Design of the high reliability GMA 2100 reduction gearbox
[AIAA PAPER 91-1905] p 768 A91-41647
PFENNINGER, W.
Opportunities for applications of natural laminar flow technology at high-subsonic speeds
[AIAA PAPER 91-1773] p 724 A91-43638
PHILLIPS, STEPHEN
Feedback linearization for control of air breathing engines
[AIAA PAPER 91-2000] p 745 A91-41671
PHILLIPS, W. P.
Super/hypersonic aerodynamic characteristics for a transatmospheric vehicle concept having a minimum drag forebody
[AIAA PAPER 91-1694] p 709 A91-42558
PIELLISCH, RICHARD J.
Composites move into jet engine design
p 755 A91-44339
PIERRE, CHRISTOPHE
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319
PIKE, J.
Intakes and boundary layer crossflows for hypersonic vehicles
[AIAA PAPER 91-2160] p 728 A91-44138
PILIUGIN, N. N.
Pareto-optimal shapes of axisymmetric bodies moving at high supersonic velocities p 707 A91-42330
PISTORIUS, C. W. I.
Reduction of the RCS of the leading edge of a conducting wing-shaped structure by means of lossless dielectric material p 770 A91-42241
PLATZER, MAX F.
Static and dynamic water tunnel flow visualization studies of a canard-configured X-31A-like fighter aircraft model
[AIAA PAPER 91-1629] p 708 A91-42537
Numerical investigation of the effect of leading edge geometry on dynamic stall of airfoils
[AIAA PAPER 91-1798] p 712 A91-42597
PLETCHER, R. H.
Jet-wake thermal characteristics of heated turbulent jets in crossflow p 770 A91-42258
POINTKOWSKI, JOSEPH
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100
POLIAEV, V. M.
Limiting thermal loads in porous structures
p 768 A91-41159
PONOMAREV, A. T.
Determination of the stress-strain state of a soft lifting system p 704 A91-41320
PORTER, A. J.
Failure detection of liquid cooled electronics in sealed packages
[AIAA PAPER 91-1423] p 742 A91-43482
POTOTZKY, ANTHONY S.
Calculating time-correlated gust loads using matched filter and random process theories p 739 A91-43312
POWELL, D. L.
A new threat detection criterion for airborne collision avoidance systems p 735 A91-41447

POWELL, KENNETH G.
An adaptively-refined Cartesian mesh solver for the Euler equations
[AIAA PAPER 91-1542] p 697 A91-40717
POWERS, JOSEPH M.
Comparisons of numerical and exact solutions for oblique detonations with structure
[AIAA PAPER 91-1677] p 721 A91-43587
PRATT, D. T.
Combusting flow simulations of detonation and shock-induced combustion waves for ram accelerator configurations with viscous effect
[AIAA PAPER 91-1674] p 721 A91-43584
PRATT, N. H.
An experimental evaluation of thermochromic liquid crystals for surface temperature and heat flux measurements in shock tube flows p 767 A91-40645
PRESZ, WALTER M., JR.
Mixer/ejector noise suppressors
[AIAA PAPER 91-2243] p 753 A91-44169
PRICE, JOSEPH M.
Hypersonic rarefied flow about a compression corner - DSMC simulation and experiment
[AIAA PAPER 91-1313] p 716 A91-43385
PRIDDIN, C. H.
Numerical investigation of the flow within a turbofan lobed mixer p 749 A91-42812
PRUITT, M. O.
Forming of aluminum-lithium sheet for fighter aircraft applications p 765 A91-43913
PRUNTY, JACK
Thermostructural concepts for hypervelocity vehicles
p 764 A91-43311
PUNDHIR, D. S.
A study of aeroacoustic performance of a contra-rotating axial flow compressor stage p 706 A91-42248
PUR, RICHARD A.
Guidelines for design, construction, and evaluation of airport pavement drainage
[DOT/FAA/RD-90/31] p 763 N91-26161
PURAM, CHITH K.
Chine forebody vortex manipulation by mechanical and pneumatic techniques on a delta wing configuration
[AIAA PAPER 91-1812] p 713 A91-42605

Q

QIU, BAIGUANG
Synchronization device of digital flight controlling computer and the algorithm for system scheduling
p 742 A91-43508

R

RABE, D. C.
Application of sweep to improve efficiency of a transonic fan. II - Performance and laser test results
[AIAA PAPER 91-2544] p 730 A91-44287
RADCHENKO, A. V.
Determination of the stress-strain state of a soft lifting system p 704 A91-41320
RADESPIEL, R.
Upwind implicit residual smoothing method for multi-stage schemes
[AIAA PAPER 91-1533] p 696 A91-40708
Transition predictions using Reynolds-averaged Navier-Stokes and linear stability analysis methods
[AIAA PAPER 91-1641] p 720 A91-43567
RAFFIN, M.
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124
RAGHUNATHAN, S.
Effect of model cooling on periodic transonic flow
[AIAA PAPER 91-1714] p 709 A91-42562
RAHM, S. G.
Inlet/fan cowl design for increased angle-of-attack requirements of transport aircraft - Methodology and test results
[AIAA PAPER 91-2481] p 730 A91-44263
RAI, MAN M.
Direct numerical simulation of transition and turbulence in a spatially evolving boundary layer
[AIAA PAPER 91-1607] p 702 A91-40779
RAMAPRIAN, B. R.
LDV measurements in the roll-up region of the tip vortex from a rectangular wing
[AIAA PAPER 91-1685] p 709 A91-42554
RAMM, M. S.
Wave processes occurring in supersonic motion of blunted body through dust layer p 695 A91-40656
RAMSEY, JOHN K.
Influence of thickness and camber on the aeroelastic stability of supersonic throughflow fans
p 715 A91-42814
RANGWALLA, AKIL A.
Application of an unsteady Navier-Stokes solver to transonic turbine design
[AIAA PAPER 91-2468] p 729 A91-44254
RAO, DHANVADA M.
Chine forebody vortex manipulation by mechanical and pneumatic techniques on a delta wing configuration
[AIAA PAPER 91-1812] p 713 A91-42605
RAO, G. V. R.
Numerical investigation on shock wave/boundary-layer interactions in a constant area diffuser at Mach 3
[AIAA PAPER 91-1766] p 724 A91-43635
RATCLIFFE, S.
Alternative strategies for traffic flow-management in Europe p 734 A91-41442
RATZER, GERALD F. G.
Visual systems for ATC training p 761 A91-42792
RAULT, D. F. G.
An efficient DSMC algorithm applied to a delta wing
[AIAA PAPER 91-1316] p 717 A91-43388
RAWLINSON, E. G.
Development of IR sensor window cooling requirements for endoatmospheric interceptors
[AIAA PAPER 91-1439] p 764 A91-44338
RE, R. J.
Scale model test results of several STOVL ventral nozzle concepts
[AIAA PAPER 91-2134] p 752 A91-44134
REBER, R.
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126
REDDY, D. R.
3-D Navier-Stokes analysis of crossing, glancing shocks/turbulent boundary layer interactions
[AIAA PAPER 91-1758] p 723 A91-43631
The design/analysis of flows through turbomachinery: A viscous/inviscid approach
[NASA-TM-104447] p 755 N91-25148
REED, R. DALE
Science requirements and feasibility/design studies of a very-high-altitude aircraft for atmospheric research
p 740 N91-25481
REEDER, M. F.
Supersonic jet mixing enhancement by vortex generators
[AIAA PAPER 91-2263] p 705 A91-41738
REISENTHEL, P.
Application of indicial theory to the prediction of unsteady separation
[AIAA PAPER 91-1742] p 710 A91-42572
REN, ZHONGSHU
Titanium alloy integrated centrifugal impeller 5 coordinate computer assisted manufacturing technology
[AD-A234797] p 766 N91-26300
RETELLE, JOHN P., JR.
The pilot's associate: Exploiting the intelligent advantage p 781 N91-25122
REYHNER, T. A.
A numerical method for 3D boundary layers with a small crossflow
[AIAA PAPER 91-2473] p 775 A91-44258
RIGGINS, D. W.
Analysis of losses in supersonic mixing and reacting flows
[AIAA PAPER 91-2266] p 774 A91-44180
RINOIE, KENICHI
Velocity measurements inside the leading edge vortex formed on a delta wing
[NAL-TR-1087] p 732 N91-25115
RIZK, N. K.
Model for airblast atomization p 771 A91-42801
Three-dimensional analysis of gas turbine combustors
p 749 A91-42819
Low NOx rich-lean combustion concept application
[AIAA PAPER 91-1962] p 751 A91-44075
RIZZI, ARTHUR
Navier-Stokes computations of hypersonic flow past a blunt edge delta wing at several angles of attack
[AIAA PAPER 91-1698] p 709 A91-42559
ROAN, V. P.
An ejector performance correlation factor
[AIAA PAPER 91-2545] p 748 A91-41810
ROBERTS, ANDREW C.
Flight test and numerical simulation of transonic flow around YAV-8B Harrier II wing
[AIAA PAPER 91-1628] p 719 A91-43559
ROBERTS, G. T.
An experimental evaluation of thermochromic liquid crystals for surface temperature and heat flux measurements in shock tube flows p 767 A91-40645
ROCK, KENNETH E.
Enhanced capability of the Combustion-Heated Scramjet Test Facility
[AIAA PAPER 91-2502] p 762 A91-44267
ROCKWELL, DONALD O.
Control of vortex structure on a delta wing by small amplitude perturbations of angle-of-attack
p 706 A91-42094
RODI, P. E.
An experimental/computational study of heat transfer in sharp fin induced turbulent interactions at Mach 5
[AIAA PAPER 91-1764] p 724 A91-43633
RODRIGUEZ, G.
A new vertical shock tube for Rayleigh-Taylor instability measurements p 759 A91-40637
RODRIGUEZ, JAMES N.
Combustion-driven blowdown facilities for chemical laser research
[AIAA PAPER 91-1455] p 772 A91-43528
RODRIGUEZ, K. M.
Studies of shock/shock interaction on smooth and transpiration-cooled hemispherical nosetips in hypersonic flow
[AIAA PAPER 91-1765] p 724 A91-43634
ROE, PHILIP L.
Effect of a multi-dimensional flux function on the monotonicity of Euler and Navier-Stokes computations
[AIAA PAPER 91-1530] p 696 A91-40705
ROGER, ROBERT P.
CFD computations for aero-optical analysis of supersonic shear layers
[AIAA PAPER 91-1659] p 720 A91-43574
ROKHSAZ, K.
Effect of thickness on the unsteady aerodynamics of closely coupled oscillating airfoils p 716 A91-43308
ROLLBUHLER, JIM
Fuel-rich, catalytic reaction experimental results
[AIAA PAPER 91-2463] p 754 A91-44250
ROMER, W. W.
MACGS - A zonal grid generation system for complex aero-propulsion configurations
[AIAA PAPER 91-2156] p 738 A91-41714
RONAN, T. J.
High speed rotorcraft propulsion system studies
[AIAA PAPER 91-2150] p 752 A91-44135
ROSEN, A.
An investigation of a hovering rotor in ground effect
p 704 A91-41462
Unified treatment for dealing with auxiliary conditions in blade dynamics p 770 A91-42294
A simulation model of a single rotor helicopter
p 739 A91-43080
ROSSOW, C.-C.
Upwind implicit residual smoothing method for multi-stage schemes
[AIAA PAPER 91-1533] p 696 A91-40708
ROTH, KARLIN R.
A powered lift experiment for CFD validation
[AIAA PAPER 91-1731] p 723 A91-43619
ROUSE, G. C.
APU exhaust plume effects in underbody installations
[AIAA PAPER 91-1904] p 744 A91-41646
ROYCHOUDHURY, SUBIR
Effects of nozzle lip geometry on spray atomization and emissions advanced gas turbine combustors
[AIAA PAPER 91-2201] p 753 A91-44153
ROZNO, V. G.
Release of benz(a)pyrene with the exhaust gases of gas turbine engines burning natural gas
p 764 A91-41173
RUBIN, S. G.
Pressure-based flux vector splitting for blunt geometries p 703 A91-40797
Supersonic viscous flow calculations for axisymmetric, two and three-dimensional configurations
[AIAA PAPER 91-1802] p 725 A91-43649
RUEB, JUSTIN D.
KC-135 ground collision avoidance system questionnaire
[AD-A234385] p 733 N91-26125
Evaluation of the C/EC/KC-135 Ground Collision Avoidance System (GCAS), study 1
[AD-A235301] p 737 N91-26130
RUED, K.
Heat management concepts for hypersonic propulsion systems
[AIAA PAPER 91-2493] p 769 A91-41798
RUFENACH, C. L.
Comparison of aircraft synthetic aperture radar and buoy spectra during the Norwegian Continental Shelf Experiment of 1988 p 779 A91-42224
RUMSEY, CHRISTOPHER L.
Effect of a multi-dimensional flux function on the monotonicity of Euler and Navier-Stokes computations
[AIAA PAPER 91-1530] p 696 A91-40705

RUSSEL, C. A.
Comparison of aircraft synthetic aperture radar and buoy spectra during the Norwegian Continental Shelf Experiment of 1988 p 779 A91-42224

RUSSELL, PHILIP B.
Science requirements and feasibility/design studies of a very-high-altitude aircraft for atmospheric research p 740 N91-25481

RUTHERFORD, JOHN W.
High-speed rotorcraft propulsion [AIAA PAPER 91-2147] p 746 A91-41709

RUTLEDGE, W. H.
Effect of the grid system on heat transfer computations for high speed flows [DE91-010874] p 777 N91-25375

RYSEV, O. V.
Determination of the stress-strain state of a soft lifting system p 704 A91-41320

S

SAFRONOV, A. V.
The level of self-oscillations of aerodynamic control surfaces under nonseparating transonic gas flow p 703 A91-41218

SAKATA, K.
Aerodynamic characteristics of Mach-3 air-intake tested in supersonic wind tunnel [AIAA PAPER 91-2011] p 727 A91-44091
Supersonic air-intake study aiming at future airbreathing engine [AIAA PAPER 91-2012] p 751 A91-44092

SALMAN, AHMED A.
Effects of leading-edge flap oscillation on unsteady delta wing flow and rock control [AIAA PAPER 91-1796] p 725 A91-43647

SAMIMY, M.
Supersonic jet mixing enhancement by vortex generators [AIAA PAPER 91-2263] p 705 A91-41738

SAMUELSEN, G. S.
Dynamics of discrete phase in a gas turbine co-axial, counter-swirling, combustor dome swirl cup [AIAA PAPER 91-2353] p 746 A91-41758

SANKAR, L. N.
A three-dimensional Navier-Stokes/full-potential coupled analysis for viscous transonic flow [AIAA PAPER 91-1595] p 701 A91-40769

SANKARAN, K. K.
Forming of aluminum-lithium sheet for fighter aircraft applications p 765 A91-43913
Application of aluminum-lithium alloys to fighter aircraft p 766 A91-43916

SARIPALLI, K. R.
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration [AIAA PAPER 91-1689] p 748 A91-42556

SATO, MAMORU
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78 [NAL-TR-1076] p 732 N91-25116

SAVCHENKO, V. I.
Characteristics of the working cycle of a low-pressure pneumatic nozzle with a sector structure of the fuel jet p 744 A91-41174

SAXER, ANDRE P.
Quasi-3-D non-reflecting boundary conditions for Euler equations calculations [AIAA PAPER 91-1603] p 702 A91-40775

SCAGGS, N.
Mach 6 turbulent boundary layer characteristics on smooth and rough surfaces [AIAA PAPER 91-1762] p 711 A91-42580

SCHADOW, K. C.
Reduced pressure oscillations in a dump combustor with tapered corrugations [AIAA PAPER 91-2354] p 753 A91-44208

SCHETZ, J. A.
Mixing studies of helium in air at Mach 6 [AIAA PAPER 91-2268] p 705 A91-41739
Analysis of external burning on inclined surfaces in supersonic flow [AIAA PAPER 91-2390] p 747 A91-41767
New mixing-length model for turbulent high-speed flows p 707 A91-42277
Combined tangential-normal injection into a supersonic flow p 715 A91-42816

SCHIFF, LEWIS B.
Navier-Stokes solutions for an oscillating double-delta wing [AIAA PAPER 91-1624] p 718 A91-43556

SCHLACHTA, HENRY B.
Interoperability versus integration of Omega and GPS p 735 A91-41443

SCHLAEPFER, H. W.
The wear mechanisms occurring in abradable seals of gas turbines p 768 A91-41508

SCHMID, R. K.
The wear mechanisms occurring in abradable seals of gas turbines p 768 A91-41508

SCHMID, THOMAS E.
Ceramic composites for aircraft gas turbine engines [AIAA PAPER 91-1892] p 750 A91-44045

SCHMIDT, A. A.
Wave processes occurring in supersonic motion of blunted body through dust layer p 695 A91-40656

SCHMITT, V.
Synthesis of experimental riblet studies in transonic conditions p 716 A91-43142

SCHNEIDER, J. J.
Technology needs for high-speed rotorcraft, volume 1 [NASA-CR-177585] p 742 N91-26139

SCHNEIDER, LEO E.
Combustion-driven blowdown facilities for chemical laser research [AIAA PAPER 91-1455] p 772 A91-43528

SCHNEIDER, STEVEN P.
A quiet flow Ludwieg tube for study of transition in compressible boundary layers: Design and feasibility [NASA-CR-188499] p 731 N91-25107

SCHNERR, GUENTER H.
Drag and lift in nonadiabatic transonic flow [AIAA PAPER 91-1716] p 710 A91-42564

SCHOBEIRI, T.
A row-by-row off-design performance calculation method for turbines [AIAA PAPER 91-2132] p 745 A91-41705

SCHODL, RICHARD
Velocity measurements in turbine engines - New developments using the laser two-focus method p 771 A91-43328

SCHOENFELD, THILO
Methods to enhance the accuracy of finite volume schemes 2 [FFA-147] p 779 N91-26466

SCHOLES, R.
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market [NASA-CR-177576] p 734 N91-26126

SCHRECK, SCOTT J.
Flow field structure and development near the root of a straight wing pitching at constant rate [AIAA PAPER 91-1793] p 725 A91-43646

SCHROEDER, J. S.
New capabilities for aeromechanical testing and evaluation of aircraft turbine engines [AIAA PAPER 91-2498] p 747 A91-41801

SCHWEIKER, MARY L.
Airport capacity and delay analyses [DOT/FAA/CT-TN91/18] p 762 N91-25152

SCOFIELD, C. P.
NASA/Ames Research Center DC-8 data system p 782 N91-25458
C-130 Automated Digital Data System (CADDS) p 780 N91-25482

SCOTT, C., II
Regression and combustion characteristics of boron containing fuels for solid fuel ramjets p 748 A91-42805

SCOTT, JAMES G.
Establishment of a remotely piloted helicopter test flight program for higher harmonic control research [AD-A234978] p 741 N91-26135

SCOTT, MARK W.
Summary of technology needs for high speed rotorcraft study [AIAA PAPER 91-2148] p 693 A91-41710

SCOTT, MATTHEW T.
Navier-Stokes correlation of a swept helicopter rotor tip at high alpha [AIAA PAPER 91-1752] p 711 A91-42574

SEGINER, A.
An investigation of a hovering rotor in ground effect p 704 A91-41462

SEIBERT, GEORGE L.
Laser velocimetry measurements of supersonic vortex flows on a simple razor-edged delta wing [AIAA PAPER 91-1684] p 709 A91-42553

SELBERG, B. P.
Effect of thickness on the unsteady aerodynamics of closely coupled oscillating airfoils p 716 A91-43308

SENSENBRENNER, F. JAMES, JR.
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046

SERGIENKO, A. A.
Gasdynamic interaction of flow with an oscillating shell p 703 A91-41157

SETTLES, G. S.
Hypersonic shock/boundary-layer interaction database [AIAA PAPER 91-1763] p 711 A91-42581
A physical model of the swept shock wave/boundary-layer interaction flowfield [AIAA PAPER 91-1768] p 712 A91-42582

SEYBERT, A. F.
Acoustical analysis of gear housing vibration [NASA-TM-103691] p 777 N91-25411

SEYWALD, HANS
Optimal control problems with switching points p 782 N91-25694

SHAKOCIUS, AARON M.
Refurbishing AV-8 on-board oxygen generation system beds [AD-A235083] p 741 N91-26136

SHANG, JOSEPH S.
Numerical simulation of vortex breakdown over a delta wing [AIAA PAPER 91-1814] p 726 A91-43655

SHARMA, P. B.
A study of aeroacoustic performance of a contra-rotating axial flow compressor stage p 706 A91-42248

SHEN, S. B.
Repair of F-104 aircraft nosedome by composite patching p 693 A91-43009

SHERIF, S. A.
Jet-wake thermal characteristics of heated turbulent jets in crossflow p 770 A91-42258

SHI, G. Z.
Neural network based expert system for compressor stall monitoring [AIAA PAPER 91-2500] p 781 A91-44266

SHIGEMATSU, JUNJI
A numerical investigation for supersonic inlet with throat cavity [AIAA PAPER 91-2477] p 729 A91-44260

SHIH, PETER K.
Thermostructural concepts for hypervelocity vehicles p 764 A91-43311

SHIN, JAIWON
Applied high-speed imaging for the icing research program at NASA Lewis Research Center [NASA-TM-104415] p 779 N91-26490

SHINDO, S.
Aerodynamic characteristics of Mach-3 air-intake tested in supersonic wind tunnel [AIAA PAPER 91-2011] p 727 A91-44091

SHIRAISHI, KAZUO
A numerical investigation for supersonic inlet with throat cavity [AIAA PAPER 91-2477] p 729 A91-44260

SHIRINZADEH, B.
Study of cluster formation and its effects on Rayleigh and Raman scattering measurements in a Mach 6 wind tunnel [AIAA PAPER 91-1496] p 718 A91-43547

SHOKRON, E.
Sizing supersonic freejet nozzle and inlet location for simulation of the transition phase in integral rocket ramjet p 763 A91-43084

SHOOSMITH, JOHN N.
Introduction to the LaRC central scientific computing complex [NASA-TM-104092] p 782 N91-25623

SHREEVE, R. P.
Inlet turbulence distortion and viscous flow development in a controlled-diffusion compressor cascade at very high incidence [AIAA PAPER 91-2004] p 704 A91-41673

SHUCHMAN, R. A.
Comparison of aircraft synthetic aperture radar and buoy spectra during the Norwegian Continental Shelf Experiment of 1988 p 779 A91-42224

SHULSTAD, J. C.
A radar-data communication network for ATC in the Benelux nations and northern Germany p 736 A91-41853

SICLARI, M. J.
Asymmetric separated flows over slender bodies at supersonic speeds p 714 A91-42730
CFD prediction of the near-field sonic boom environment for two low boom HSCT configurations [AIAA PAPER 91-1631] p 784 A91-43560

SIDDIQUI, M. S.
Effect of the grid system on heat transfer computations for high speed flows [DE91-010874] p 777 N91-25375

SILVERSTEIN, C. C.
Heat pipe radiation cooling of advanced hypersonic propulsion system components [AIAA PAPER 91-2358] p 746 A91-41759

SINGH, D. J.
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles [AIAA PAPER 91-2273] p 760 A91-41741

Effect of nose bluntness on flowfield over slender bodies in hypersonic flows p 707 A91-42256

SINHA, N.
Prediction of jet mean flow structure in support of HSCT noise suppression concepts
[AIAA PAPER 91-2253] p 774 A91-44171

SIPAROV, S. V.
Stabilization of the sling load of a helicopter
p 756 A91-41169

SITU, M.
New mixing-length model for turbulent high-speed flows p 707 A91-42277

SIVO, J. M.
Supersonic film cooling effectiveness using air and helium for a range of injectant temperatures and Mach numbers
[AIAA PAPER 91-1416] p 772 A91-43477

SLATER, HOWARD
Applied high-speed imaging for the icing research program at NASA Lewis Research Center
[NASA-TM-104415] p 779 N91-26490

SLOMSKI, J. F.
Some characteristics of and dynamic scaling behavior in strong vortex flows
[AIAA PAPER 91-1821] p 713 A91-42609

SMITH, A. F.
A comparison of large AA8090, AA8091 and AA7010 die forgings for helicopter structural applications
p 765 A91-43912

SMITH, C. E.
A CFD study of jet mixing in reduced flow areas for lower combustor emissions
[AIAA PAPER 91-2460] p 747 A91-41788
CFD analysis of jet mixing in low NOx flametube combustors
[NASA-TM-104466] p 756 N91-26146

SMITH, CHARLES A.
Aeroacoustic and aerodynamic applications of the theory of nonequilibrium thermodynamics
[NASA-TP-3118] p 776 N91-25352

SMITH, LEROY H., JR.
Wake ingestion propulsion benefit
[AIAA PAPER 91-2007] p 769 A91-41676

SMITH, LINDA G.
Laser velocimetry measurements of supersonic vortex flows on a simple razor-edged delta wing
[AIAA PAPER 91-1684] p 709 A91-42553

SMITH, MICHAEL W.
Instantaneous planar visualization of reacting supersonic flows using silane seeding
[AIAA PAPER 91-1690] p 772 A91-43593

SMITH, R. A.
Reduced pressure oscillations in a dump combustor with tapered corrugations
[AIAA PAPER 91-2354] p 753 A91-44208

SMITH, TODD E.
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319

SOBIECZKY, H.
Interactive design of hypersonic waverider geometries
[AIAA PAPER 91-1697] p 740 A91-43597

SODHA, M. N.
Numerical investigation of the flow within a turbofan lobed mixer p 749 A91-42812

SOMMERFIELD, DAVID M.
On the use of CFD in HSCT inlet and nozzle design
[AIAA PAPER 91-2255] p 728 A91-44173

SONDER, RAINER
Gust design procedures p 759 N91-26155

SORIN, G.
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fab simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106

SOUTHCOMBE, G.
Condition monitoring of aircraft high lift systems
p 738 A91-41535

SOWA, W. A.
Dynamics of discrete phase in a gas turbine co-axial, counter-swirling, combustor dome swirl cup
[AIAA PAPER 91-2353] p 746 A91-41758

SOWDEN, R. E.
Ground support equipment maintenance data analysis
p 760 A91-41538

SPRING, S. D.
An experimental investigation into the effects turbulator profile and spacing have on heat transfer coefficients and friction factors in small cooled turbine airfoils
[AIAA PAPER 91-2033] p 773 A91-44099

SRINIVASAN, SHIVAKUMAR
Navier-Stokes computations of hypersonic flow past a blunt edge delta wing at several angles of attack
[AIAA PAPER 91-1698] p 709 A91-42559

STALKER, R. J.
A compression ignition driver for a free piston shock tunnel p 759 A91-40638
New generation of free-piston shock tunnels
p 760 A91-40640

STALLINGS, D. W.
Aerothermal test methodology for the development of structural components for hypersonic vehicles
[AIAA PAPER 91-1441] p 764 A91-43498

STEFFEN, CHRISTOPHER J., JR.
Development of a new flux splitting scheme
p 768 A91-40793

STEGER, JOSEPH L.
Collar grids for intersecting geometric components within the Chimera overlapped grid scheme
[AIAA PAPER 91-1587] p 700 A91-40761

STEINETZ, BRUCE
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799

STENGEL, ROBERT F.
Systematic methods for knowledge acquisition and expert system development p 781 A91-43926

STEPANEK, S. A.
Aerothermal test methodology for the development of structural components for hypersonic vehicles
[AIAA PAPER 91-1441] p 764 A91-43498

STEPHENS, CRAIG A.
Thermal modeling and analysis of a cryogenic tank design exposed to extreme heating profiles
[AIAA PAPER 91-1383] p 772 A91-43447

STEVENS, JAMES R.
Performance evaluation of semi-freejet tests of the Generic High Speed Engine
[AIAA PAPER 91-2163] p 753 A91-44141

STEWART, JAMES F.
A preliminary investigation of the use of throttles for emergency flight control
[AIAA PAPER 91-2222] p 756 A91-41731

STEWART, M. E. M.
Multiblock mesh generation for multiple element airfoils with Euler solutions p 714 A91-42719

STILES, GERALD J.
The wild weasel development programs, one run, one hit, one error
[RAND-P-7661-RGS] p 778 N91-26431

STOLLERY, JOHN L.
Some aspects of shock-wave boundary layer interaction at hypersonic speeds p 695 A91-40578

STONER, R. C.
Areas for future CFD development as illustrated by transport aircraft applications
[AIAA PAPER 91-1527] p 696 A91-40703

STONIER, ROGER A.
Stealth aircraft and technology from World War II to the Gulf. I - History and background p 743 A91-43772

STOOKESBERRY, D.
Hodograph solution for compressible flow past a corner and comparison with Euler numerical predictions
[AIAA PAPER 91-1547] p 697 A91-40722

STORTZ, MICHAEL W.
Flight test and numerical simulation of transonic flow around YAV-8B Harrier II wing
[AIAA PAPER 91-1628] p 719 A91-43559

STRAUSS, KURT
Survey of current aircraft engine conditions
[AD-A235143] p 756 N91-26144

STUDENNY, JOHN
Interoperability versus integration of Omega and GPS
p 735 A91-41443

SUIKAT, REINER
An optimal pole placement gain scheduling algorithm using output feedback p 782 N91-25643

SULLINS, G. A.
A demonstration of mode transition in a scramjet combustor
[AIAA PAPER 91-2395] p 754 A91-44225

SULLIVAN, J. P.
The vortex interaction in a propeller/stator flow field
[AIAA PAPER 91-1818] p 726 A91-43657

SUNG, CHAO-HO
Numerical evaluation of vortex flow control devices
[AIAA PAPER 91-1825] p 713 A91-42612

SURBER, LEWIS E.
The impact of LO-configured forebodies on inlet approach flowfields
[AIAA PAPER 91-2599] p 730 A91-44304

SWANSON, R. C.
Multigrid for hypersonic viscous two- and three-dimensional flows
[AIAA PAPER 91-1572] p 699 A91-40746

SWEENEY, D.
Functional baseline specification for ATC data link service implementation in the host computer system
[DOT/FAA/CT-91/12] p 779 N91-26433

SWEET, D.
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126

SWENSON, HARRY N.
Computer aiding for low-altitude helicopter flight
[NASA-TM-103861] p 737 N91-25142

SWIERSTRA, SIP
Ground-based 4-D guidance of flights in strong winds
p 734 A91-41438

SYKES, J. E. H.
The effects of bearing misalignment on the non-linear vibration of aero-engine rotor-damper assemblies
p 744 A91-41536

SZYDLOWSKI, EDWARD
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100

T

TABAKOFF, W.
Investigation of coatings at high temperature for use in turbomachinery p 744 A91-41507

TAI, T. C.
On three-dimensional flow separation criteria
[AIAA PAPER 91-1740] p 710 A91-42571

TAKAHASHI, R. K.
Unsteady hot streak simulation through a 1-1/2 stage turbine engine
[AIAA PAPER 91-3382] p 775 A91-44321

TAKALLU, M. A.
Periodic blade loads of a high speed propeller at small angle of attack
[AIAA PAPER 91-2250] p 705 A91-41735

TAKEDA, KATSUMI
The reduction of cavity noise at subsonic speeds
[NAL-TR-1081] p 784 N91-25815

TALPALLIKAR, M. V.
A CFD study of jet mixing in reduced flow areas for lower combustor emissions
[AIAA PAPER 91-2460] p 747 A91-41788
CFD analysis of jet mixing in low NOx flametube combustors
[NASA-TM-104466] p 756 N91-26146

TAM, CHRISTOPHER
Computation of broadband mixing noise from turbomachinery
[AD-A233991] p 784 N91-26878

TAM, CLEMENT K.
Numerical study of the X-31 high angle-of-attack flow characteristics
[AIAA PAPER 91-1630] p 708 A91-42538

TAMURA, ATSUHIRO
A numerical analysis of the flow passing through a cascade with tip clearance - Subsonic flow through a linear cascade composed of flat plates p 695 A91-40575

TAMURA, YOSHIAKI
Unified zonal method based on the fortified Navier-Stokes concept
[AIAA PAPER 91-1558] p 698 A91-40732

TAN, ANZHONG
Surface heat transfer change induced by unsteady shock reflections and numerical simulations on shock reflection
p 695 A91-40647

TANAHASHI, YOSHIHARU
Surface heat transfer change induced by unsteady shock reflections and numerical simulations on shock reflection
p 695 A91-40647

TANAKA, A.
Supersonic air-intake study aiming at future airbreathing engine
[AIAA PAPER 91-2012] p 751 A91-44092

TANAKA, ATSUSHIGE
A numerical investigation for supersonic inlet with throat cavity
[AIAA PAPER 91-2477] p 729 A91-44260

TANG, GUI-MING
Experimental investigation of the shock wave and turbulent boundary layer interaction induced by a cylindrical protuberance p 695 A91-40604

TASLIM, M. E.
An experimental investigation into the effects turbulator profile and spacing have on heat transfer coefficients and friction factors in small cooled turbine airfoils
[AIAA PAPER 91-2033] p 773 A91-44099

TATUM, KENNETH E.
Computational and experimental aftbody flow fields for hypersonic, airbreathing configurations with scramjet exhaust flow simulation
[AIAA PAPER 91-1709] p 709 A91-42561

TAYLOR, ARTHUR C., III
Approximate analysis and sensitivity analysis methods for viscous flow involving variation of geometric shape
[AIAA PAPER 91-1569] p 767 A91-40743
An efficient method for estimating neighboring steady-state numerical solutions to the Euler equations
[AIAA PAPER 91-1680] p 722 A91-43589
TEEGEN, UWE
Constraint management requirements for on-line aircraft route planning p 737 N91-25126
TEODORESCU-TINTEA, C.
On the acoustical performances of noise suppressors with depressive networks for jet engines test rigs and supersonic wind tunnel facilities p 784 A91-42999
TERUI, YUSHI
Observation of laminar boundary layer transition on light monoplane wing surface
[NAL-TR-1077] p 777 N91-25366
THAKKER, A. B.
Flight service evalulation of thermal barrier coatings by physical vapor deposition at 5200 h p 764 A91-41511
THOMAS, J. L.
A generalized patched-grid algorithm with application to the F-18 forebody with actuated control strake
p 715 A91-42736
THOMAS, JAMES L.
Grid convergence for adaptive methods
[AIAA PAPER 91-1592] p 701 A91-40766
THOMAS, R. H.
Mixing studies of helium in air at Mach 6
[AIAA PAPER 91-2268] p 705 A91-41739
Combined tangential-normal injection into a supersonic flow p 715 A91-42816
THOMPSON, D. S.
A comparison of implicit multigrid Euler solvers implemented on a multiprocessor computer
[AIAA PAPER 91-1580] p 700 A91-40754
THOMPSON, JOE F.
Adaptive EAGLE - Solution-adaptive and quality-enhancing multi-block grids for arbitrary domains
[AIAA PAPER 91-1593] p 701 A91-40767
THOMPSON, M. W.
A demonstration of mode transition in a scramjet combustor
[AIAA PAPER 91-2395] p 754 A91-44225
THOMPSON, MICHAEL W.
Performance evaluation of semi-freejet tests of the Generic High Speed Engine
[AIAA PAPER 91-2163] p 753 A91-44141
THOMPSON, P.
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126
THORNING, A. G.
ACAS in Europe - A U.K. view p 733 A91-41448
THORNTON, EARL A.
Structured and unstructured remeshing method for high-speed flows p 713 A91-42630
TIARN, WEIHNURNG
CFD evaluation of transonic-supersonic wave front propagation effects
[AIAA PAPER 91-1657] p 708 A91-42547
TIRRES, LIZET
A comparison of the analytical and experimental performance of the solid version of a cooled radial rotor
[AIAA PAPER 91-2133] p 752 A91-44133
TIWARI, S. N.
Effect of nose bluntness on flowfield over slender bodies in hypersonic flows p 707 A91-42256
Application of a Reynolds Stress turbulence model to a supersonic hydrogen-air diffusion flame
[AIAA PAPER 91-1786] p 725 A91-43643
TJATRA, I. W.
Transonic flutter analysis of aerodynamic surfaces in the presence of structural nonlinearities
p 713 A91-42710
TOBIN, K. W., JR.
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150
TOH, K. H.
A new concept for a hubless rotary jet
[AIAA PAPER 91-1903] p 750 A91-44051
TOMIC, RADLOJUB
Analysis of structural damping of titanium alloy shell structures as compared with that of aluminium alloy structures p 765 A91-41606
TONG, MIKE
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799
TORELLA, G.
Expert systems for training purposes
[AIAA PAPER 91-2508] p 780 A91-41805
TORIZ, F. C.
Flight service evalulation of thermal barrier coatings by physical vapor deposition at 5200 h p 764 A91-41511
TOWNEND, L. H.
Intakes and boundary layer crossflows for hypersonic vehicles
[AIAA PAPER 91-2160] p 728 A91-44138
TREXLER, CARL
Tests in helium illustrate high Mach number inlet-forebody interactions p 776 N91-25338
TRMAL, G. J.
Condition monitoring of aircraft high lift systems
p 738 A91-41535
TSENG, W.
Potential flow applications to complex configurations
[AIAA PAPER 91-1634] p 719 A91-43562
TSUNG, FU-LIN
A three-dimensional Navier-Stokes/full-potential coupled analysis for viscous transonic flow
[AIAA PAPER 91-1595] p 701 A91-40769
TU, EUGENE
A parametric study of the leading edge attachment line for the F-16XL
[AIAA PAPER 91-1621] p 718 A91-43555
TUEGEL, E. J.
Forming of aluminum-lithium sheet for fighter aircraft applications p 765 A91-43913
Application of aluminum-lithium alloys to fighter aircraft
p 766 A91-43916
TUNG, CHI
Pivoting seat for fighter aircraft
[AD-D014822] p 733 N91-25120
TURKEL, E.
Multigrid for hypersonic viscous two- and three-dimensional flows
[AIAA PAPER 91-1572] p 699 A91-40746
TURLEY, W. D.
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150
TURNER, MARK G.
A novel implementation of an implicit k-epsilon turbulence model coupled with an explicit Navier-Stokes solver p 703 A91-40796
TURNER, WILLIAM
Three-dimensional upwinding Navier-Stokes code with k-epsilon model for supersonic flows
[AIAA PAPER 91-1669] p 721 A91-43580
TYLER, CHARLES
Laser velocimetry measurements of supersonic vortex flows on a simple razor-edged delta wing
[AIAA PAPER 91-1684] p 709 A91-42553
TYSINGER, THOMAS L.
Parallel block multigrid solution of the compressible Navier-Stokes equations p 702 A91-40792

U

UENISHI, K.
CFD-based 3D turbofan exhaust nozzle analysis system
[AIAA PAPER 91-2478] p 754 A91-44261
UENISHI, KENJI
Three-dimensional upwinding Navier-Stokes code with k-epsilon model for supersonic flows
[AIAA PAPER 91-1669] p 721 A91-43580

V

VALCO, MARK J.
Advanced Rotorcraft Transmission (ART) program-Boeing helicopters status report
[NASA-TM-104474] p 778 N91-25412
VALENTINE, TIM
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046
VAN LEER, BRAM
Effect of a multi-dimensional flux function on the monotonicity of Euler and Navier-Stokes computations
[AIAA PAPER 91-1530] p 696 A91-40705
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740
VARMA, R. R.
Diagonal implicit multigrid solution of compressible turbulent flows
[AIAA PAPER 91-1571] p 699 A91-40745
VASEY-GLANDON, V. M.
Forming of aluminum-lithium sheet for fighter aircraft applications p 765 A91-43913
Application of aluminum-lithium alloys to fighter aircraft
p 766 A91-43916
VATSA, V. N.
Multigrid for hypersonic viscous two- and three-dimensional flows
[AIAA PAPER 91-1572] p 699 A91-40746
VEMAGANTI, GURURAJA R.
Structured and unstructured remeshing method for high-speed flows p 713 A91-42630
VENKATAKRISHNAN, V.
Implicit solvers for unstructured meshes
[AIAA PAPER 91-1537] p 696 A91-40712
VENKATAPATHY, ETHIRAJ
Application of a solution adaptive grid scheme, SAGE, to complex three-dimensional flows
[AIAA PAPER 91-1594] p 701 A91-40768
Trim angle measurements in free-flight facilities
[AIAA PAPER 91-1632] p 719 A91-43561
VENKATESWARA RAO, G.
Post-critical behaviour of a uniform cantilever column subjected to a tip concentrated subtangential follower force with small damping p 768 A91-41584
VENNERI, SAMUEL L.
Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990 p 780 A91-42703
VENUGOPAL, N.
Combined energy management and calculus of variations approach for optimizing hypersonic vehicle trajectories p 739 A91-42738
VERHOFF, A.
Hodograph solution for compressible flow past a corner and comparison with Euler numerical predictions
[AIAA PAPER 91-1547] p 697 A91-40722
VERHOFF, AUGUST
Aeropropulsion analysis of tactical aircraft - Status and plans
[AIAA PAPER 91-1528] p 740 A91-43673
VIJGEN, PAUL M.
Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis
[AIAA PAPER 91-1635] p 719 A91-43563
VIJGEN, PAUL M. H. W.
Incompressible boundary layer transition flight experiments over a nonaxisymmetric fuselage forebody and comparisons with laminar boundary layer stability theory p 777 N91-25359
VIKEN, JEFF
Opportunities for applications of natural laminar flow technology at high-subsonic speeds
[AIAA PAPER 91-1773] p 724 A91-43638
VISBAL, MIGUEL R.
Numerical simulation of the unsteady vortex structure over a delta wing
[AIAA PAPER 91-1811] p 726 A91-43653
The laminar horseshoe vortex system formed at a cylinder/plate juncture
[AIAA PAPER 91-1826] p 727 A91-43659
VITTAL, B. R.
Design and development of a compact bifurcated turboprop inlet
[AIAA PAPER 91-2017] p 727 A91-44093
VOELKER, L. S.
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113
VOLPE, G.
On the use and the accuracy of compressible flow codes at low Mach numbers
[AIAA PAPER 91-1662] p 721 A91-43577
VONPRAGENAU, GEORGE L.
Dynamic tester for rotor seals and bearings
[NASA-CASE-MFS-28493-1] p 763 N91-25155

W

WAGNER, R. D.
Opportunities for applications of natural laminar flow technology at high-subsonic speeds
[AIAA PAPER 91-1773] p 724 A91-43638
WAINAUSKI, HARRY S.
Wind tunnel results of counter rotation prop-fans designed with lifting line and Euler code methods
[AIAA PAPER 91-2499] p 755 A91-44265
WAKAMATSU, YOSHIO
Parametric study of airframe-integrated scramjet cooling requirement p 749 A91-42817
WAKELEY, WILLIAM H.
On the use of CFD in HSCT inlet and nozzle design
[AIAA PAPER 91-2255] p 728 A91-44173
WALKER, M.
On three-dimensional flow separation criteria
[AIAA PAPER 91-1740] p 710 A91-42571
WALSH, JOANNE L.
Performance optimization of helicopter rotor blades
[NASA-TM-104054] p 741 N91-26137

WANG, H. Y.
Dynamics of discrete phase in a gas turbine co-axial, counter-swirling, combustor dome swirl cup
[AIAA PAPER 91-2353] p 746 A91-41758
WANG, YIFEI
An approach to aerodynamic characteristics of low radar cross-section fuselages p 718 A91-43501
WANG, ZHONG-QI
An application of topological method to analysing the three-dimensional flow in cascades. II - Topological analysis on the vector field patterns of skin-frictions and section streamlines p 694 A91-40569
WANIE, K. M.
Navier-Stokes results for hypersonic inlet flows
[AIAA PAPER 91-2472] p 729 A91-44257
WARDLAW, A. B., JR.
Vortical flows about a long cylinder at M = 3.5 and alpha = 18 deg
[AIAA PAPER 91-1808] p 726 A91-43651
WARREN, GARY P.
Grid convergence for adaptive methods
[AIAA PAPER 91-1592] p 701 A91-40766
WARREN, WALTER R., JR.
Combustion-driven blowdown facilities for chemical laser research
[AIAA PAPER 91-1455] p 772 A91-43528
WARSI, S.
Large-scale advanced propeller blade pressure distributions - Prediction and data p 715 A91-42820
WATANABE, TOSHINORI
A numerical analysis of the flow passing through a cascade with tip clearance - Subsonic flow through a linear cascade composed of flat plates p 695 A91-40575
WAZYNIAK, J. A.
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration
[AIAA PAPER 91-1689] p 748 A91-42556
WEATHERLY, D. C.
Performance comparisons of Navier-Stokes codes for simulating three-dimensional hypersonic crossflow/jet interaction
[AIAA PAPER 91-2096] p 728 A91-44127
WEBSTER, STEVE L.
Geogrid reinforced base course for flexible pavements for light aircraft: Literature review and test section design
[DOT/FAA/RD-90/28] p 763 N91-26160
WEBSTER, W. P.
Numerical simulation of vortex breakdown over a delta wing
[AIAA PAPER 91-1814] p 726 A91-43655
WEGENER, STEVEN
Science requirements and feasibility/design studies of a very-high-altitude aircraft for atmospheric research p 740 N91-25481
WEIDNER, JOHN
Tests in helium illustrate high Mach number inlet-forebody interactions p 776 N91-25338
WEINSTEIN, C. J.
Opportunities for advanced speech processing in military computer-based systems
[AD-A233724] p 778 N91-26412
WEN, DIANZHONG
Titanium alloy integrated centrifugal impeller 5 coordinate computer assisted manufacturing technology
[AD-A234797] p 766 N91-26300
WENHUA, LI
Application of transformational ideas to automatic flight control design
[AD-A234758] p 758 N91-26148
WERNER, MARIAN
Experimental X-band synthetic aperture radar in aircraft p 735 A91-41825
WHITAKER, KEVIN W.
Thrust vectoring using non-axisymmetric nozzles with flexible contours
[AIAA PAPER 91-2368] p 746 A91-41761
WHITE, J. A.
Multigrid for hypersonic viscous two- and three-dimensional flows
[AIAA PAPER 91-1572] p 699 A91-40746
WHITEHEAD, B. A.
A neural network for the analysis of aircraft test data p 781 N91-25133
WIETING, ALLAN R.
Structured and unstructured remeshing method for high-speed flows p 713 A91-42630
WILBER, GEORGE F.
Intelligent real-time knowledge based inflight mission management p 737 N91-25128
WILCOX, DAVID C.
Progress in hypersonic turbulence modeling
[AIAA PAPER 91-1785] p 724 A91-43642
WILDE, PETER
Methods to enhance the accuracy of finite volume schemes 2
[FFA-147] p 779 N91-26466
WILKERSON, J. B.
Technology needs for high-speed rotorcraft, volume 1
[NASA-CR-177585] p 742 N91-26139
WILKINSON, STEPHEN P.
Goertler instability and hypersonic quiet nozzle design
[AIAA PAPER 91-1648] p 708 A91-42542
WILLIAMS, J. C.
Trends in aircraft engine materials
[AIAA PAPER 91-1890] p 693 A91-41643
WILMOTH, R. G.
An efficient DSMC algorithm applied to a delta wing
[AIAA PAPER 91-1316] p 717 A91-43388
WILSON, J. R.
Sub-contractors play new strategic roles p 694 A91-43273
WILSON, K. J.
Reduced pressure oscillations in a dump combustor with tapered corrugations
[AIAA PAPER 91-2354] p 753 A91-44208
WING, DAVID J.
Static performance of a multiaxis thrust vectoring cruciform nozzle
[AIAA PAPER 91-2137] p 745 A91-41707
WOAN, CHUNG-JIN
Numerical study of the X-31 high angle-of-attack flow characteristics
[AIAA PAPER 91-1630] p 708 A91-42538
WOLBER, DAVE
Structured representation for requirements and specifications
[NASA-CR-187522] p 783 N91-26797
WOLF, THOMAS D.
A preliminary investigation of the use of throttles for emergency flight control
[AIAA PAPER 91-2222] p 756 A91-41731
WOOD, M. E.
The design and commissioning of an acoustic liner for propeller noise testing in the ARA transonic wind tunnel p 783 A91-41540
WU, C. C.
Asymptotic methods for the prediction of transonic wind tunnel wall interference
[AIAA PAPER 91-1712] p 762 A91-44334
WU, T. W.
Acoustical analysis of gear housing vibration
[NASA-TM-103691] p 777 N91-25411
WU, X. F.
Acoustical analysis of gear housing vibration
[NASA-TM-103691] p 777 N91-25411
WUSK, MICHAEL S.
Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis
[AIAA PAPER 91-1635] p 719 A91-43563
WYNNE, A.
Visualization of airblast atomized spray structure under varying air pressure conditions
[AIAA PAPER 91-2199] p 769 A91-41726

X

XIA, JIAN
Synchronization device of digital flight controlling computer and the algorithm for system scheduling p 742 A91-43508
XIE, L.
A new concept for a hubless rotary jet
[AIAA PAPER 91-1903] p 750 A91-44051
XU, GUOHUA
Prediction of helicopter rotor rotational noise p 784 A91-43503
XU, ZHONG
Failure analysis of structural systems p 739 A91-43512

Y

YADLIN, YORAM
Parallel block multigrid solution of the compressible Navier-Stokes equations p 702 A91-40792
YAHIA, H.
FCS skewed sensors array - Practical considerations p 742 A91-43082
YAMAMOTO, KAZUOMI
A numerical investigation for supersonic inlet with throat cavity
[AIAA PAPER 91-2477] p 729 A91-44260
YAMAMOTO, O.
Large-scale advanced propeller blade pressure distributions - Prediction and data p 715 A91-42820
YAMAMOTO, YUKIMITSU
Numerical simulation of hypersonic viscous flow for the design of H-II orbiting plane (HOPE). II
[AIAA PAPER 91-1390] p 717 A91-43453
YANAGI, R.
Aerodynamic characteristics of Mach-3 air-intake tested in supersonic wind tunnel
[AIAA PAPER 91-2011] p 727 A91-44091
YANG, A. S.
Theoretical study of supersonic flow separation over a rearward facing step
[AIAA PAPER 91-2161] p 753 A91-44139
YANG, HENRY T. Y.
Reliability of initially compressed uncertain laminated plates in supersonic flow p 770 A91-42292
YANG, J. Y.
High resolution nonoscillatory schemes for unsteady gas dynamics p 702 A91-40795
YAROS, STEVEN F.
Use of the PARC code for generic NASP nozzles operating at off-design transonic conditions
[AIAA PAPER 91-2154] p 705 A91-41713
YATES, LESLIE A.
Trim angle measurements in free-flight facilities
[AIAA PAPER 91-1632] p 719 A91-43561
YEH, DAVID T.
Numerical study of the X-31 high angle-of-attack flow characteristics
[AIAA PAPER 91-1630] p 708 A91-42538
YETTER, J. A.
Scale model test results of several STOVL ventral nozzle concepts
[AIAA PAPER 91-2134] p 752 A91-44134
YING, SUSAN X.
A numerical study of compressible viscous flow in a novel exhaust system
[AIAA PAPER 91-1728] p 723 A91-43617
YON, STEVEN
Unsteady fluid dynamic model for propeller induced flow fields
[AIAA PAPER 91-1664] p 709 A91-42550
YOON, SEOKKWAN
An implicit three-dimensional Navier-Stokes solver for compressible flow
[AIAA PAPER 91-1555] p 698 A91-40729
YORK, B. J.
Prediction of jet mean flow structure in support of HSCT noise suppression concepts
[AIAA PAPER 91-2253] p 774 A91-44171
YOSHIDA, M.
Development of a vitiated air heater for engine test facilities
[AIAA PAPER 91-2501] p 761 A91-41802
YOUNGHANS, JAMES L.
A numerical study of compressible viscous flow in a novel exhaust system
[AIAA PAPER 91-1728] p 723 A91-43617
YOUNGREN, HAROLD
Viscous/inviscid method for preliminary design of transonic cascades
[AIAA PAPER 91-2364] p 706 A91-41760
YOUNT, R. E.
High speed rotorcraft propulsion system studies
[AIAA PAPER 91-2150] p 752 A91-44135
YU, HONG-RU
Experimental investigation of the shock wave and turbulent boundary layer interaction induced by a cylindrical protuberance p 695 A91-40604
YU, N. J.
Navier-Stokes calculations for attached and separated flows using different turbulence models
[AIAA PAPER 91-1791] p 712 A91-42594
YUNGSTER, SHAYE
Navier-Stokes simulation of the supersonic combustion flowfield in a ram accelerator
[AIAA PAPER 91-1916] p 773 A91-44057

Z

ZAHEDI, AHMAD
Advanced technology engine casing designs
[AIAA PAPER 91-1893] p 750 A91-44046
ZALIAEV, I. A.
Design of a language processor for aviation engine testing p 760 A91-41164
ZAMAN, K. B. M. Q.
Supersonic jet mixing enhancement by vortex generators
[AIAA PAPER 91-2263] p 705 A91-41738
ZANIEWSKI, JOHN P.
Unified methodology for airport pavement analysis and design. Volume 1: State of the art
[DOT/FAA/RD-91/15-VOL-1] p 762 N91-25154

ZARIFI-RAD, F.
Effect of model cooling on periodic transonic flow
[AIAA PAPER 91-1714] p 709 A91-42562

ZEILER, THOMAS A.
Calculating time-correlated gust loads using matched filter and random process theories p 739 A91-43312

ZHANG, CAIWEN
An approach to aerodynamic characteristics of low radar cross-section fuselages p 718 A91-43501

ZHANG, Z. C.
An experimental evaluation of thermochromic liquid crystals for surface temperature and heat flux measurements in shock tube flows p 767 A91-40645

ZHANG, ZONGFEN
A new method for the vibration of thin-walled beams p 772 A91-43706

ZHAO, RUMING
Application of shock tunnel at pressure and heat transfer experiments on turbine blade p 760 A91-40649

ZHENG, YOUXIN
LDV measurements in the roll-up region of the tip vortex from a rectangular wing
[AIAA PAPER 91-1685] p 709 A91-42554

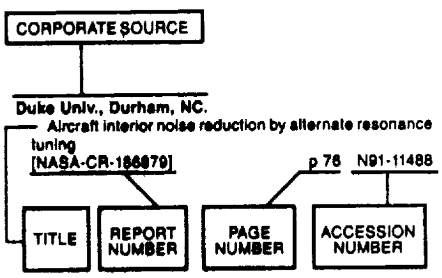
ZHU, JUNZHENG
An approximate computation method to compute low-speed aerodynamic characteristics of wing with separation p 718 A91-43510

ZINGG, D. W.
Viscous airfoil computations using Richardson extrapolation
[AIAA PAPER 91-1559] p 698 A91-40733

ZUMWALT, G. W.
C.F.D. of the base flow on a plane body between a subsonic flow on one side and a supersonic flow on the other
[AIAA PAPER 91-2372] p 729 A91-44215

CORPORATE SOURCE INDEX

Typical Corporate Source Index Listing



Listings in this index are arranged alphabetically by corporate source. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

A

Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
Technical evaluation report on the flight mechanics panel symposium on progress in military airlift
[AGARD-AR-300] p 733 N91-25119
Knowledge Based System Applications for Guidance and Control
[AGARD-CP-474] p 736 N91-25121
Handling qualities of unstable highly augmented aircraft
[AGARD-AR-279] p 740 N91-25146
AGARD handbook on advanced casting
[AGARD-AG-299] p 775 N91-25302
Mission planning systems for tactical aircraft (pre-flight and in-flight)
[AGARD-AR-296] p 783 N91-25750
Experimental techniques in the field of low density aerodynamics
[AGARD-AG-318(E)] p 733 N91-26124
Manual on the flight of flexible aircraft in turbulence
[AGARD-AG-317] p 758 N91-26150
Digital signal conditioning for flight test, volume 19
[AGARD-AG-160-VOL-19] p 778 N91-26432

AeroChem Research Labs., Inc., Princeton, NJ.
Three-dimensional jet noise computations
[AIAA PAPER 91-2256] p 784 A91-44174

Aerojet-General Corp., Sacramento, CA.
Lightweight ceramic components for propulsion applications
[AIAA PAPER 91-2217] p 774 A91-44159

Aerometrics, Inc., Sunnyvale, CA.
A quantitative study of unsteady compressible flow on an oscillating airfoil
[AIAA PAPER 91-1683] p 722 A91-43590

Aeronautical Research Inst. of Sweden, Stockholm.
Methods to enhance the accuracy of finite volume schemes 2
[FFA-147] p 779 N91-26466

Aeronautical Systems Div., Wright-Patterson AFB, OH.
KC-135 ground collision avoidance system questionnaire
[AD-A234385] p 733 N91-26125
Evaluation of the C/EC/KC-135 Ground Collision Avoidance System (GCAS), study 1
[AD-A235301] p 737 N91-26130
A look at digital nose wheel steering
[AD-A233944] p 741 N91-26131
Results of the aeronautical systems division critical process team on integrated product development
[AD-A235419] p 785 N91-26995

Air Force Inst. of Tech., Wright-Patterson AFB, OH.
Application of transformational ideas to automatic flight control design
[AD-A234758] p 758 N91-26148
Titanium alloy integrated centrifugal impeller 5 coordinate computer assisted manufacturing technology
[AD-A234797] p 766 N91-26300

Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.
The impact of LO-configured forebodies on inlet approach flowfields
[AIAA PAPER 91-2599] p 730 A91-44304

Analytical Services and Materials, Inc., Hampton, VA.
Multigrid for hypersonic viscous two- and three-dimensional flows
[AIAA PAPER 91-1572] p 699 A91-40746
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles
[AIAA PAPER 91-2273] p 760 A91-41741
Prediction of internal performance for two-dimensional convergent-divergent nozzles
[AIAA PAPER 91-2369] p 706 A91-41762
Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41766
A generalized patched-grid algorithm with application to the F-18 forebody with actuated control strake
p 715 A91-42736
Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis
[AIAA PAPER 91-1635] p 719 A91-43563
Secondary instability of high-speed flows and the influence of wall cooling and suction
[AIAA PAPER 91-1647] p 720 A91-43572
Opportunities for applications of natural laminar flow technology at high-subsonic speeds
[AIAA PAPER 91-1773] p 724 A91-43638
CFD code validation for nozzle flowfields
[AIAA PAPER 91-2565] p 775 A91-44295

Argonne National Lab., IL.
The potential role of maglev in short-haul airline operations
[DE91-010813] p 777 N91-25408

Army Aviation Systems Command, Hampton, VA.
Computational rotorcraft flowfield research at the U.S. Army AeroStructures Directorate p 703 A91-41148

Army Aviation Systems Command, Moffett Field, CA.
A quantitative study of unsteady compressible flow on an oscillating airfoil
[AIAA PAPER 91-1683] p 722 A91-43590

Army Engineer Waterways Experiment Station, Vicksburg, MS.
Geogrid reinforced base course for flexible pavements for light aircraft: Literature review and test section design
[DOT/FAA/RD-90/28] p 763 N91-26160

Army War Coll., Carlisle Barracks, PA.
What fuels our future?
[AD-A233674] p 767 N91-26387

B

Bell Helicopter Co., Fort Worth, TX.
Conclusions from high-speed rotorcraft studies
[AIAA PAPER 91-2149] p 693 A91-41711

Bell Telephone Labs., Inc., Middletown, NJ.
Systematic methods for knowledge acquisition and expert system development p 781 A91-43926

Birmingham Univ. (England).
The fatigue response of the aluminium-lithium alloy, 8090 p 765 A91-43657

Boeing Canada, Toronto (Ontario).
Analysis by the statistical discrete gust method
p 759 N91-26156

Boeing Co., Wichita, KS.
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies
p 771 A91-43310

Boeing Commercial Airplane Co., Seattle, WA.
Civil tiltrotor missions and applications. Phase 2: The commercial passenger market
[NASA-CR-177576] p 734 N91-26126

Boeing Helicopter Co., Philadelphia, PA.
Technology needs for high-speed rotorcraft, volume 1
[NASA-CR-177585] p 742 N91-26139

Boeing Military Airplane Development, Seattle, WA.
Intelligent real-time knowledge based inflight mission management p 737 N91-25128
Structured representation for requirements and specifications
[NASA-CR-187522] p 783 N91-26797

C

California Inst. of Tech., Pasadena.
An experimental investigation of structure, mixing, and combustion in compressible turbulent shear layers
[AD-A235278] p 766 N91-26281

California Univ., Berkeley.
A study of flow separation on an aspect ratio three flap at Mach number 2.4
[AIAA PAPER 91-1620] p 718 A91-43554

California Univ., Davis.
Collar grids for intersecting geometric components within the Chimera overlapped grid scheme
[AIAA PAPER 91-1587] p 700 A91-40761

California Univ., Los Angeles.
Size dependence of gaseous cluster reactivity and evaporation dynamics as a mechanistic probe
[AD-A233811] p 766 N91-26249

Calspan Corp., Buffalo, NY.
Studies of shock/shock interaction on smooth and transpiration-cooled hemispherical nosetips in hypersonic flow
[AIAA PAPER 91-1765] p 724 A91-43634

Case Western Reserve Univ., Cleveland, OH.
Feedback linearization for control of air breathing engines
[AIAA PAPER 91-2000] p 745 A91-41671

CCS Associates, Bethel Park, PA.
Heat pipe radiation cooling of advanced hypersonic propulsion system components
[AIAA PAPER 91-2358] p 746 A91-41759

CFD Research Corp., Huntsville, AL.
A CFD study of jet mixing in reduced flow areas for lower combustor emissions
[AIAA PAPER 91-2460] p 747 A91-41788

Colorado Univ., Boulder.
Flight test and numerical simulation of transonic flow around YAV-8B Harrier II wing
[AIAA PAPER 91-1628] p 719 A91-43559
Hypersonic waverider analysis - A comparison of numerical and experimental results
[AIAA PAPER 91-1696] p 739 A91-43596
Interactive design of hypersonic waverider geometries
[AIAA PAPER 91-1697] p 740 A91-43597
Theoretical studies of the kinematics, dynamics, stability, and control of unsteady/vortical flows
[AD-A235190] p 779 N91-26477

Committee on Science, Space and Technology (U.S. House).
National Aeronautics and Space Administration Multiyear Authorization Act of 1991 p 785 N91-27046

Computer Sciences Corp., Moffett Field, CA.
Implicit solvers for unstructured meshes
[AIAA PAPER 91-1537] p 696 A91-40712

Coordinating Research Council, Inc., Atlanta, GA.
Survey of current aircraft engine conditions
[AD-A235143] p 756 N91-26144

SOURCE

Cornell Univ., Ithaca, NY.
Diagonal implicit multigrid solution of compressible turbulent flows
[AIAA PAPER 91-1571] p 699 A91-40745

D

DCW Industries, La Canada, CA.
Progress in hypersonic turbulence modeling
[AIAA PAPER 91-1785] p 724 A91-43642
Department of the Navy, Washington, DC.
Pivoting seat for fighter aircraft
[AD-D014822] p 733 N91-25120
Deutsche Airbus G.m.b.H., Hamburg (Germany, F.R.).
Gust design procedures p 759 N91-26155
Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).
Constraint management requirements for on-line aircraft route planning p 737 N91-25126
Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.).
Hypersonic rarefied flow about a compression corner - DSMC simulation and experiment
[AIAA PAPER 91-1313] p 716 A91-43385
Douglas Aircraft Co., Inc., Long Beach, CA.
New airfoil design concept p 716 A91-43307
Duke Univ., Durham, NC.
Prediction of unsteady aerodynamic loads in cascades using the linearized Euler equations on deforming grids
[AIAA PAPER 91-3378] p 730 A91-44318
Aircraft interior noise reduction by alternate resonance tuning
[NASA-CR-185453] p 785 N91-26889

E

Eloret Corp., Palo Alto, CA.
Trim angle measurements in free-flight facilities
[AIAA PAPER 91-1632] p 719 A91-43561
Eloret Corp., Sunnyvale, CA.
Application of a solution adaptive grid scheme, SAGE, to complex three-dimensional flows
[AIAA PAPER 91-1594] p 701 A91-40768

F

Federal Aviation Administration, Atlantic City, NJ.
NAS operational test and evaluation/integration of the Maintenance Management System (MMS) test procedures
[DOT/FAA/CT-TN90/63] p 694 N91-25100
Airport capacity and delay analyses
[DOT/FAA/CT-TN91/18] p 762 N91-25152
Demonstration Precision Runway Monitor (PRM) proof of performance test results
[DOT/FAA/CT-TN91/3] p 762 N91-25153
Federal Aviation Administration, Cambridge, MA.
Unified methodology for airport pavement analysis and design. Volume 1: State of the art
[DOT/FAA/RD-91/15-VOL-1] p 762 N91-25154
Federal Aviation Administration, Seattle, WA.
Certification procedures and requirements
p 759 N91-26154
Florence Univ. (Italy).
Three-dimensional Navier-Stokes analysis of turbine passage heat transfer
[AIAA PAPER 91-2241] p 774 A91-44167
Florida Atlantic Univ., Boca Raton.
Dynamics of elastic bending and torsion of hingeless rotors with dynamic stall
[AD-A234775] p 741 N91-26134
Florida State Univ., Tallahassee.
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821
Computation of broadband mixing noise from turbomachinery
[AD-A233991] p 784 N91-26878
Florida Univ., Gainesville.
Effects of nozzle lip geometry on spray atomization and emissions advanced gas turbine combustors
[AIAA PAPER 91-2201] p 753 A91-44153
FWG Associates, Inc., Tullahoma, TN.
Guide to measurement of winds with instrumented aircraft
[NASA-CR-188601] p 780 N91-25553

G

G and C Systems, Inc., San Juan Capistrano, CA.
Autonomous aircraft initiative study
[NASA-CR-186013] p 742 N91-26140
General Electric Co., Cincinnati, OH.
Scale model test results of several STOVL ventral nozzle concepts
[AIAA PAPER 91-2134] p 752 A91-44134
George Washington Univ., Hampton, VA.
Goertler instability and hypersonic quiet nozzle design
[AIAA PAPER 91-1648] p 708 A91-42542
Vortex breakdown in a supersonic jet
[AIAA PAPER 91-1815] p 726 A91-43656
George Washington Univ., Washington, DC.
A new concept for a hubless rotary jet
[AIAA PAPER 91-1903] p 750 A91-44051
Grumman Aerospace Corp., Bethpage, NY.
CFD prediction of the near-field sonic boom environment for two low boom HSCT configurations
[AIAA PAPER 91-1631] p 784 A91-43560
Computational simulations for fighter and hypersonic vehicle inlet-forebody interactions p 776 N91-25347

H

High Technology Corp., Hampton, VA.
Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis
[AIAA PAPER 91-1635] p 719 A91-43563
Compressible stability of growing boundary layers using parabolized stability equations
[AIAA PAPER 91-1636] p 720 A91-43564
Waves produced from a harmonic point source in a supersonic boundary layer
[AIAA PAPER 91-1646] p 720 A91-43571

I

Illinois Univ., Urbana.
Guidelines for design, construction, and evaluation of airport pavement drainage
[DOT/FAA/RD-90/31] p 763 N91-26161
Institute for Computer Applications in Science and Engineering, Hampton, VA.
Implicit solvers for unstructured meshes
[AIAA PAPER 91-1537] p 696 A91-40712
Compressible stability of growing boundary layers using parabolized stability equations
[AIAA PAPER 91-1636] p 720 A91-43564

J

Johns Hopkins Univ., Columbia, MD.
Computational Fluid Dynamics Code Validation/Calibration. JANNAF Airbreathing Propulsion Subcommittee Workshop: High-Speed Inlet Forebody Interactions
[CPIA-PUBL-551] p 775 N91-25336

K

Kansas Coll. of Technology, Salina.
Detection and avoidance of errors in computer software p 783 N91-25937
Kansas Univ., Lawrence.
Development of a system of interactive computer programs for airplane conceptual design and advanced airplane analysis p 740 N91-25144
Incompressible boundary layer transition flight experiments over a nonaxisymmetric fuselage forebody and comparisons with laminar boundary layer stability theory p 777 N91-25359
An optimal pole placement gain scheduling algorithm using output feedback p 782 N91-25643
Kansas Univ. Center for Research, Inc., Lawrence.
Three-dimensional Navier-Stokes analysis of turbine passage heat transfer
[AIAA PAPER 91-2241] p 774 A91-44167
Korea Advanced Inst. of Science and Technology, Seoul (Republic of Korea).
Static aeroelastic analysis of a three-dimensional oblique wing p 714 A91-42711

L

Lockheed Aeronautical Systems Co., Thousand Oaks, CA.
The pilot's associate: Exploiting the intelligent advantage p 781 N91-25122
Lockheed Engineering and Sciences Co., Hampton, VA.
Periodic blade loads of a high speed propeller at small angle of attack
[AIAA PAPER 91-2250] p 705 A91-41735
Computational and experimental afterbody flow fields for hypersonic, airbreathing configurations with scramjet exhaust flow simulation
[AIAA PAPER 91-1709] p 709 A91-42561
Structured and unstructured remeshing method for high-speed flows p 713 A91-42630
Calculating time-correlated gust loads using matched filter and random process theories p 739 A91-43312
An analytical comparison of convective heat transfer correlations in supercritical hydrogen
[AIAA PAPER 91-1382] p 771 A91-43446
Lockheed Engineering and Sciences Co., Houston, TX.
Collar grids for intersecting geometric components within the Chimera overlapped grid scheme
[AIAA PAPER 91-1587] p 700 A91-40761
Los Alamos National Lab., NM.
Heat pipe radiation cooling of advanced hypersonic propulsion system components
[AIAA PAPER 91-2358] p 746 A91-41759
Lucas Western, Inc., City of Industry, CA.
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1906] p 769 A91-41648

M

Maryland Univ., College Park.
A numerical study of the flow establishment time in hypersonic shock tunnels
[AIAA PAPER 91-1706] p 722 A91-43604
Dynamic analysis of advanced tip rotors including three-dimensional aerodynamics p 731 N91-25111
Massachusetts Inst. of Tech., Cambridge.
Computation and visualization of leading edge vortex flows p 714 A91-42721
Calculated aerodynamics of wings in severe maneuver
[AD-A235241] p 732 N91-26120
Massachusetts Inst. of Tech., Lexington.
Opportunities for advanced speech processing in military computer-based systems
[AD-A233724] p 778 N91-26412
MCAT Inst., San Jose, CA.
Laser velocimetry measurements of oscillating airfoil dynamic stall flow field
[AIAA PAPER 91-1799] p 725 A91-43648
McDonnell Aircraft Co., Saint Louis, MO.
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration
[AIAA PAPER 91-1689] p 748 A91-42556
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089
Integrated control and avionics for air superiority: A knowledge-based decision aiding system
p 743 N91-25138
McDonnell-Douglas Corp., Saint Louis, MO.
The impact of LO-configured forebodies on inlet approach flowfields
[AIAA PAPER 91-2599] p 730 A91-44304
High-speed forebody-inlet code validation experience at MCAIR p 776 N91-25348
McDonnell-Douglas Helicopter Co., Mesa, AZ.
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1906] p 769 A91-41648
High-speed rotorcraft propulsion
[AIAA PAPER 91-2147] p 746 A91-41709
McDonnell-Douglas Research Labs., Saint Louis, MO.
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration
[AIAA PAPER 91-1689] p 748 A91-42556
Michigan Univ., Ann Arbor.
Effect of a multi-dimensional flux function on the monotonicity of Euler and Navier-Stokes computations
[AIAA PAPER 91-1530] p 696 A91-40705
An adaptively-refined Cartesian mesh solver for the Euler equations
[AIAA PAPER 91-1542] p 697 A91-40717
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319
Mississippi State Univ., Starkville.
A drag analysis of the early stages of large-scale high-altitude free balloon ascents p 731 N91-25108
Missouri Univ., Rolla.
Analysis of losses in supersonic mixing and reacting flows
[AIAA PAPER 91-2266] p 774 A91-44180

Mitre Corp., McLean, VA.
Functional baseline specification for ATC data link service implementation in the host computer system
[DOT/FAA/CT-91/12] p 779 N91-26433

N

National Aeronautics and Space Administration, Washington, DC.
Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990 p 780 A91-42703

National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
Higher order accuracy for upwind methods by using the compatibility equations
[AIAA PAPER 91-1543] p 697 A91-40718
A 3-D upwind Euler solver for unstructured meshes
[AIAA PAPER 91-1548] p 697 A91-40723
An implicit three-dimensional Navier-Stokes solver for compressible flow
[AIAA PAPER 91-1555] p 698 A91-40729
Surface reconstruction from scattered data through pruning of unstructured grids
[AIAA PAPER 91-1584] p 700 A91-40758
Collar grids for intersecting geometric components within the Chimera overlapped grid scheme
[AIAA PAPER 91-1587] p 700 A91-40761
Direct numerical simulation of transition and turbulence in a spatially evolving boundary layer
[AIAA PAPER 91-1607] p 702 A91-40779
A numerical investigation of turbulent baseflow
p 703 A91-40799
Comment on 'Critique of turbulence models for shock-induced flow separation' p 707 A91-42307
Unsteady fluid dynamic model for propeller induced flow fields
[AIAA PAPER 91-1664] p 709 A91-42550
Static aeroelastic analysis of a three-dimensional oblique wing p 714 A91-42711
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821
A parametric study of the leading edge attachment line for the F-16XL
[AIAA PAPER 91-1621] p 718 A91-43555
Navier-Stokes solutions for an oscillating double-delta wing
[AIAA PAPER 91-1624] p 718 A91-43556
Flight test and numerical simulation of transonic flow around YAV-8B Harrier II wing
[AIAA PAPER 91-1628] p 719 A91-43559
Trim angle measurements in free-flight facilities
[AIAA PAPER 91-1632] p 719 A91-43561
Potential flow applications to complex configurations
[AIAA PAPER 91-1634] p 719 A91-43562
Numerical study of juncture flows
[AIAA PAPER 91-1660] p 720 A91-43575
A quantitative study of unsteady compressible flow on an oscillating airfoil
[AIAA PAPER 91-1683] p 722 A91-43590
Numerical performance estimates for a generic hypersonic forebody
[AIAA PAPER 91-1695] p 722 A91-43595
A powered lift experiment for CFD validation
[AIAA PAPER 91-1731] p 723 A91-43619
Laser velocimetry measurements of oscillating airfoil dynamic stall flow field
[AIAA PAPER 91-1799] p 725 A91-43648
Application of an unsteady Navier-Stokes solver to transonic turbine design
[AIAA PAPER 91-2468] p 729 A91-44254
Applications of higher harmonic control to hingeless rotor systems
[NASA-TM-103846] p 694 N91-25102
Computer aiding for low-altitude helicopter flight
[NASA-TM-103861] p 737 N91-25142
Sensitivity of inlet performance predictions to CFD numerical and physical modeling p 776 N91-25345
Aeroacoustic and aerodynamic applications of the theory of nonequilibrium thermodynamics
[NASA-TP-3118] p 776 N91-25352
NASA/Ames Research Center DC-8 data system
p 782 N91-25458
Science requirements and feasibility/design studies of a very-high-altitude aircraft for atmospheric research
p 740 N91-25481
C-130 Automated Digital Data System (CADDS)
p 780 N91-25482
Format and basic geometry of a perspective display of air traffic for the cockpit
[NASA-TM-86680] p 743 N91-26142

National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A preliminary investigation of the use of throttles for emergency flight control
[AIAA PAPER 91-2222] p 756 A91-41731
A parametric study of the leading edge attachment line for the F-16XL
[AIAA PAPER 91-1621] p 718 A91-43555
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089
A simulation evaluation of a four-engine jet transport using engine thrust modulation for flightpath control
[AIAA PAPER 91-2223] p 757 A91-44162
A knowledge-based system design/information tool for aircraft flight control systems p 757 N91-25139
A simulation study of turbofan engine deterioration estimation using Kalman filtering techniques
[NASA-TM-104233] p 755 N91-25147
Combined compressive and shear buckling analysis of hypersonic aircraft structural sandwich panels
[NASA-TM-4290] p 778 N91-25422
Development of an integrated aeroservoelastic analysis program and correlation with test data
[NASA-TP-3120] p 694 N91-26113

National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
Computational aspects of chemically reacting flows
[AIAA PAPER 91-1574] p 699 A91-40748

National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
Effect of a multi-dimensional flux function on the monotonicity of Euler and Navier-Stokes computations
[AIAA PAPER 91-1530] p 696 A91-40705
Implicit solvers for unstructured meshes
[AIAA PAPER 91-1537] p 696 A91-40712
Multigrid for hypersonic viscous two- and three-dimensional flows
[AIAA PAPER 91-1572] p 699 A91-40746
A Runge-Kutta discontinuous finite element method for high speed flows
[AIAA PAPER 91-1575] p 699 A91-40749
Asynchronous, macrotasked relaxation strategies for the solution of viscous, hypersonic flows
[AIAA PAPER 91-1579] p 700 A91-40753
Grid convergence for adaptive methods
[AIAA PAPER 91-1592] p 701 A91-40766
Computational rotorcraft flowfield research at the U.S. Army AeroStructures Directorate p 703 A91-41148
A parametric experimental study of isolated rectangular nozzles
[AIAA PAPER 91-2136] p 738 A91-41706
Static performance of a multiaxis thrust vectoring cruciform nozzle
[AIAA PAPER 91-2137] p 745 A91-41707
Use of the PARC code for generic NASP nozzles operating at off-design transonic conditions
[AIAA PAPER 91-2154] p 705 A91-41713
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles
[AIAA PAPER 91-2273] p 760 A91-41741
Prediction of internal performance for two-dimensional convergent-divergent nozzles
[AIAA PAPER 91-2369] p 706 A91-41762
Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41768
Effect of nose bluntness on flowfield over slender bodies in hypersonic flows p 707 A91-42256
Comparison of cryogenic wind tunnel, flight, and computational results for a thin, low-aspect-ratio wing
[AIAA PAPER 91-1626] p 708 A91-42536
Goertler instability and hypersonic quiet nozzle design
[AIAA PAPER 91-1648] p 708 A91-42542
Super/hypersonic aerodynamic characteristics for a transatmospheric vehicle concept having a minimum drag forebody
[AIAA PAPER 91-1694] p 709 A91-42558
Computational and experimental aftbody flow fields for hypersonic, airbreathing configurations with scramjet exhaust flow simulation
[AIAA PAPER 91-1709] p 709 A91-42561
Structured and unstructured remeshing method for high-speed flows p 713 A91-42630
Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990 p 780 A91-42703
A generalized patched-grid algorithm with application to the F-18 forebody with actuated control strake
p 715 A91-42736
Recent advances in hypersonic technology
p 716 A91-43103
Calculating time-correlated gust loads using matched filter and random process theories p 739 A91-43312
Hypersonic rarefied flow about a compression corner - DSMC simulation and experiment
[AIAA PAPER 91-1313] p 716 A91-43385
Hypersonic rarefied flow about a delta wing - Direct simulation and comparison with experiment
[AIAA PAPER 91-1315] p 716 A91-43387
An efficient DSMC algorithm applied to a delta wing
[AIAA PAPER 91-1316] p 717 A91-43388
An analytical comparison of convective heat transfer correlations in supercritical hydrogen
[AIAA PAPER 91-1382] p 771 A91-43446
Viscous equilibrium computations using program LAURA
[AIAA PAPER 91-1389] p 717 A91-43452
Enhancements to the high speed convective heating and viscous drag prediction techniques of the Aerodynamic Preliminary Analysis System (APAS)
[AIAA PAPER 91-1435] p 717 A91-43494
Study of cluster formation and its effects on Rayleigh and Raman scattering measurements in a Mach 6 wind tunnel
[AIAA PAPER 91-1496] p 718 A91-43547
CFD prediction of the near-field sonic boom environment for two low boom HSCT configurations
[AIAA PAPER 91-1631] p 784 A91-43560
Flight experiments measuring boundary-layer disturbances in laminar flow and correlation with stability analysis
[AIAA PAPER 91-1635] p 719 A91-43563
Compressible stability of growing boundary layers using parabolized stability equations
[AIAA PAPER 91-1636] p 720 A91-43564
Instantaneous planar visualization of reacting supersonic flows using silane seeding
[AIAA PAPER 91-1690] p 772 A91-43593
Hypersonic waverider analysis - A comparison of numerical and experimental results
[AIAA PAPER 91-1696] p 739 A91-43596
Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel
[AIAA PAPER 91-1725] p 723 A91-43615
Studies of shock/shock interaction on smooth and transpiration-cooled hemispherical nosetips in hypersonic flow
[AIAA PAPER 91-1765] p 724 A91-43634
Opportunities for applications of natural laminar flow technology at high-subsonic speeds
[AIAA PAPER 91-1773] p 724 A91-43638
Mach 3.5 boundary-layer transition on a cone at angle of attack
[AIAA PAPER 91-1804] p 725 A91-43650
Vortex breakdown in a supersonic jet
[AIAA PAPER 91-1815] p 726 A91-43656
The fatigue response of the aluminium-lithium alloy, 8090 p 765 A91-43857
Mixing enhancement of reacting parallel fuel jets in a supersonic combustor
[AIAA PAPER 91-1914] p 750 A91-44055
Scale model test results of several STOVL ventral nozzle concepts
[AIAA PAPER 91-2134] p 752 A91-44134
Analysis of losses in supersonic mixing and reacting flows
[AIAA PAPER 91-2266] p 774 A91-44180
Enhanced capability of the Combustion-Heated Scramjet Test Facility
[AIAA PAPER 91-2502] p 762 A91-44267
CFD code validation for nozzle flowfields
[AIAA PAPER 91-2565] p 775 A91-44295
The impact of LO-configured forebodies on inlet approach flowfields
[AIAA PAPER 91-2599] p 730 A91-44304
Low-speed, powered ground effects of a generic, hypersonic configuration
[NASA-TP-3092] p 730 N91-25103
Development of an adaptive failure detection and identification system for detecting aircraft control element failures
[NASA-TP-3051] p 758 N91-25151
Tests in helium illustrate high Mach number inlet-forebody interactions p 776 N91-25338
A numerical study of hypersonic forebody/inlet integration problem p 732 N91-25343
Introduction to the LaRC central scientific computing complex
[NASA-TM-104092] p 782 N91-25623
Langley aerospace test highlights, 1990
[NASA-TM-104090] p 786 N91-26112
Performance optimization of helicopter rotor blades
[NASA-TM-104054] p 741 N91-26137
Measurement of atmospheric turbulence
p 780 N91-26151

National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A new Lagrangian random choice method for steady two-dimensional supersonic/hypersonic flow
[AIAA PAPER 91-1546] p 697 A91-40721
Generalized conjugate-gradient methods for the Navier-Stokes equations
[AIAA PAPER 91-1556] p 698 A91-40730
Numerical flux formulas for the Euler and Navier-Stokes equations. II - Progress in flux-vector splitting
[AIAA PAPER 91-1566] p 698 A91-40740
Development of a new flux splitting scheme
p 768 A91-40793
CFD analysis of a hydrogen fueled ramjet engine at Mach 3.44
[AIAA PAPER 91-1919] p 745 A91-41653
Feedback linearization for control of air breathing engines
[AIAA PAPER 91-2000] p 745 A91-41671
Supersonic jet mixing enhancement by vortex generators
[AIAA PAPER 91-2263] p 705 A91-41738
A CFD study of jet mixing in reduced flow areas for lower combustor emissions
[AIAA PAPER 91-2460] p 747 A91-41788
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799
A three-dimensional Navier-Stokes stage analysis of the flow through a compact radial turbine
[AIAA PAPER 91-2564] p 748 A91-41815
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration
[AIAA PAPER 91-1689] p 748 A91-42556
Influence of thickness and camber on the aeroelastic stability of supersonic throughflow fans
p 715 A91-42814
Large-scale advanced propeller blade pressure distributions - Prediction and data p 715 A91-42820
3-D Navier-Stokes analysis of crossing, glancing shocks/turbulent boundary layer interactions
[AIAA PAPER 91-1758] p 723 A91-43631
Static performance tests of a flight-type STOVL ejector
[AIAA PAPER 91-1902] p 750 A91-44050
Navier-Stokes simulation of the supersonic combustion flowfield in a ram accelerator
[AIAA PAPER 91-1916] p 773 A91-44057
Effects of nozzle lip geometry on spray atomization and emissions advanced gas turbine combustors
[AIAA PAPER 91-2201] p 753 A91-44153
Fuel-rich, catalytic reaction experimental results
[AIAA PAPER 91-2463] p 754 A91-44250
A design strategy for the use of vortex generators to manage inlet-engine distortion using computational fluid dynamics
[AIAA PAPER 91-2474] p 729 A91-44259
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319
Evaluation of panel code predictions with experimental results of inlet performance for a 17-inch ducted prop/fab simulator operating at Mach 0.2
[NASA-TM-104428] p 731 N91-25106
The design/analysis of flows through turbomachinery: A viscous/inviscid approach
[NASA-TM-104447] p 755 N91-25148
Acoustical analysis of gear housing vibration
[NASA-TM-103691] p 777 N91-25411
Advanced Rotorcraft Transmission (ART) program-Boeing helicopters status report
[NASA-TM-104474] p 778 N91-25412
Magnetic bearings-state of the art
[NASA-TM-104465] p 778 N91-25413
CFD analysis of jet mixing in low NOx flametube combustors
[NASA-TM-104466] p 756 N91-26146
Applied high-speed imaging for the icing research program at NASA Lewis Research Center
[NASA-TM-104415] p 779 N91-26490

National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
Dynamic tester for rotor seals and bearings
[NASA-CASE-MFS-28493-1] p 763 N91-25155

National Aerospace Lab., Emmeloord (Netherlands).
Acquisition of statistical gust load data by commercial airplanes p 758 N91-26152

National Aerospace Lab., Tokyo (Japan).
A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114
Velocity measurements inside the leading edge vortex formed on a delta wing
[NAL-TR-1087] p 732 N91-25115
An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116
Estimation of the aeroelastic characteristics from flight test data of the STOL research aircraft ASKA
[NAL-TR-1083] p 740 N91-25145
Observation of laminar boundary layer transition on light monoplane wing surface
[NAL-TR-1077] p 777 N91-25366
The reduction of cavity noise at subsonic speeds
[NAL-TR-1081] p 784 N91-25815

Naval Air Development Center, Warminster, PA.
Potential flow applications to complex configurations
[AIAA PAPER 91-1634] p 719 A91-43562
Flight control law synthesis using neural network theory
[AD-A234990] p 758 N91-26149

Naval Postgraduate School, Monterey, CA.
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821
Navier-Stokes solutions for an oscillating double-delta wing
[AIAA PAPER 91-1624] p 718 A91-43556
Laser velocimetry measurements of oscillating airfoil dynamic stall flow field
[AIAA PAPER 91-1799] p 725 A91-43648
Establishment of a remotely piloted helicopter test flight program for higher harmonic control research
[AD-A234978] p 741 N91-26135

Naval Research Lab., Washington, DC.
Experimental investigation of a unique airbreathing pulsed laser propulsion concept
[AIAA PAPER 91-1922] p 751 A91-44059

North Carolina State Univ., Raleigh.
An explicit, rotated upwind algorithm for solution of the Euler/Navier-Stokes equations
[AIAA PAPER 91-1531] p 696 A91-40706
Comparison of cryogenic wind tunnel, flight, and computational results for a thin, low-aspect-ratio wing
[AIAA PAPER 91-1626] p 708 A91-42536
An approximate viscous shock layer approach to calculating hypersonic flows about blunt-nosed bodies
[AIAA PAPER 91-1348] p 717 A91-43417
Evaluation of a three-dimensional Navier-Stokes solver for transonic flow over a low-aspect-ratio wing mounted in a wind tunnel
[AIAA PAPER 91-1725] p 723 A91-43615

O

Oak Ridge National Lab., TN.
Fiber-sensor design for turbine engines
[DE91-010787] p 755 N91-25150
Ceramic technology for advanced heat engines project
[DE91-010451] p 766 N91-26384

Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
Improved reduction of gust loads data for gust intensity p 758 N91-26153

Ohio State Univ., Columbus.
Supersonic jet mixing enhancement by vortex generators
[AIAA PAPER 91-2263] p 705 A91-41738

Old Dominion Univ., Norfolk, VA.
Aerodynamic shape optimization using sensitivity analysis on third-order Euler equations
[AIAA PAPER 91-1577] p 699 A91-40751
Effect of nose bluntness on flowfield over slender bodies in hypersonic flows p 707 A91-42256
Multigrid and upwind viscous flow solver on three-dimensional overlapped and embedded grids
p 707 A91-42284
An efficient method for estimating neighboring steady-state numerical solutions to the Euler equations
[AIAA PAPER 91-1680] p 722 A91-43589
Application of a Reynolds Stress turbulence model to a supersonic hydrogen-air diffusion flame
[AIAA PAPER 91-1786] p 725 A91-43643
Effects of leading-edge flap oscillation on unsteady delta wing flow and rock control
[AIAA PAPER 91-1796] p 725 A91-43647
An extension of essentially nonoscillatory shock-capturing schemes to multidimensional systems of conservation laws p 776 N91-25355
Navier-Stokes simulations of flows about complex configurations using domain decomposition techniques
p 777 N91-25362
Viscous flow simulations of internal store carriage and separation
[NASA-CR-185343] p 732 N91-26123

P

Pennsylvania State Univ., University Park.
Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41768
Hypersonic shock/boundary-layer interaction database
[AIAA PAPER 91-1763] p 711 A91-42581

Pratt and Whitney Aircraft, West Palm Beach, FL.
Preliminary flight evaluation of an engine performance optimization algorithm
[AIAA PAPER 91-1998] p 751 A91-44089

Pratt and Whitney Aircraft Group, East Hartford, CT.
Flow visualization studies of the internal flow characteristics in a simulated mixed flow vectored thrust ASTOVL engine configuration
[AIAA PAPER 91-1689] p 748 A91-42556

Pratt and Whitney Aircraft Group, West Palm Beach, FL.
Application of an unsteady Navier-Stokes solver to transonic turbine design
[AIAA PAPER 91-2468] p 729 A91-44254

PRC Systems Services Co., Edwards, CA.
Autonomous aircraft initiative study
[NASA-CR-186013] p 742 N91-26140

Princeton Univ., NJ.
Systematic methods for knowledge acquisition and expert system development p 781 A91-43926
Three-dimensional jet noise computations
[AIAA PAPER 91-2256] p 784 A91-44174

Purdue Univ., West Lafayette, IN.
Active unsteady aerodynamic suppression of rotating stall in an incompressible flow centrifugal compressor with vaned diffuser
[AIAA PAPER 91-1898] p 704 A91-41644
Flutter control of incompressible flow turbomachine blade rows by splitter blades
[AIAA PAPER 91-1900] p 704 A91-41645
The vortex interaction in a propeller/stator flow field
[AIAA PAPER 91-1818] p 726 A91-43657
Transient performance of fan engine with water ingestion
[AIAA PAPER 91-1897] p 750 A91-44049
A quiet flow Ludwieg tube for study of transition in compressible boundary layers: Design and feasibility
[NASA-CR-188499] p 731 N91-25107

R

Rafael Armament Development Authority, Haifa (Israel).
Mach 2 and Mach 3 mixing and combustion in scramjets
[AIAA PAPER 91-2394] p 747 A91-41768

RAND Corp., Santa Monica, CA.
How low can an unmanned air vehicle fly?
[RAND-P-7680-RGS] p 741 N91-26138
VHSIC electronics and the cost of Air Force avionics in the 1990s
[RAND-R-3843-AF] p 743 N91-26143
The wild weasel development programs, one run, one hit, one error
[RAND-P-7661-RGS] p 778 N91-26431

Rensselaer Polytechnic Inst., Troy, NY.
Experimental investigation of a unique airbreathing pulsed laser propulsion concept
[AIAA PAPER 91-1922] p 751 A91-44059

Rockwell International Corp., Los Angeles, CA.
Numerical study of the X-31 high angle-of-attack flow characteristics
[AIAA PAPER 91-1630] p 708 A91-42538

Rockwell International Science Center, Thousand Oaks, CA.
Numerical study of juncture flows
[AIAA PAPER 91-1660] p 720 A91-43575

Rutgers Univ., New Brunswick, NJ.
On the quasi-conical flowfield structure of the swept shock wave-turbulent boundary layer interaction
[AIAA PAPER 91-1759] p 724 A91-43632
An experimental/computational study of heat transfer in sharp fin induced turbulent interactions at Mach 5
[AIAA PAPER 91-1764] p 724 A91-43633

S

San Diego State Univ., CA.
Unsteady fluid dynamic model for propeller induced flow fields
[AIAA PAPER 91-1664] p 709 A91-42550

Sandia National Labs., Albuquerque, NM.
Effect of the grid system on heat transfer computations for high speed flows
[DE91-010874] p 777 N91-25375

School of Aerospace Medicine, Brooks AFB, TX.
Refurbishing AV-8 on-board oxygen generation system beds
[AD-A235083] p 741 N91-26136

Science Applications International Corp., Fort Washington, PA.
Prediction of jet mean flow structure in support of HSCT noise suppression concepts
[AIAA PAPER 91-2253] p 774 A91-44171

Scientific Research Associates, Inc., Glastonbury, CT.
A design strategy for the use of vortex generators to manage inlet-engine distortion using computational fluid dynamics
[AIAA PAPER 91-2474] p 729 A91-44259

Sikorsky Aircraft, Stratford, CT.
Advanced Rotorcraft Transmission (ART) program status
[AIAA PAPER 91-1909] p 769 A91-41650

Societe d'Applications Generales d'Electricite et de Mecanique, Cergy-Pontoise (France).
SEAN: A navigation aid expert system for combat aircraft p 737 N91-25137

Stanford Univ., CA.
Direct numerical simulation of transition and turbulence in a spatially evolving boundary layer
[AIAA PAPER 91-1607] p 702 A91-40779
Performance characteristics of an underexpanded multiple jet ejector p 749 A91-42821
An identification algorithm based on smoothing p 782 N91-25642

Sterling Federal Systems, Inc., Moffett Field, CA.
Application of an unsteady Navier-Stokes solver to transonic turbine design
[AIAA PAPER 91-2468] p 729 A91-44254

Sterling Software, Palo Alto, CA.
Application of a solution adaptive grid scheme, SAGE, to complex three-dimensional flows
[AIAA PAPER 91-1594] p 701 A91-40768

Sverdrup Technology, Inc., Arnold AFS, TN.
CFD calibration and application to the design of flow tailoring devices for simulating forebody influences on fighter aircraft inlet flows p 776 N91-25339

Sverdrup Technology, Inc., Brook Park, OH.
CFD analysis of a hydrogen fueled ramjet engine at Mach 3.44
[AIAA PAPER 91-1919] p 745 A91-41653
Feedback linearization for control of air breathing engines
[AIAA PAPER 91-2000] p 745 A91-41671
Thermal and structural assessments of a ceramic wafer seal in hypersonic engine
[AIAA PAPER 91-2494] p 747 A91-41799
Large-scale advanced propeller blade pressure distributions - Prediction and data p 715 A91-42820
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319

Sydney Univ. (Australia).
An efficient DSMC algorithm applied to a delta wing
[AIAA PAPER 91-1316] p 717 A91-43388

Synetics Corp., Wakefield, MA.
Coordination and synchronization of loran-C and GPS to universal coordinated time
[AD-A233221] p 737 N91-25141

T

Tel-Aviv Univ. (Israel).
Multigrid for hypersonic viscous two- and three-dimensional flows
[AIAA PAPER 91-1572] p 699 A91-40746
The delay of turbulent boundary layer separation by oscillatory active control
[ITN-91-85104] p 779 N91-26482

Tennessee Univ., Tullahoma.
Neural network based expert system for compressor stall monitoring
[AIAA PAPER 91-2500] p 781 A91-44266

Texas A&M Univ., College Station.
A row-by-row off-design performance calculation method for turbines
[AIAA PAPER 91-2132] p 745 A91-41705

Texas Univ., Arlington.
The peak surface pressure in fin-generated shock-wave boundary-layer interactions p 696 A91-40672

Texas Univ., Austin.
A Runge-Kutta discontinuous finite element method for high speed flows
[AIAA PAPER 91-1575] p 699 A91-40749
An experimental/computational study of heat transfer in sharp fin induced turbulent interactions at Mach 5
[AIAA PAPER 91-1764] p 724 A91-43633

Toledo Univ., OH.
Localization of aeroelastic modes in mistuned high-energy turbines
[AIAA PAPER 91-3379] p 775 A91-44319

U

United Technologies Research Center, East Hartford, CT.
Investigation of hot streak migration and film cooling effects on the heat transfer in rotor/stator interacting flows
[AD-A235420] p 756 N91-26145

Universitaet der Bundeswehr Muenchen, Neubiberg (Germany, F.R.).
Knowledge-based cockpit assistant for IFR operations p 736 N91-25125

University of Western Michigan, Kalamazoo.
Failure detection of liquid cooled electronics in sealed packages
[AIAA PAPER 91-1423] p 742 A91-43482

V

Vanderbilt Univ., Nashville, TN.
A neural network for the analysis of aircraft test data p 781 N91-25133

Vigyan Research Associates, Inc., Hampton, VA.
Periodic blade loads of a high speed propeller at small angle of attack
[AIAA PAPER 91-2250] p 705 A91-41735
Hypersonic rarefied flow about a delta wing - Direct simulation and comparison with experiment
[AIAA PAPER 91-1315] p 716 A91-43387
Assessment of meanflow solutions for instability analysis of transitioning flows
[AIAA PAPER 91-1638] p 720 A91-43565

Virginia Polytechnic Inst. and State Univ., Blacksburg.
Generalized conjugate-gradient methods for the Navier-Stokes equations
[AIAA PAPER 91-1556] p 698 A91-40730
Mixing studies of helium in air at Mach 6
[AIAA PAPER 91-2268] p 705 A91-41739
Least-squares/parabolized Navier-Stokes procedure for optimizing hypersonic wind tunnel nozzles
[AIAA PAPER 91-2273] p 760 A91-41741
Optimal control problems with switching points p 782 N91-25694
State space models for aeroelastic and viscoelastic systems
[AD-A234730] p 732 N91-26117

Virginia Univ., Charlottesville.
Structured and unstructured remeshing method for high-speed flows p 713 A91-42630

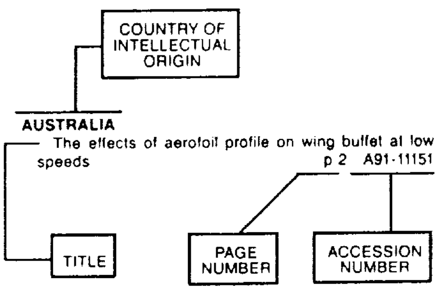
W

Washington Univ., Seattle.
Experiments on hypersonic ramjet propulsion cycles using a ram accelerator
[AIAA PAPER 91-2489] p 762 A91-44264
Self-propelled slender axisymmetric body flows: Errors in the Poisson equation field calculation p 731 N91-25110

Waterloo Univ. (Ontario).
A new Lagrangian random choice method for steady two-dimensional supersonic/hypersonic flow
[AIAA PAPER 91-1546] p 697 A91-40721

Wichita State Univ., KS.
Methods for obtaining and reducing experimental droplet impingement data on arbitrary bodies p 771 A91-43310

Typical Foreign Technology Index Listing



Listings in this index are arranged alphabetically by country of intellectual origin. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the citation in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

A

AUSTRALIA

A compression ignition driver for a free piston shock tunnel p 759 A91-40638

New generation of free-piston shock tunnels p 760 A91-40640

Laminar heat transfer to spherically blunted cones in high enthalpy hyper velocity flows p 695 A91-40646

Experimental and computational investigation of isothermal swirling flow in an axisymmetric dump combustor p 749 A91-42806

B

BRAZIL

Kernel function occurring in subsonic unsteady potential flow p 707 A91-42280

An investigation of hypersonic shock tunnel testing at an equilibrium interface condition of 4100 K - Theory and experiment [AIAA PAPER 91-1707] p 761 A91-42560

C

CANADA

Viscous airfoil computations using Richardson extrapolation [AIAA PAPER 91-1559] p 698 A91-40733

Interoperability versus integration of Omega and GPS p 735 A91-41443

Performance implications of gas-turbine pressure-gain combustors [AIAA PAPER 91-1879] p 744 A91-41641

Design optimization of an electronic fuel control unit featuring two digital actuators [AIAA PAPER 91-2003] p 745 A91-41672

Low profile Satcom aircraft antenna development p 736 A91-42781

TABS - An automated pre-flight planning system p 733 A91-42783

Visual systems for ATC training p 761 A91-42792

Computer modelling of implanted component faults in a gas turbine engine [AIAA PAPER 91-1912] p 750 A91-44053

Analysis by the statistical discrete gust method p 759 N91-26156

CHINA, PEOPLE'S REPUBLIC OF

An application of topological method to analysing the three-dimensional flow in cascades. II - Topological analysis on the vector field patterns of skin-frictions and section streamlines p 694 A91-40569

Experimental investigation of the shock wave and turbulent boundary layer interaction induced by a cylindrical protuberance p 695 A91-40604

Application of shock tunnel at pressure and heat transfer experiments on turbine blade p 760 A91-40649

Correlative behaviours of shock/boundary layer interaction induced by sharp fin and semicone [AIAA PAPER 91-1756] p 711 A91-42577

An approach to aerodynamic characteristics of low radar cross-section fuselages p 718 A91-43501

A primary study of Reynolds number effect in transonic flow p 718 A91-43502

Prediction of helicopter rotor rotational noise p 784 A91-43503

Synchronization device of digital flight controlling computer and the algorithm for system scheduling p 742 A91-43508

An approximate computation method to compute low-speed aerodynamic characteristics of wing with separation p 718 A91-43510

A study on the stiffness simulation calculation method of flutter models of after body and horizontal tail of a new type aeroplane p 739 A91-43511

Failure analysis of structural systems p 739 A91-43512

A new method for the vibration of thin-walled beams p 772 A91-43706

A new concept on compressor and turbine for aerospace propulsion [AIAA PAPER 91-2591] p 755 A91-44303

Application of transformational ideas to automatic flight control design [AD-A234758] p 758 N91-26148

Titanium alloy integrated centrifugal impeller 5 coordinate computer assisted manufacturing technology [AD-A234797] p 766 N91-26300

F

FRANCE

A new vertical shock tube for Rayleigh-Taylor instability measurements p 759 A91-40637

Finite element simulation of compressible flows with shocks [AIAA PAPER 91-1551] p 767 A91-40725

Reflections on the spaceplane p 785 A91-41548

Leading edge effect on rarefied hypersonic flow over a flat plate [AIAA PAPER 91-1749] p 710 A91-42573

Investigation of the tip shape influence on the flowfield around hovering rotor blades [AIAA PAPER 91-1754] p 711 A91-42576

A general method for practical conformal mapping of aerodynamic shapes p 715 A91-42902

A method for correcting wall pressure measurements in subsonic compressible flow p 715 A91-42957

Synthesis of experimental riblet studies in transonic conditions p 716 A91-43142

A multidomain Euler code applied to hypersonic flows [AIAA PAPER 91-1699] p 722 A91-43598

Properties of commercially available Al-Li alloys' possible use on civil aircraft p 766 A91-43920

Technical evaluation report on the flight mechanics panel symposium on progress in military airlift [AGARD-AR-300] p 733 N91-25119

Knowledge Based System Applications for Guidance and Control [AGARD-CP-474] p 736 N91-25121

A neural network for the analysis of aircraft test data p 781 N91-25133

SEAN: A navigation aid expert system for combat aircraft p 737 N91-25137

Handling qualities of unstable highly augmented aircraft [AGARD-AR-279] p 740 N91-25146

AGARD handbook on advanced casting [AGARD-AG-299] p 775 N91-25302

Mission planning systems for tactical aircraft (pre-flight and in-flight) [AGARD-AR-296] p 783 N91-25750

Experimental techniques in the field of low density aerodynamics [AGARD-AG-318(E)] p 733 N91-26124

Manual on the flight of flexible aircraft in turbulence [AGARD-AG-317] p 758 N91-26150

Improved reduction of gust loads data for gust intensity p 758 N91-26153

Digital signal conditioning for flight test, volume 19 [AGARD-AG-160-VOL-19] p 778 N91-26432

G

GERMANY,FEDERAL REPUBLIC OF

Upwind implicit residual smoothing method for multi-stage schemes [AIAA PAPER 91-1533] p 696 A91-40708

Heat management concepts for hypersonic propulsion systems [AIAA PAPER 91-2493] p 769 A91-41798

Experimental X-band synthetic aperture radar in aircraft p 735 A91-41825

Concept and results of the Azimuth Quick-Look Processor for aircraft SAR of the DLR p 735 A91-41828

Specification of an inertial navigation system for experimental SAR p 735 A91-41829

The development of 'Radar data quality control and Radar Analysis Support System RDQC/RASS' p 735 A91-41834

Determination of orientation accuracy in curved flight paths p 736 A91-41835

Estimating the period length of periodic signals p 770 A91-41846

Intelligent radar data processing p 770 A91-41849

A knowledge-based tracker for aircraft formations p 736 A91-41851

A radar-data communication network for ATC in the Benelux nations and northern Germany p 736 A91-41853

Accurate airborne surface temperature measurements with chopper-stabilized radiometers p 742 A91-42142

Drag and lift in nonadiabatic transonic flow [AIAA PAPER 91-1716] p 710 A91-42564

MBB Bo 108 - Serial construction begins p 739 A91-43117

IAE V2500 - Technology for the environment p 749 A91-43118

Piaggio P180 Avanti - Efficiency using three levels of aerodynamic lift p 739 A91-43119

In-flight measurement of static pressures and boundary-layer state with integrated sensors p 742 A91-43306

With us you fly right - The influence of modern technology on the development and operation of new aircraft p 771 A91-43326

Velocity measurements in turbine engines - New developments using the laser two-focus method p 771 A91-43328

Structural mechanics research in the DLR p 771 A91-43334

Transition predictions using Reynolds-averaged Navier-Stokes and linear stability analysis methods [AIAA PAPER 91-1641] p 720 A91-43567

Navier-Stokes results for hypersonic inlet flows [AIAA PAPER 91-2472] p 729 A91-44257

Knowledge-based cockpit assistant for IFR operations p 736 N91-25125

Constraint management requirements for on-line aircraft route planning p 737 N91-25126

Gust design procedures p 759 N91-26155

I

INDIA

Post-critical behaviour of a uniform cantilever column subjected to a tip concentrated subtangential follower force with small damping p 768 A91-41584

A study of aeroacoustic performance of a contra-rotating axial flow compressor stage p 706 A91-42248

INTERNATIONAL ORGANIZATION

Ground-based 4-D guidance of flights in strong winds p 734 A91-41438

ISRAEL

Multigrid for hypersonic viscous two- and three-dimensional flows
[AIAA PAPER 91-1572] p 699 A91-40746

An investigation of a hovering rotor in ground effect p 704 A91-41462

Burning and flameholding characteristics of a miniature solid fuel ramjet combustor p 749 A91-42807

Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Collection of Papers and Supplement p 785 A91-43076

A simulation model of a single rotor helicopter p 739 A91-43080

FCS skewed sensors array - Practical considerations p 742 A91-43082

Sizing supersonic freejet nozzle and inlet location for simulation of the transition phase in integral rocket ramjet p 763 A91-43084

Estimation of aircraft attitude by angular rate measurements p 757 A91-43095

Euler solver for arbitrary configurations - Further applications p 716 A91-43100

The delay of turbulent boundary layer separation by oscillatory active control
[ITN-91-85104] p 779 N91-26482

ITALY

LU implicit TVD scheme for the solution of viscous two dimensional high speed flows
[AIAA PAPER 91-1573] p 699 A91-40747

Expert systems for training purposes
[AIAA PAPER 91-2508] p 780 A91-41805

A Finite Volume Lambda Formulation
[AIAA PAPER 91-2258] p 728 A91-44176

J

JAPAN

A numerical analysis of the flow passing through a cascade with tip clearance - Subsonic flow through a linear cascade composed of flat plates p 695 A91-40575

Surface heat transfer change induced by unsteady shock reflections and numerical simulations on shock reflection p 695 A91-40647

Unified zonal method based on the fortified Navier-Stokes concept
[AIAA PAPER 91-1558] p 698 A91-40732

Development of a vitiated air heater for engine test facilities
[AIAA PAPER 91-2501] p 761 A91-41802

Supersonic inlet flow computations using fortified Navier-Stokes approach
[AIAA PAPER 91-1730] p 710 A91-42567

Parametric study of airframe-integrated scramjet cooling requirement p 749 A91-42817

A study of supersonic aerodynamic mixing in the scramjet combustor p 771 A91-43000

Numerical simulation of hypersonic viscous flow for the design of H-II orbiting plane (HOPE). II
[AIAA PAPER 91-1390] p 717 A91-43453

Multigrid solution of hypersonic flows using rational Runge-Kutta scheme
[AIAA PAPER 91-1703] p 722 A91-43602

Detailed measurements on unsteady properties in three-dimensional show wave/turbulent boundary layer interaction induced by blunt fin at Mach number 4
[AIAA PAPER 91-1755] p 723 A91-43629

Spherical particle impact damage behaviour of a SiC fibre-reinforced chemical vapour infiltrated SiC composite p 765 A91-43752

A numerical study of surge and rotating stall in axial compressors
[AIAA PAPER 91-1896] p 727 A91-44048

Aerodynamic characteristics of Mach-3 air-intake tested in supersonic wind tunnel
[AIAA PAPER 91-2011] p 727 A91-44091

Supersonic air-intake study aiming at future airbreathing engine
[AIAA PAPER 91-2012] p 751 A91-44092

Computations of three-dimensional viscous flows in turbomachinery cascades
[AIAA PAPER 91-2237] p 728 A91-44164

A numerical investigation for supersonic inlet with throat cavity
[AIAA PAPER 91-2477] p 729 A91-44260

A computational and experimental analysis of joined-wing aerodynamics
[NAL-TR-1088T] p 732 N91-25114

Velocity measurements inside the leading edge vortex formed on a delta wing
[NAL-TR-1087] p 732 N91-25115

An investigation of a two-dimensional hybrid laminar flow control airfoil at high subsonic flow. Part 1: Aerodynamic characteristic of a basic airfoil NLAM78
[NAL-TR-1076] p 732 N91-25116

Estimation of the aeroelastic characteristics from flight test data of the STOL research aircraft ASKA
[NAL-TR-1083] p 740 N91-25145

Observation of laminar boundary layer transition on light monoplane wing surface
[NAL-TR-1077] p 777 N91-25366

The reduction of cavity noise at subsonic speeds
[NAL-TR-1081] p 784 N91-25815

K

KOREA(SOUTH)

Static aeroelastic analysis of a three-dimensional oblique wing p 714 A91-42711

N

NETHERLANDS

Acquisition of statistical gust load data by commercial airplanes p 758 N91-26152

NORWAY

Modification of the van Driest damping function to include the effects of surface roughness p 770 A91-42282

P

PORTUGAL

Numerical and experimental study of fountain flows produced by multijet impingement on a ground plane
[AIAA PAPER 91-1806] p 771 A91-42602

R

ROMANIA (RUMANIA)

On the acoustical performances of noise suppressors with depressive networks for jet engines test rigs and supersonic wind tunnel facilities p 784 A91-42999

S

SOUTH AFRICA, REPUBLIC OF

Reduction of the RCS of the leading edge of a conducting wing-shaped structure by means of lossless dielectric material p 770 A91-42241

SWEDEN

Navier-Stokes computations of hypersonic flow past a blunt edge delta wing at several angles of attack
[AIAA PAPER 91-1698] p 709 A91-42559

Methods to enhance the accuracy of finite volume schemes 2
[FFA-147] p 779 N91-26466

SWITZERLAND

The wear mechanisms occurring in abradable seals of gas turbines p 768 A91-41508

T

TAIWAN

High resolution nonoscillatory schemes for unsteady gas dynamics p 702 A91-40795

Control of vortex structure on a delta wing by small amplitude perturbations of angle-of-attack p 706 A91-42094

A block-structured solution scheme with the multigrid method for three-dimensional inviscid transonic flows p 706 A91-42096

Multigrid solutions of the three-dimensional grid equations p 706 A91-42098

Repair of F-104 aircraft nosedome by composite patching p 693 A91-43009

U

U.S.S.R.

Multi-cascade compression - Effective means to obtain high temperature dense gas in piston gas dynamic units (PGU) p 760 A91-40641

Wave processes occurring in supersonic motion of blunted body through dust layer p 695 A91-40656

A method for calculating the characteristics of a rotor with allowance for shaft vibrations p 768 A91-41155

A chart of unstable aircraft motions due to cross constraints of various origins p 756 A91-41156

Gasdynamic interaction of flow with an oscillating shell p 703 A91-41157

Limiting thermal loads in porous structures p 768 A91-41159

An integrated automatic ramjet engine control system tolerant to failures of the functional components p 780 A91-41163

Design of a language processor for aviation engine testing p 760 A91-41164

Using implicit displacement expressions for obtaining a solution in the transition zone of a hybrid computation scheme p 768 A91-41168

Stabilization of the sling load of a helicopter p 756 A91-41169

Optimization of the turbofan engine control program during the cruising flight of subsonic transport aircraft p 743 A91-41170

Thermodynamic analysis of gas turbine engines and plants at high air pressure levels p 743 A91-41171

Release of benz(a)pyrene with the exhaust gases of gas turbine engines burning natural gas p 764 A91-41173

Characteristics of the working cycle of a low-pressure pneumatic nozzle with a sector structure of the fuel jet p 744 A91-41174

The level of self-oscillations of aerodynamic control surfaces under nonseparating transonic gas flow p 703 A91-41218

Determination of the stress-strain state of a soft lifting system p 704 A91-41320

Pareto-optimal shapes of axisymmetric bodies moving at high supersonic velocities p 707 A91-42330

Nonlinear oscillations of a heavy axisymmetric body in a resistant medium with drag p 784 A91-43169

Aluminium-lithium weldable alloy 1420 - Alloying system Al-Li-Mg-Zr p 765 A91-43891

Comparative analysis of turbofan effective thrust with mixed and separated flows engines
[AIAA PAPER 91-2376] p 754 A91-44216

Combined cycle aircraft engines
[AIAA PAPER 91-2377] p 754 A91-44217

UNITED KINGDOM

Some aspects of shock-wave boundary layer interaction at hypersonic speeds p 695 A91-40578

An experimental evaluation of thermochromic liquid crystals for surface temperature and heat flux measurements in shock tube flows p 767 A91-40645

A vertex-centroid scheme for improved finite-volume solution of the Navier-Stokes equations
[AIAA PAPER 91-1540] p 697 A91-40715

Dissipation additions to flux-difference splitting
[AIAA PAPER 91-1544] p 697 A91-40719

An Omega/VLF radio compass p 734 A91-41437

The European ATC system - Constraints and traffic management p 734 A91-41439

The progressive improvement of European flow-management p 734 A91-41440

The airline's perception of air traffic management p 734 A91-41441

Alternative strategies for traffic flow-management in Europe p 734 A91-41442

Computer-drawn charts for EROPS flights p 735 A91-41446

A new threat detection criterion for airborne collision avoidance systems p 735 A91-41447

ACAS in Europe - A U K view p 733 A91-41448

Condition monitoring of aircraft high lift systems p 738 A91-41535

The effects of bearing misalignment on the non-linear vibration of aero-engine rotor-damper assemblies p 744 A91-41536

HOTOL space transport for the twenty-first century p 763 A91-41537

Ground support equipment maintenance data analysis p 760 A91-41538

Twenty-first century aero-engine design - The environmental factor p 744 A91-41539

The design and commissioning of an acoustic liner for propeller noise testing in the ARA transonic wind tunnel p 783 A91-41540

The origins and evolution of design requirements for British military aircraft p 785 A91-41541

Re-engining - The sound case for aircraft noise reduction
[AIAA PAPER 91-2144] p 783 A91-41708

Visualization of airblast atomized spray structure under varying air pressure conditions
[AIAA PAPER 91-2199] p 769 A91-41726

Effect of model cooling on periodic transonic flow
[AIAA PAPER 91-1714] p 709 A91-42562

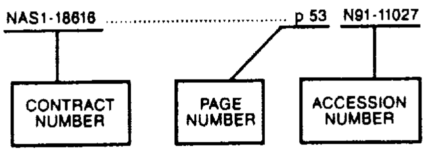
Numerical investigation of the flow within a turbofan lobed mixer p 749 A91-42812
Turbulent flow predictions for afterbody/nozzle geometries including base effects p 715 A91-42813
Sub-contractors play new strategic roles p 694 A91-43273
Visualization measurements of vortex flows p 716 A91-43309
A comparison of large AA8090, AA8091 and AA7010 die forgings for helicopter structural applications p 765 A91-43912
Intakes and boundary layer crossflows for hypersonic vehicles
[AIAA PAPER 91-2160] p 728 A91-44138
Creating a scene p 775 A91-44342

Y

YUGOSLAVIA
Analysis of structural damping of titanium alloy shell structures as compared with that of aluminium alloy structures p 765 A91-41606

CONTRACT NUMBER INDEX

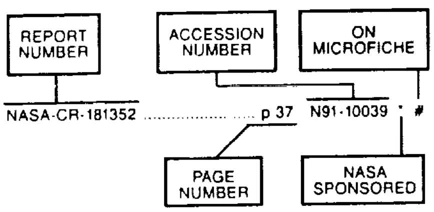
Typical Contract Number Index Listing



Listings in this index are arranged alphanumerically by contract number. Under each contract number, the accession numbers denoting documents that have been produced as a result of research done under the contract are shown. The accession number denotes the number by which the citation is identified in the abstract section. Preceding the accession number is the page number on which the citation may be found.

AF PROJ. 2304 .... p 732 N91-26117
AF PROJ. 2307 .... p 732 N91-26120
AF PROJ. 2308 .... p 766 N91-26281
AF PROJ. 7930 .... p 741 N91-26136
AF-AFOSR-ISSA-89-0067 .... p 722 A91-43590
AF-AFOSR-MIPR-90-0012 .... p 722 A91-43590
AF-AFOSR-0074-88 .... p 732 N91-26117
AF-AFOSR-0155-88 .... p 766 N91-26281
AF-AFOSR-0157-86 .... p 732 N91-26120
AF-AFOSR-86-0082 .... p 696 A91-40672
AF-AFOSR-86-0266 .... p 714 A91-42726
p 724 A91-43632
AF-AFOSR-88-0155 .... p 723 A91-43614
AF-AFOSR-88-0241 .... p 713 A91-42611
AF-AFOSR-88-0272 .... p 712 A91-42596
AF-AFOSR-89-0315 .... p 712 A91-42582
AF-AFOSR-89-0373 .... p 706 A91-41760
AF-AFOSR-89-0395 .... p 714 A91-42721
AF-AFOSR-90-0096 .... p 703 A91-40797
p 725 A91-43649
AF-AFOSR-90-0124 .... p 708 A91-42539
AF-AFOSR-90-0131 .... p 709 A91-42554
AF-AFOSR-90-0261 .... p 707 A91-42534
AF-AFOSR-90-0304 .... p 723 A91-43614
ATD-89-GNC-1504 .... p 742 N91-26140
DA PROJ. 1L1-62099-AH-76 .... p 778 N91-25412
DA PROJ. 1L1-62209-A-47A .... p 777 N91-25411
DAAG29-82-K-0093 .... p 770 A91-42294
DAAG29-84-K-0048 .... p 781 A91-43926
DAAL03-87-C-0008 .... p 710 A91-42572
DAAL03-87-G-0011 .... p 709 A91-42554
DAAL03-87-K-0037 .... p 741 N91-26134
DAAL03-88-C-0003 .... p 727 A91-43658
DAAL03-88-C-0004 .... p 770 A91-42294
DAAL03-89-C-0013 .... p 712 A91-42595
DAAL03-89-C-0032 .... p 724 A91-43642
DAAL03-91-G-0026 .... p 709 A91-42554
DACA88-85-M-0271 .... p 763 N91-26161
DACA88-85-M-0786 .... p 763 N91-26161
DACW88-85-D-0004 .... p 763 N91-26161
DASG60-86-C-0013 .... p 784 A91-44338
DE-AC04-76DP-00789 .... p 777 N91-25375
DE-AC05-84OR-21400 .... p 755 N91-25150
p 766 N91-26384
DFG-ZI-16/31 .... p 710 A91-42564
DRET-88-197 .... p 711 A91-42576
DTCG23-86-A-20022 .... p 737 N91-25141
DTFA01-89-C-00001 .... p 779 N91-26433
DTFA01-89-Z-02029 .... p 763 N91-26160
F08635-89-C-0196 .... p 762 A91-44264
F19628-90-C-0002 .... p 778 N91-26412
F33615-85-C-3022 .... p 764 A91-43311
F33615-87-C-1550 .... p 739 A91-42738
F33615-87-C-3606 .... p 739 A91-42818
F33615-88-C-2869 .... p 772 A91-43613
F33615-88-C-2904 .... p 723 A91-43612
F33615-89-C-2931 .... p 723 A91-43612
F33657-87-C-2214 .... p 749 A91-43585
p 749 A91-43586
p 724 A91-43635
F40600-82-C-0005 .... p 762 A91-44334
F40600-84-C-0010 .... p 762 A91-44334
F49620-79-C-0189 .... p 749 A91-42821
F49620-86-C-0008 .... p 743 N91-26143
F49620-88-C-0098 .... p 779 N91-26477
NAGW-1331 .... p 696 A91-40706
NAG1-1061 .... p 762 A91-44264
NAG1-1133 .... p 731 N91-25107
NAG1-1138 .... p 724 A91-43634
NAG1-1188 .... p 699 A91-40751
NAG1-1265 .... p 722 A91-43589
NAG1-327 .... p 762 A91-44264
NAG1-423 .... p 725 A91-43643
NAG1-507 .... p 714 A91-42721
NAG1-648 .... p 725 A91-43647
NAG1-664 .... p 707 A91-42284
p 732 N91-26123
NAG1-722 .... p 785 N91-26889
NAG1-855 .... p 714 A91-42721
NAG1-869 .... p 697 A91-40717
NAG1-880 .... p 739 A91-43596
p 740 A91-43597
NAG1-891 .... p 696 A91-40672
NAG2-565 .... p 711 A91-42581
NAG2-596 .... p 781 A91-44266
NAG2-665 .... p 699 A91-40745
NAG3-1144 .... p 745 A91-41705
NAG3-1163 .... p 775 A91-44319
NAG3-1192 .... p 730 A91-44318
NAG3-1194 .... p 774 A91-44167
NAG3-1232 .... p 745 A91-41671
NAG3-481 .... p 750 A91-44049
NAG3-566 .... p 771 A91-43310
NAG3-742 .... p 775 A91-44319
NAG3-860 .... p 750 A91-44051
NASA ORDER C-30002-M .... p 746 A91-41759
NAS1-15327 .... p 716 A91-43307
NAS1-18240 .... p 720 A91-43564
p 720 A91-43571
NAS1-18458 .... p 726 A91-43656
NAS1-18570 .... p 724 A91-43634
NAS1-18585 .... p 705 A91-41735
p 720 A91-43565
NAS1-18586 .... p 783 N91-26797
NAS1-18605 .... p 720 A91-43564
NAS1-18849 .... p 784 A91-44174
NAS1-19000 .... p 705 A91-41735
NAS1-19320 .... p 720 A91-43572
NAS2-12393 .... p 734 N91-26126
NAS2-12722 .... p 742 N91-26140
NAS2-12961 .... p 696 A91-40712
NAS2-13041 .... p 742 N91-26139
NAS2-13070 .... p 746 A91-41709
NAS3-24816 .... p 779 N91-26490
NAS3-25266 .... p 775 A91-44319
NAS3-25366 .... p 723 A91-43631
NAS3-25416 .... p 774 A91-44159
NAS3-25423 .... p 769 A91-41650
NAS3-25454 .... p 769 A91-41648
NAS3-25829 .... p 784 A91-44174
NAS3-25834 .... p 756 N91-26146
NAS3-25967 .... p 747 A91-41788
NAS8-37893 .... p 780 N91-25553
NCA2-192 .... p 696 A91-40672
NCA2-446 .... p 718 A91-43554
NCA2-540 .... p 696 A91-40706
NCC1-100 .... p 717 A91-43417
NCC1-24 .... p 726 A91-43656
NCC1-98 .... p 723 A91-43615
NCC2-420 .... p 701 A91-40768
p 719 A91-43581
NCC2-458 .... p 709 A91-42550
NCC2-493 .... p 742 A91-43482
NCC2-583 .... p 719 A91-43581
NCC2-630 .... p 719 A91-43559
NGL-31-001-252 .... p 781 A91-43926
NGT-50172 .... p 724 A91-43633
NSC-78-0210-D002-11 .... p 702 A91-40795
NSERC-A-7928 .... p 744 A91-41641
NSF CTS-89-57213 .... p 707 A91-42534
NSF DMC-86-57917 .... p 767 A91-40743
p 722 A91-43589
NSF DMS-87-03971 .... p 708 A91-42544
NSF DMS-89-06292 .... p 707 A91-42534
NSF ECE-85-16915 .... p 770 A91-42292
NSF EET-88-57500 .... p 697 A91-40717
NSF ENG-78-12901 .... p 770 A91-42258
NSF ISI-89-60133 .... p 708 A91-42544
NSF MEA-82-11713 .... p 770 A91-42258
NSG-1321 .... p 713 A91-42630
N00014-81-C-0692 .... p 779 A91-42224
N00014-86-K-0759 .... p 708 A91-42539
N00014-89-J-1350 .... p 766 N91-26249
N00014-89-J-1448 .... p 714 A91-42721
N00014-89-J-1836 .... p 784 N91-26878
N00014-90-J-1182 .... p 701 A91-40770
N00014-90-J-1315 .... p 707 A91-42534
N00014-91-C-0001 .... p 775 N91-25336
N00140-88-C-0677 .... p 756 N91-26145
N00167-86-K-0019 .... p 707 A91-42298
N00167-87-C-0021 .... p 784 A91-43514
N60530-87-WR-30009 .... p 748 A91-42805
W-31-109-ENG-38 .... p 777 N91-25408
505-35-31 .... p 743 N91-26142
505-59-36 .... p 694 N91-25102
505-60-01-01 .... p 782 N91-25623
505-61-00 .... p 776 N91-25352
505-62-OK .... p 778 N91-25412
505-62-10 .... p 755 N91-25148
505-63-36-06 .... p 741 N91-26137
505-63-5B .... p 778 N91-25413
505-63-51 .... p 777 N91-25411
505-64-10-07 .... p 783 N91-26797
505-64-36 .... p 737 N91-25142
505-66-41-04 .... p 758 N91-25151
505-66-71 .... p 742 N91-26140
532-06-37 .... p 742 N91-26139
532-09-01 .... p 778 N91-25422
533-02-21 .... p 755 N91-25147
533-02-51 .... p 694 N91-26113
535-03-10 .... p 731 N91-25106
537-02-21 .... p 756 N91-26146
763-01-31-22 .... p 730 N91-25103

Typical Report Number Index Listing



Listings in this index are arranged alphanumerically by report number. The page number indicates the page on which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

A-85126 .... p 743 N91-26142 * #
A-90084 .... p 776 N91-25352 * #
A-90263 .... p 694 N91-25102 * #
A-91140 .... p 737 N91-25142 * #
A-91159 .... p 742 N91-26139 * #

AD-A233221 .... p 737 N91-25141 #
AD-A233674 .... p 767 N91-26387 #
AD-A233724 .... p 778 N91-26412 #
AD-A233811 .... p 766 N91-26249 #
AD-A233944 .... p 741 N91-26131 #
AD-A233991 .... p 784 N91-26878 #
AD-A234385 .... p 733 N91-26125 #
AD-A234730 .... p 732 N91-26117 #
AD-A234758 .... p 758 N91-26148 #
AD-A234775 .... p 741 N91-26134 #
AD-A234797 .... p 766 N91-26300 #
AD-A234978 .... p 741 N91-26135 #
AD-A234990 .... p 758 N91-26149 #
AD-A235083 .... p 741 N91-26136 #
AD-A235143 .... p 756 N91-26144 #
AD-A235190 .... p 779 N91-26477 #
AD-A235241 .... p 732 N91-26120 #
AD-A235278 .... p 766 N91-26281 #
AD-A235301 .... p 737 N91-26130 #
AD-A235419 .... p 785 N91-26995 #
AD-A235420 .... p 756 N91-26145 #

AD-D014822 .... p 733 N91-25120 #

AFOSR-91-0235TR .... p 779 N91-26477 #
AFOSR-91-0272TR .... p 732 N91-26117 #
AFOSR-91-0380TR .... p 732 N91-26120 #

AGARD-AG-160-VOL-19 .... p 778 N91-26432 #
AGARD-AG-299 .... p 775 N91-25302 #
AGARD-AG-317 .... p 758 N91-26150 #
AGARD-AG-318(E) .... p 733 N91-26124 #

AGARD-AR-279 .... p 740 N91-25146 #
AGARD-AR-296 .... p 783 N91-25750 #
AGARD-AR-300 .... p 733 N91-25119 #

AGARD-CP-474 .... p 736 N91-25121 #

AIAA PAPER 91-1313 .... p 716 A91-43385 * #
AIAA PAPER 91-1315 .... p 716 A91-43387 * #
AIAA PAPER 91-1316 .... p 717 A91-43388 * #
AIAA PAPER 91-1317 .... p 717 A91-43389 #
AIAA PAPER 91-1348 .... p 717 A91-43417 * #
AIAA PAPER 91-1382 .... p 771 A91-43446 * #
AIAA PAPER 91-1383 .... p 772 A91-43447 #
AIAA PAPER 91-1389 .... p 717 A91-43452 * #
AIAA PAPER 91-1390 .... p 717 A91-43453 #
AIAA PAPER 91-1416 .... p 772 A91-43477 #
AIAA PAPER 91-1423 .... p 742 A91-43482 * #
AIAA PAPER 91-1435 .... p 717 A91-43494 * #
AIAA PAPER 91-1439 .... p 764 A91-44338 #
AIAA PAPER 91-1441 .... p 764 A91-43498 #
AIAA PAPER 91-1455 .... p 772 A91-43528 #
AIAA PAPER 91-1496 .... p 718 A91-43547 * #
AIAA PAPER 91-1527 .... p 696 A91-40703 #
AIAA PAPER 91-1528 .... p 740 A91-43673 #
AIAA PAPER 91-1530 .... p 696 A91-40705 * #
AIAA PAPER 91-1531 .... p 696 A91-40706 #
AIAA PAPER 91-1533 .... p 696 A91-40708 #
AIAA PAPER 91-1537 .... p 696 A91-40712 #
AIAA PAPER 91-1540 .... p 697 A91-40715 #
AIAA PAPER 91-1542 .... p 697 A91-40717 * #
AIAA PAPER 91-1543 .... p 697 A91-40718 * #
AIAA PAPER 91-1544 .... p 697 A91-40719 #
AIAA PAPER 91-1546 .... p 697 A91-40721 * #
AIAA PAPER 91-1547 .... p 697 A91-40722 #
AIAA PAPER 91-1548 .... p 697 A91-40723 * #
AIAA PAPER 91-1551 .... p 767 A91-40725 #
AIAA PAPER 91-1553 .... p 698 A91-40727 #
AIAA PAPER 91-1555 .... p 698 A91-40729 * #
AIAA PAPER 91-1556 .... p 698 A91-40730 * #
AIAA PAPER 91-1558 .... p 698 A91-40732 #
AIAA PAPER 91-1559 .... p 698 A91-40733 #
AIAA PAPER 91-1566 .... p 698 A91-40740 * #
AIAA PAPER 91-1569 .... p 767 A91-40743 #
AIAA PAPER 91-1571 .... p 699 A91-40745 * #
AIAA PAPER 91-1572 .... p 699 A91-40746 * #
AIAA PAPER 91-1573 .... p 699 A91-40747 #
AIAA PAPER 91-1574 .... p 699 A91-40748 * #
AIAA PAPER 91-1575 .... p 699 A91-40749 * #
AIAA PAPER 91-1577 .... p 699 A91-40751 * #
AIAA PAPER 91-1579 .... p 700 A91-40753 * #
AIAA PAPER 91-1580 .... p 700 A91-40754 #
AIAA PAPER 91-1584 .... p 700 A91-40758 * #
AIAA PAPER 91-1585 .... p 700 A91-40759 #
AIAA PAPER 91-1587 .... p 700 A91-40761 #
AIAA PAPER 91-1589 .... p 700 A91-40763 #
AIAA PAPER 91-1591 .... p 701 A91-40765 #
AIAA PAPER 91-1592 .... p 701 A91-40766 * #
AIAA PAPER 91-1593 .... p 701 A91-40767 #
AIAA PAPER 91-1594 .... p 701 A91-40768 * #
AIAA PAPER 91-1595 .... p 701 A91-40769 #
AIAA PAPER 91-1596 .... p 727 A91-43675 #
AIAA PAPER 91-1597 .... p 701 A91-40770 #
AIAA PAPER 91-1598 .... p 702 A91-40771 #
AIAA PAPER 91-1603 .... p 702 A91-40775 #
AIAA PAPER 91-1604 .... p 702 A91-40776 #
AIAA PAPER 91-1606 .... p 702 A91-40778 #
AIAA PAPER 91-1607 .... p 702 A91-40779 * #
AIAA PAPER 91-1620 .... p 718 A91-43554 * #
AIAA PAPER 91-1621 .... p 718 A91-43555 #
AIAA PAPER 91-1622 .... p 707 A91-42534 #
AIAA PAPER 91-1623 .... p 707 A91-42535 #
AIAA PAPER 91-1624 .... p 718 A91-43556 * #
AIAA PAPER 91-1625 .... p 719 A91-43557 #
AIAA PAPER 91-1626 .... p 708 A91-42536 * #
AIAA PAPER 91-1627 .... p 719 A91-43558 #
AIAA PAPER 91-1628 .... p 719 A91-43559 * #
AIAA PAPER 91-1629 .... p 708 A91-42537 #
AIAA PAPER 91-1630 .... p 708 A91-42538 * #
AIAA PAPER 91-1631 .... p 784 A91-43560 * #
AIAA PAPER 91-1632 .... p 719 A91-43561 * #
AIAA PAPER 91-1634 .... p 719 A91-43562 * #
AIAA PAPER 91-1635 .... p 719 A91-43563 * #
AIAA PAPER 91-1636 .... p 720 A91-43564 * #
AIAA PAPER 91-1637 .... p 708 A91-42539 #
AIAA PAPER 91-1638 .... p 720 A91-43565 * #
AIAA PAPER 91-1641 .... p 720 A91-43567 #
AIAA PAPER 91-1646 .... p 720 A91-43571 * #
AIAA PAPER 91-1647 .... p 720 A91-43572 * #
AIAA PAPER 91-1648 .... p 708 A91-42542 * #
AIAA PAPER 91-1653 .... p 708 A91-42544 #
AIAA PAPER 91-1657 .... p 708 A91-42547 #
AIAA PAPER 91-1659 .... p 720 A91-43574 #
AIAA PAPER 91-1660 .... p 720 A91-43575 * #
AIAA PAPER 91-1662 .... p 721 A91-43577 #
AIAA PAPER 91-1664 .... p 709 A91-42550 * #
AIAA PAPER 91-1669 .... p 721 A91-43580 #
AIAA PAPER 91-1674 .... p 721 A91-43584 #
AIAA PAPER 91-1675 .... p 749 A91-43585 #
AIAA PAPER 91-1676 .... p 749 A91-43586 #
AIAA PAPER 91-1677 .... p 721 A91-43587 #
AIAA PAPER 91-1679 .... p 721 A91-43588 #
AIAA PAPER 91-1680 .... p 722 A91-43589 * #
AIAA PAPER 91-1683 .... p 722 A91-43590 * #
AIAA PAPER 91-1684 .... p 709 A91-42553 #
AIAA PAPER 91-1685 .... p 709 A91-42554 #
AIAA PAPER 91-1687 .... p 761 A91-43592 #
AIAA PAPER 91-1689 .... p 748 A91-42556 * #
AIAA PAPER 91-1690 .... p 772 A91-43593 * #
AIAA PAPER 91-1693 .... p 739 A91-43594 #
AIAA PAPER 91-1694 .... p 709 A91-42558 * #
AIAA PAPER 91-1695 .... p 722 A91-43595 * #
AIAA PAPER 91-1696 .... p 739 A91-43596 * #
AIAA PAPER 91-1697 .... p 740 A91-43597 * #
AIAA PAPER 91-1698 .... p 709 A91-42559 #
AIAA PAPER 91-1699 .... p 722 A91-43598 #
AIAA PAPER 91-1703 .... p 722 A91-43602 #
AIAA PAPER 91-1706 .... p 722 A91-43604 * #
AIAA PAPER 91-1707 .... p 761 A91-42560 #
AIAA PAPER 91-1709 .... p 709 A91-42561 * #
AIAA PAPER 91-1712 .... p 762 A91-44334 #
AIAA PAPER 91-1714 .... p 709 A91-42562 #
AIAA PAPER 91-1716 .... p 710 A91-42564 #
AIAA PAPER 91-1721 .... p 723 A91-43612 #
AIAA PAPER 91-1723 .... p 772 A91-43613 #
AIAA PAPER 91-1724 .... p 723 A91-43614 #
AIAA PAPER 91-1725 .... p 723 A91-43615 * #
AIAA PAPER 91-1728 .... p 723 A91-43617 #
AIAA PAPER 91-1730 .... p 710 A91-42567 #
AIAA PAPER 91-1731 .... p 723 A91-43619 * #
AIAA PAPER 91-1733 .... p 710 A91-42568 #
AIAA PAPER 91-1740 .... p 710 A91-42571 #
AIAA PAPER 91-1742 .... p 710 A91-42572 #
AIAA PAPER 91-1749 .... p 710 A91-42573 #
AIAA PAPER 91-1752 .... p 711 A91-42574 #
AIAA PAPER 91-1753 .... p 711 A91-42575 #
AIAA PAPER 91-1754 .... p 711 A91-42576 #
AIAA PAPER 91-1755 .... p 723 A91-43629 #
AIAA PAPER 91-1756 .... p 711 A91-42577 #
AIAA PAPER 91-1758 .... p 723 A91-43631 * #
AIAA PAPER 91-1759 .... p 724 A91-43632 * #
AIAA PAPER 91-1762 .... p 711 A91-42580 #
AIAA PAPER 91-1763 .... p 711 A91-42581 * #
AIAA PAPER 91-1764 .... p 724 A91-43633 #
AIAA PAPER 91-1765 .... p 724 A91-43634 * #
AIAA PAPER 91-1766 .... p 724 A91-43635 #
AIAA PAPER 91-1768 .... p 712 A91-42582 #
AIAA PAPER 91-1773 .... p 724 A91-43638 * #
AIAA PAPER 91-1785 .... p 724 A91-43642 * #
AIAA PAPER 91-1786 .... p 725 A91-43643 * #
AIAA PAPER 91-1791 .... p 712 A91-42594 #
AIAA PAPER 91-1793 .... p 725 A91-43646 #
AIAA PAPER 91-1795 .... p 712 A91-42595 #
AIAA PAPER 91-1796 .... p 725 A91-43647 * #
AIAA PAPER 91-1797 .... p 712 A91-42596 #
AIAA PAPER 91-1798 .... p 712 A91-42597 #
AIAA PAPER 91-1799 .... p 725 A91-43648 * #
AIAA PAPER 91-1802 .... p 725 A91-43649 #
AIAA PAPER 91-1804 .... p 725 A91-43650 * #
AIAA PAPER 91-1806 .... p 771 A91-42602 #
AIAA PAPER 91-1807 .... p 712 A91-42603 #
AIAA PAPER 91-1808 .... p 726 A91-43651 #
AIAA PAPER 91-1809 .... p 726 A91-43652 #
AIAA PAPER 91-1810 .... p 713 A91-42604 #
AIAA PAPER 91-1811 .... p 726 A91-43653 #
AIAA PAPER 91-1812 .... p 713 A91-42605 #
AIAA PAPER 91-1813 .... p 726 A91-43654 #
AIAA PAPER 91-1814 .... p 726 A91-43655 #
AIAA PAPER 91-1815 .... p 726 A91-43656 * #
AIAA PAPER 91-1818 .... p 726 A91-43657 * #
AIAA PAPER 91-1819 .... p 727 A91-43658 #
AIAA PAPER 91-1821 .... p 713 A91-42609 #
AIAA PAPER 91-1824 .... p 713 A91-42611 #
AIAA PAPER 91-1825 .... p 713 A91-42612 #
AIAA PAPER 91-1826 .... p 727 A91-43659 #
AIAA PAPER 91-1879 .... p 744 A91-41641 #
AIAA PAPER 91-1890 .... p 693 A91-41643 #
AIAA PAPER 91-1892 .... p 750 A91-44045 #
AIAA PAPER 91-1893 .... p 750 A91-44046 #
AIAA PAPER 91-1895 .... p 773 A91-44047 #
AIAA PAPER 91-1896 .... p 727 A91-44048 #
AIAA PAPER 91-1897 .... p 750 A91-44049 * #
AIAA PAPER 91-1898 .... p 704 A91-41644 * #

AIAA PAPER 91-1900 p 704 A91-41645 * #
AIAA PAPER 91-1902 p 750 A91-44050 * #
AIAA PAPER 91-1903 p 750 A91-44051 * #
AIAA PAPER 91-1904 p 744 A91-41646 #
AIAA PAPER 91-1905 p 768 A91-41647 #
AIAA PAPER 91-1906 p 769 A91-41648 * #
AIAA PAPER 91-1909 p 769 A91-41650 * #
AIAA PAPER 91-1910 p 769 A91-41651 #
AIAA PAPER 91-1911 p 744 A91-41652 #
AIAA PAPER 91-1912 p 750 A91-44053 #
AIAA PAPER 91-1913 p 773 A91-44054 #
AIAA PAPER 91-1914 p 750 A91-44055 * #
AIAA PAPER 91-1916 p 773 A91-44057 * #
AIAA PAPER 91-1919 p 745 A91-41653 * #
AIAA PAPER 91-1922 p 751 A91-44059 * #
AIAA PAPER 91-1962 p 751 A91-44075 #
AIAA PAPER 91-1965 p 751 A91-44077 #
AIAA PAPER 91-1967 p 773 A91-44078 #
AIAA PAPER 91-1998 p 751 A91-44089 * #
AIAA PAPER 91-2000 p 745 A91-41671 * #
AIAA PAPER 91-2003 p 745 A91-41672 #
AIAA PAPER 91-2004 p 704 A91-41673 #
AIAA PAPER 91-2007 p 769 A91-41676 #
AIAA PAPER 91-2008 p 751 A91-44090 #
AIAA PAPER 91-2011 p 727 A91-44091 #
AIAA PAPER 91-2012 p 751 A91-44092 #
AIAA PAPER 91-2017 p 727 A91-44093 #
AIAA PAPER 91-2024 p 752 A91-44094 #
AIAA PAPER 91-2026 p 752 A91-44095 #
AIAA PAPER 91-2028 p 752 A91-44096 #
AIAA PAPER 91-2030 p 727 A91-44097 #
AIAA PAPER 91-2031 p 752 A91-44098 #
AIAA PAPER 91-2032 p 745 A91-41684 #
AIAA PAPER 91-2033 p 773 A91-44099 #
AIAA PAPER 91-2076 p 773 A91-44116 #
AIAA PAPER 91-2096 p 728 A91-44127 #
AIAA PAPER 91-2101 p 745 A91-41696 #
AIAA PAPER 91-2130 p 704 A91-41704 #
AIAA PAPER 91-2131 p 761 A91-44132 #
AIAA PAPER 91-2132 p 745 A91-41705 * #
AIAA PAPER 91-2133 p 752 A91-44133 #
AIAA PAPER 91-2134 p 752 A91-44134 * #
AIAA PAPER 91-2136 p 738 A91-41706 * #
AIAA PAPER 91-2137 p 745 A91-41707 * #
AIAA PAPER 91-2144 p 783 A91-41708 #
AIAA PAPER 91-2147 p 746 A91-41709 * #
AIAA PAPER 91-2148 p 693 A91-41710 #
AIAA PAPER 91-2149 p 693 A91-41711 * #
AIAA PAPER 91-2150 p 752 A91-44135 #
AIAA PAPER 91-2154 p 705 A91-41713 * #
AIAA PAPER 91-2155 p 728 A91-44137 #
AIAA PAPER 91-2156 p 738 A91-41714 #
AIAA PAPER 91-2160 p 728 A91-44138 #
AIAA PAPER 91-2161 p 753 A91-44139 #
AIAA PAPER 91-2163 p 753 A91-44141 #
AIAA PAPER 91-2199 p 769 A91-41726 #
AIAA PAPER 91-2201 p 753 A91-44153 * #
AIAA PAPER 91-2217 p 774 A91-44159 * #
AIAA PAPER 91-2222 p 756 A91-41731 * #
AIAA PAPER 91-2223 p 757 A91-44162 * #
AIAA PAPER 91-2233 p 746 A91-41733 #
AIAA PAPER 91-2237 p 728 A91-44164 #
AIAA PAPER 91-2239 p 728 A91-44165 #
AIAA PAPER 91-2240 p 774 A91-44166 #
AIAA PAPER 91-2241 p 774 A91-44167 * #
AIAA PAPER 91-2242 p 753 A91-44168 #
AIAA PAPER 91-2243 p 753 A91-44169 #
AIAA PAPER 91-2244 p 705 A91-41734 #
AIAA PAPER 91-2250 p 705 A91-41735 * #
AIAA PAPER 91-2253 p 774 A91-44171 * #
AIAA PAPER 91-2255 p 728 A91-44173 #
AIAA PAPER 91-2256 p 784 A91-44174 #
AIAA PAPER 91-2258 p 728 A91-44176 #
AIAA PAPER 91-2263 p 705 A91-41738 * #
AIAA PAPER 91-2266 p 774 A91-44180 * #
AIAA PAPER 91-2268 p 705 A91-41739 * #
AIAA PAPER 91-2270 p 705 A91-41740 #
AIAA PAPER 91-2273 p 760 A91-41741 * #
AIAA PAPER 91-2274 p 761 A91-44183 #
AIAA PAPER 91-2353 p 746 A91-41758 #
AIAA PAPER 91-2354 p 753 A91-44208 #
AIAA PAPER 91-2358 p 746 A91-41759 * #
AIAA PAPER 91-2360 p 753 A91-44209 #
AIAA PAPER 91-2364 p 706 A91-41760 #
AIAA PAPER 91-2368 p 746 A91-41761 #
AIAA PAPER 91-2369 p 706 A91-41762 * #
AIAA PAPER 91-2372 p 729 A91-44215 #
AIAA PAPER 91-2373 p 747 A91-41764 #
AIAA PAPER 91-2374 p 693 A91-41765 #
AIAA PAPER 91-2376 p 754 A91-44216 #
AIAA PAPER 91-2377 p 754 A91-44217 #
AIAA PAPER 91-2380 p 754 A91-44218 #
AIAA PAPER 91-2382 p 754 A91-44219 #
AIAA PAPER 91-2390 p 747 A91-41767 #
AIAA PAPER 91-2394 p 747 A91-41768 * #
AIAA PAPER 91-2395 p 754 A91-44225 #
AIAA PAPER 91-2460 p 747 A91-41788 * #
AIAA PAPER 91-2463 p 754 A91-44250 * #
AIAA PAPER 91-2468 p 729 A91-44254 #
AIAA PAPER 91-2470 p 774 A91-44255 #
AIAA PAPER 91-2472 p 729 A91-44257 #
AIAA PAPER 91-2473 p 775 A91-44258 #
AIAA PAPER 91-2474 p 729 A91-44259 * #
AIAA PAPER 91-2477 p 729 A91-44260 #
AIAA PAPER 91-2478 p 754 A91-44261 #
AIAA PAPER 91-2480 p 747 A91-41791 #
AIAA PAPER 91-2481 p 730 A91-44263 #
AIAA PAPER 91-2489 p 762 A91-44264 * #
AIAA PAPER 91-2491 p 738 A91-41796 #
AIAA PAPER 91-2493 p 769 A91-41798 #
AIAA PAPER 91-2494 p 747 A91-41799 * #
AIAA PAPER 91-2498 p 747 A91-41801 #
AIAA PAPER 91-2499 p 755 A91-44265 #
AIAA PAPER 91-2500 p 781 A91-44266 * #
AIAA PAPER 91-2501 p 761 A91-41802 #
AIAA PAPER 91-2502 p 762 A91-44267 * #
AIAA PAPER 91-2508 p 780 A91-41805 #
AIAA PAPER 91-2527 p 748 A91-41808 #
AIAA PAPER 91-2544 p 730 A91-44287 #
AIAA PAPER 91-2545 p 748 A91-41810 #
AIAA PAPER 91-2558 p 738 A91-41813 #
AIAA PAPER 91-2564 p 748 A91-41815 * #
AIAA PAPER 91-2565 p 775 A91-44295 * #
AIAA PAPER 91-2591 p 755 A91-44303 #
AIAA PAPER 91-2599 p 730 A91-44304 * #
AIAA PAPER 91-3378 p 730 A91-44318 * #
AIAA PAPER 91-3379 p 775 A91-44319 * #
AIAA PAPER 91-3380 p 730 A91-44320 #
AIAA PAPER 91-3382 p 775 A91-44321 #
AIAA PAPER 91-3399 p 755 A91-44329 #

AIAA-91-2010 p 755 N91-25148 * #
AIAA-91-3354 p 731 N91-25106 * #

ANL/CP-72295 p 777 N91-25408 #

ARO-24738.7-EG p 741 N91-26134 #

ASD-TR-90-5010 p 733 N91-26125 #
ASD-TR-90-5014 p 785 N91-26995 #
ASD-TR-90-5018 p 741 N91-26131 #
ASD-TR-91-5004-STUDY-1 p 737 N91-26130 #

ASME-91-GT-217 p 756 N91-26146 * #

AVSCOM-TR-90-C-002 p 777 N91-25411 * #
AVSCOM-TR-91-C-032 p 778 N91-25412 * #

CONF-9104211-1 p 777 N91-25408 #
CONF-9104214-1 p 755 N91-25150 #

CPIA-PUBL-551 p 775 N91-25336 #

CRC-573 p 756 N91-26144 #

DE91-010451 p 766 N91-26384 #
DE91-010787 p 755 N91-25150 #
DE91-010813 p 777 N91-25408 #
DE91-010874 p 777 N91-25375 #

DOT-VNTSC-FA1J1-91-7-VOL-1 p 762 N91-25154 #

DOT/FAA/CT-TN90/63 p 694 N91-25100 #
DOT/FAA/CT-TN91/18 p 762 N91-25152 #
DOT/FAA/CT-TN91/3 p 762 N91-25153 #

DOT/FAA/CT-91/12 p 779 N91-26433 #

DOT/FAA/RD-90/28 p 763 N91-26160 #
DOT/FAA/RD-90/31 p 763 N91-26161 #
DOT/FAA/RD-91/15-VOL-1 p 762 N91-25154 #

D6-55699-1-PHASE-2 p 734 N91-26126 * #

E-5910 p 777 N91-25411 * #
E-6246 p 779 N91-26490 * #
E-6261 p 731 N91-25106 * #
E-6288 p 755 N91-25148 * #
E-6309 p 778 N91-25413 * #
E-6313 p 756 N91-26146 * #
E-6321 p 778 N91-25412 * #

ENF-TM-90-6 p 741 N91-26131 #

ESD-TR-90-133 p 778 N91-26412 #

FFA-147 p 779 N91-26466 #

FTD-ID(RS)T-0754-90 p 766 N91-26300 #
FTD-ID(RS)T-1276-90 p 758 N91-26148 #

H-1543 p 694 N91-26113 * #
H-1609 p 742 N91-26140 * #
H-1616 p 755 N91-25147 * #
H-1694 p 778 N91-25422 * #

ISBN-0-8330-1026-3 p 743 N91-26143 #
ISBN-92-835-0455-0 p 775 N91-25302 #
ISBN-92-835-0609-X p 740 N91-25146 #
ISBN-92-835-0610-3 p 736 N91-25121 #
ISBN-92-835-0613-8 p 733 N91-26124 #
ISBN-92-835-0615-4 p 783 N91-25750 #
ISBN-92-835-0617-0 p 758 N91-26150 #
ISBN-92-835-0619-7 p 733 N91-25119 #
ISBN-92-835-0621-9 p 778 N91-26432 #

ISSN-0389-4010 p 732 N91-25114 #
ISSN-0389-4010 p 732 N91-25115 #
ISSN-0389-4010 p 732 N91-25116 #
ISSN-0389-4010 p 740 N91-25145 #
ISSN-0389-4010 p 777 N91-25366 #

ITN-91-85104 p 779 N91-26482

L-16801 p 758 N91-25151 * #
L-16861 p 730 N91-25103 * #

LC-89-70202 p 743 N91-26143 #

MTR-90W00164 p 779 N91-26433 #

NADC-91004-60 p 758 N91-26149 #

NAL-TR-1076 p 732 N91-25116 #
NAL-TR-1077 p 777 N91-25366 #
NAL-TR-1081 p 784 N91-25815 #
NAL-TR-1083 p 740 N91-25145 #
NAL-TR-1087 p 732 N91-25115 #
NAL-TR-1088T p 732 N91-25114 #

NAS 1.15:103691 p 777 N91-25411 * #
NAS 1.15:103846 p 694 N91-25102 * #
NAS 1.15:103861 p 737 N91-25142 * #
NAS 1.15:104054 p 741 N91-26137 * #
NAS 1.15:104090 p 786 N91-26112 * #
NAS 1.15:104092 p 782 N91-25623 * #
NAS 1.15:104233 p 755 N91-25147 * #
NAS 1.15:104415 p 779 N91-26490 * #
NAS 1.15:104428 p 731 N91-25106 * #
NAS 1.15:104447 p 755 N91-25148 * #
NAS 1.15:104465 p 778 N91-25413 * #
NAS 1.15:104466 p 756 N91-26146 * #
NAS 1.15:104474 p 778 N91-25412 * #
NAS 1.15:4290 p 778 N91-25422 * #
NAS 1.15:86680 p 743 N91-26142 * #
NAS 1.26:177576 p 734 N91-26126 * #
NAS 1.26:177585 p 742 N91-26139 * #
NAS 1.26:185343 p 732 N91-26123 * #
NAS 1.26:185453 p 785 N91-26889 * #
NAS 1.26:186013 p 742 N91-26140 * #
NAS 1.26:187522 p 783 N91-26797 * #
NAS 1.26:188499 p 731 N91-25107 * #
NAS 1.26:188601 p 780 N91-25553 * #
NAS 1.60:3051 p 758 N91-25151 * #
NAS 1.60:3092 p 730 N91-25103 * #
NAS 1.60:3118 p 776 N91-25352 * #
NAS 1.60:3120 p 694 N91-26113 * #
NAS 1.71:MFS-28493-1 p 763 N91-25155 * #

NASA-CASE-MFS-28493-1 p 763 N91-25155 * #

NASA-CR-177576 p 734 N91-26126 * #
NASA-CR-177585 p 742 N91-26139 * #
NASA-CR-185343 p 732 N91-26123 * #
NASA-CR-185453 p 785 N91-26889 * #
NASA-CR-186013 p 742 N91-26140 * #
NASA-CR-187522 p 783 N91-26797 * #
NASA-CR-188499 p 731 N91-25107 * #
NASA-CR-188601 p 780 N91-25553 * #

NASA-TM-103691 p 777 N91-25411 * #
NASA-TM-103846 p 694 N91-25102 * #
NASA-TM-103861 p 737 N91-25142 * #
NASA-TM-104054 p 741 N91-26137 * #
NASA-TM-104090 p 786 N91-26112 * #
NASA-TM-104092 p 782 N91-25623 * #
NASA-TM-104233 p 755 N91-25147 * #
NASA-TM-104415 p 779 N91-26490 * #
NASA-TM-104428 p 731 N91-25106 * #
NASA-TM-104447 p 755 N91-25148 * #
NASA-TM-104465 p 778 N91-25413 * #
NASA-TM-104466 p 756 N91-26146 * #
NASA-TM-104474 p 778 N91-25412 * #
NASA-TM-4290 p 778 N91-25422 * #
NASA-TM-86680 p 743 N91-26142 * #

NASA-TP-3051 p 758 N91-25151 * #
NASA-TP-3092 p 730 N91-25103 * #

NASA-TP-3118 .... p 776 N91-25352 * #
NASA-TP-3120 .... p 694 N91-26113 * #

ORNL/TM-11719 .... p 766 N91-26384 #

R/DC-10/89 .... p 737 N91-25141 #

RAND-P-7661-RGS .... p 778 N91-26431 #
RAND-P-7680-RGS .... p 741 N91-26138 #

RAND-R-3843-AF .... p 743 N91-26143 #

REPT-1-5-36452 .... p 779 N91-26477 #

SAND-91-0884C .... p 777 N91-25375 #

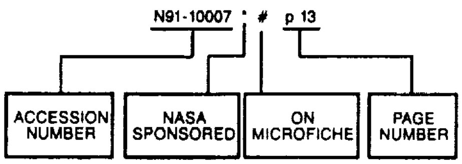
TR-68 .... p 766 N91-26249 #
TR-904 .... p 778 N91-26412 #

US-PATENT-APPL-SN-589703 ..... p 733 N91-25120 #
US-PATENT-APPL-SN-678780 ..... p 763 N91-25155 * #

USAFSAM-TP-90-22 .... p 741 N91-26136 #

USCG-D-13-90 .... p 737 N91-25141 #

Typical Accession Number Index Listing



Listings in this index are arranged alphanumerically by accession number. The page number listed to the right indicates the page on which the citation is located. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

A91-40569 # p 694
A91-40575 p 695
A91-40578 p 695
A91-40604 p 695
A91-40637 p 759
A91-40638 p 759
A91-40640 * p 760
A91-40641 p 760
A91-40645 p 767
A91-40646 p 695
A91-40647 p 695
A91-40649 p 760
A91-40656 p 695
A91-40672 p 696
A91-40701 p 767
A91-40703 # p 696
A91-40705 * # p 696
A91-40706 # p 696
A91-40708 # p 696
A91-40712 # p 696
A91-40715 # p 697
A91-40717 * # p 697
A91-40718 * # p 697
A91-40719 # p 697
A91-40721 * # p 697
A91-40722 # p 697
A91-40723 * # p 697
A91-40725 # p 767
A91-40727 # p 698
A91-40729 * # p 698
A91-40730 * # p 698
A91-40732 # p 698
A91-40733 # p 698
A91-40740 * # p 698
A91-40743 # p 767
A91-40745 * # p 699
A91-40746 * # p 699
A91-40747 # p 699
A91-40748 * # p 699
A91-40749 * # p 699
A91-40751 * # p 699
A91-40753 * # p 700
A91-40754 # p 700
A91-40758 * # p 700
A91-40759 # p 700
A91-40761 # p 700
A91-40763 # p 700
A91-40765 # p 701
A91-40766 * # p 701
A91-40767 # p 701
A91-40768 * # p 701
A91-40769 # p 701
A91-40770 # p 701
A91-40771 # p 702
A91-40775 # p 702
A91-40776 # p 702
A91-40778 # p 702
A91-40779 * # p 702
A91-40792 # p 702
A91-40793 * # p 768
A91-40795 # p 702
A91-40796 # p 703
A91-40797 # p 703
A91-40799 * # p 703
A91-40802 # p 703
A91-40812 p 768
A91-41148 * # p 703
A91-41155 p 768
A91-41156 p 756
A91-41157 p 703
A91-41159 p 768
A91-41163 p 780
A91-41164 p 760
A91-41168 p 768
A91-41169 p 756
A91-41170 p 743
A91-41171 p 743
A91-41173 p 764
A91-41174 p 744
A91-41218 p 703
A91-41320 p 704
A91-41437 p 734
A91-41438 p 734
A91-41439 p 734
A91-41440 p 734
A91-41441 p 734
A91-41442 p 734
A91-41443 p 735
A91-41446 p 735
A91-41447 p 735
A91-41448 p 733
A91-41462 p 704
A91-41507 p 744
A91-41508 p 768
A91-41511 p 764
A91-41535 p 738
A91-41536 p 744
A91-41537 p 763
A91-41538 p 760
A91-41539 p 744
A91-41540 p 783
A91-41541 p 785
A91-41543 p 738
A91-41548 p 785
A91-41569 p 764
A91-41584 p 768
A91-41606 p 765
A91-41641 # p 744
A91-41643 # p 693
A91-41644 * # p 704
A91-41645 * # p 704
A91-41646 # p 744
A91-41647 # p 768
A91-41648 * # p 769
A91-41650 * # p 769
A91-41651 # p 769
A91-41652 # p 744
A91-41653 * # p 745
A91-41671 * # p 745
A91-41672 # p 745
A91-41673 # p 704
A91-41676 # p 769
A91-41684 # p 745
A91-41696 # p 745
A91-41704 # p 704
A91-41705 * # p 745
A91-41706 * # p 738
A91-41707 * # p 745
A91-41708 # p 783
A91-41709 * # p 746
A91-41710 # p 693
A91-41711 * # p 693
A91-41713 * # p 705
A91-41714 # p 738
A91-41726 # p 769
A91-41731 * # p 756
A91-41733 # p 746
A91-41734 # p 705
A91-41735 * # p 705
A91-41738 * # p 705
A91-41739 * # p 705
A91-41740 # p 705
A91-41741 * # p 760
A91-41758 # p 746
A91-41759 * # p 746
A91-41760 # p 706
A91-41761 # p 746
A91-41762 * # p 706
A91-41764 # p 747
A91-41765 # p 693
A91-41767 # p 747
A91-41768 * # p 747
A91-41788 * # p 747
A91-41791 # p 747
A91-41796 # p 738
A91-41798 # p 769
A91-41799 * # p 747
A91-41801 # p 747
A91-41802 # p 761
A91-41805 # p 780
A91-41808 # p 748
A91-41810 # p 748
A91-41813 # p 738
A91-41815 * # p 748
A91-41825 p 735
A91-41828 p 735
A91-41829 p 735
A91-41834 p 735
A91-41835 p 736
A91-41846 p 770
A91-41849 p 770
A91-41851 p 736
A91-41853 p 736
A91-42094 # p 706
A91-42096 # p 706
A91-42098 # p 706
A91-42142 p 742
A91-42224 p 779
A91-42241 p 770
A91-42248 p 706
A91-42256 * # p 707
A91-42258 # p 770
A91-42277 # p 707
A91-42279 # p 707
A91-42280 # p 707
A91-42282 # p 770
A91-42284 * # p 707
A91-42292 # p 770
A91-42294 # p 770
A91-42298 # p 707
A91-42307 * # p 707
A91-42330 p 707
A91-42534 # p 707
A91-42535 # p 707
A91-42536 * # p 708
A91-42537 # p 708
A91-42538 * # p 708
A91-42539 # p 708
A91-42542 * # p 708
A91-42544 # p 708
A91-42547 # p 708
A91-42550 * # p 709
A91-42553 # p 709
A91-42554 # p 709
A91-42556 * # p 748
A91-42558 * # p 709
A91-42559 # p 709
A91-42560 # p 761
A91-42561 * # p 709
A91-42562 # p 709
A91-42564 # p 710
A91-42567 # p 710
A91-42568 # p 710
A91-42571 # p 710
A91-42572 # p 710
A91-42573 # p 710
A91-42574 # p 711
A91-42575 # p 711
A91-42576 # p 711
A91-42577 # p 711
A91-42580 # p 711
A91-42581 * # p 711
A91-42582 # p 712
A91-42594 # p 712
A91-42595 # p 712
A91-42596 # p 712
A91-42597 # p 712
A91-42602 # p 771
A91-42603 # p 712
A91-42604 # p 713
A91-42605 # p 713
A91-42609 # p 713
A91-42611 # p 713
A91-42612 # p 713
A91-42630 * # p 713
A91-42703 p 780
A91-42709 p 781
A91-42710 p 713
A91-42711 * p 714
A91-42719 p 714
A91-42721 * p 714
A91-42726 p 714
A91-42728 p 714
A91-42730 p 714
A91-42736 * p 715
A91-42738 p 739
A91-42780 p 736
A91-42781 # p 736
A91-42783 p 733
A91-42789 p 761
A91-42792 p 761
A91-42801 # p 771
A91-42805 # p 748
A91-42806 # p 749
A91-42807 # p 749
A91-42812 # p 749
A91-42813 # p 715
A91-42814 * # p 715
A91-42815 # p 749
A91-42816 # p 715
A91-42817 # p 749
A91-42818 # p 739
A91-42819 # p 749
A91-42820 * # p 715
A91-42821 * # p 749
A91-42902 p 715
A91-42957 # p 715
A91-42999 # p 784
A91-43000 # p 771
A91-43009 p 693
A91-43076 p 785
A91-43077 # p 693
A91-43078 # p 716
A91-43079 # p 781
A91-43080 # p 739
A91-43082 # p 742
A91-43084 # p 763
A91-43095 # p 757
A91-43100 # p 716
A91-43103 * # p 716
A91-43117 p 739
A91-43118 p 749
A91-43119 p 739
A91-43142 p 716
A91-43169 p 784
A91-43273 p 694
A91-43306 # p 742
A91-43307 * # p 716
A91-43308 # p 716
A91-43309 # p 716
A91-43310 * # p 771
A91-43311 # p 764
A91-43312 * # p 739
A91-43315 p 742
A91-43326 p 771
A91-43328 p 771
A91-43334 p 771
A91-43385 * # p 716
A91-43387 * # p 716
A91-43388 * # p 717
A91-43389 # p 717
A91-43417 * # p 717
A91-43446 * # p 771
A91-43447 # p 772
A91-43452 * # p 717
A91-43453 # p 717
A91-43477 # p 772
A91-43482 * # p 742
A91-43494 * # p 717
A91-43498 # p 764
A91-43501 # p 718
A91-43502 # p 718
A91-43503 # p 784
A91-43508 # p 742
A91-43510 # p 718
A91-43511 # p 739
A91-43512 # p 739
A91-43514 p 784
A91-43528 # p 772
A91-43547 * # p 718
A91-43554 * # p 718
A91-43555 # p 718
A91-43556 * # p 718
A91-43557 # p 719
A91-43558 # p 719
A91-43559 * # p 719
A91-43560 * # p 784
A91-43561 * # p 719
A91-43562 * # p 719
A91-43563 * # p 719
A91-43564 * # p 720
A91-43565 * # p 720
A91-43567 # p 720
A91-43571 * # p 720
A91-43572 * # p 720
A91-43574 # p 720
A91-43575 * # p 720
A91-43577 # p 721
A91-43580 # p 721
A91-43584 # p 721
A91-43585 # p 749
A91-43586 # p 749
A91-43587 # p 721
A91-43588 # p 721
A91-43589 * # p 722
A91-43590 * # p 722
A91-43592 # p 761
A91-43593 * # p 772
A91-43594 # p 739
A91-43595 * # p 722
A91-43596 * # p 739
A91-43597 * # p 740
A91-43598 # p 722
A91-43602 # p 722
A91-43604 * # p 722
A91-43612 # p 723
A91-43613 # p 772
A91-43614 # p 723
A91-43615 * # p 723

A91-43617 # p 723
A91-43619 * # p 723
A91-43629 # p 723
A91-43631 * # p 723
A91-43632 * # p 724
A91-43633 # p 724
A91-43634 * # p 724
A91-43635 # p 724
A91-43638 * # p 724
A91-43642 * # p 724
A91-43643 * # p 725
A91-43646 # p 725
A91-43647 * # p 725
A91-43648 * # p 725
A91-43649 # p 725
A91-43650 * # p 725
A91-43651 # p 726
A91-43652 # p 726
A91-43653 # p 726
A91-43654 # p 726
A91-43655 # p 726
A91-43656 * # p 726
A91-43657 * # p 726
A91-43658 # p 727
A91-43659 # p 727
A91-43673 # p 740
A91-43675 # p 727
A91-43706 p 772
A91-43752 p 765
A91-43772 p 743
A91-43857 * p 765
A91-43891 p 765
A91-43912 p 765
A91-43913 p 765
A91-43916 p 766
A91-43920 p 766
A91-43926 * p 781
A91-43932 p 757
A91-44045 # p 750
A91-44046 # p 750
A91-44047 # p 773
A91-44048 # p 727
A91-44049 * # p 750
A91-44050 * # p 750
A91-44051 * # p 750
A91-44053 # p 750
A91-44054 # p 773
A91-44055 * # p 750
A91-44057 * # p 773
A91-44059 * # p 751
A91-44075 # p 751
A91-44077 # p 751
A91-44078 # p 773
A91-44089 * # p 751
A91-44090 # p 751
A91-44091 # p 727
A91-44092 # p 751
A91-44093 # p 727
A91-44094 # p 752
A91-44095 # p 752
A91-44096 # p 752
A91-44097 # p 727
A91-44098 # p 752
A91-44099 # p 773
A91-44116 # p 773
A91-44127 # p 728
A91-44132 # p 761
A91-44133 # p 752
A91-44134 * # p 752
A91-44135 # p 752
A91-44137 # p 728
A91-44138 # p 728
A91-44139 # p 753
A91-44141 # p 753
A91-44153 * # p 753
A91-44159 * # p 774
A91-44162 * # p 757
A91-44164 # p 728
A91-44165 # p 728
A91-44166 # p 774
A91-44167 * # p 774
A91-44168 # p 753
A91-44169 # p 753
A91-44171 * # p 774
A91-44173 # p 728
A91-44174 # p 784
A91-44176 # p 728
A91-44180 * # p 774
A91-44183 # p 761
A91-44208 # p 753
A91-44209 # p 753
A91-44215 # p 729
A91-44216 # p 754
A91-44217 # p 754
A91-44218 # p 754
A91-44219 # p 754
A91-44225 # p 754
A91-44250 * # p 754
A91-44254 # p 729
A91-44255 # p 774
A91-44257 # p 729
A91-44258 # p 775
A91-44259 * # p 729
A91-44260 # p 729
A91-44261 # p 754
A91-44263 # p 730
A91-44264 * # p 762
A91-44265 # p 755
A91-44266 * # p 781
A91-44267 * # p 762
A91-44287 # p 730
A91-44295 * # p 775
A91-44303 # p 755
A91-44304 * # p 730
A91-44318 * # p 730
A91-44319 * # p 775
A91-44320 # p 730
A91-44321 # p 775
A91-44329 # p 755
A91-44334 # p 762
A91-44338 # p 764
A91-44339 # p 755
A91-44340 # p 694
A91-44342 # p 775
A91-44345 # p 740

N91-25100 # p 694
N91-25102 * # p 694
N91-25103 * # p 730
N91-25106 * # p 731
N91-25107 * # p 731
N91-25108 p 731
N91-25110 p 731
N91-25111 p 731
N91-25114 # p 732
N91-25115 # p 732
N91-25116 # p 732
N91-25119 # p 733
N91-25120 # p 733
N91-25121 # p 736
N91-25122 # p 781
N91-25125 # p 736
N91-25126 # p 737
N91-25128 # p 737
N91-25133 # p 781
N91-25137 # p 737
N91-25138 # p 743
N91-25139 # p 757
N91-25141 # p 737
N91-25142 * # p 737
N91-25144 p 740
N91-25145 # p 740
N91-25146 # p 740
N91-25147 * # p 755
N91-25148 * # p 755
N91-25150 # p 755
N91-25151 * # p 758
N91-25152 # p 762
N91-25153 # p 762
N91-25154 # p 762
N91-25155 * # p 763
N91-25302 # p 775
N91-25336 # p 775
N91-25338 * # p 776
N91-25339 # p 776
N91-25343 * # p 732
N91-25345 * # p 776
N91-25347 # p 776
N91-25348 # p 776
N91-25352 * # p 776
N91-25355 p 776
N91-25359 p 777
N91-25362 p 777
N91-25366 # p 777
N91-25375 # p 777
N91-25408 # p 777
N91-25411 * # p 777
N91-25412 * # p 778
N91-25413 * # p 778
N91-25422 * # p 778
N91-25458 * # p 782
N91-25481 * # p 740
N91-25482 * # p 780
N91-25553 * # p 780
N91-25623 * # p 782
N91-25642 p 782
N91-25643 p 782
N91-25684 p 782
N91-25750 # p 783
N91-25815 # p 784
N91-25937 * # p 783
N91-26112 * # p 786
N91-26113 * # p 694
N91-26117 # p 732
N91-26120 # p 732
N91-26123 * # p 732
N91-26124 # p 733
N91-26125 # p 733
N91-26126 * # p 734
N91-26130 # p 737
N91-26131 # p 741
N91-26134 # p 741
N91-26135 # p 741
N91-26136 # p 741
N91-26137 * # p 741
N91-26138 # p 741
N91-26139 * # p 742
N91-26140 * # p 742
N91-26142 * # p 743
N91-26143 # p 743
N91-26144 # p 756
N91-26145 # p 756
N91-26146 * # p 756
N91-26148 # p 758
N91-26149 # p 758
N91-26150 # p 758
N91-26151 * # p 780
N91-26152 # p 758
N91-26153 # p 758
N91-26154 # p 759
N91-26155 # p 759
N91-26156 # p 759
N91-26160 # p 763
N91-26161 # p 763
N91-26249 # p 766
N91-26281 # p 766
N91-26300 # p 766
N91-26384 # p 766
N91-26387 # p 767
N91-26412 # p 778
N91-26431 # p 778
N91-26432 # p 778
N91-26433 # p 779
N91-26466 # p 779
N91-26477 # p 779
N91-26482 p 779
N91-26490 * # p 779
N91-26797 * # p 783
N91-26878 # p 784
N91-26889 * # p 785
N91-26995 # p 785
N91-27046 # p 785

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