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Aeronautical Engineering
A Continuing Bibliography with Indexes

NASA SP-7037(226)
May 1988

National Aeronautics and Space Administration

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NASA SP-7037(226)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 226)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in April 1988 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA Scientific and Technical Information Division 1988
National Aeronautics and Space Administration
Washington, DC

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 515 reports, journal articles and other documents originally announced in April 1988 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

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 bibliography 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. The *IAA* items will precede the *STAR* items within each category

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

An annual cummulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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Category 17 Social Sciences 268
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Category 18 Space Sciences N.A.
Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

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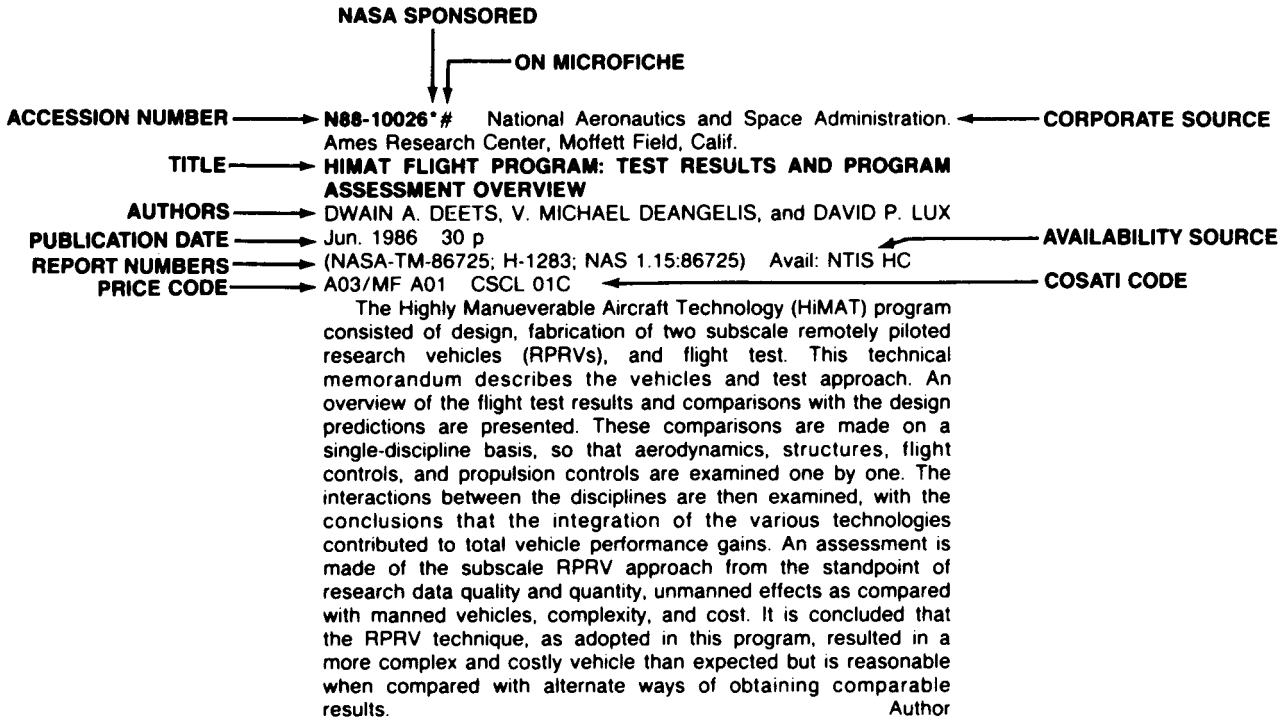
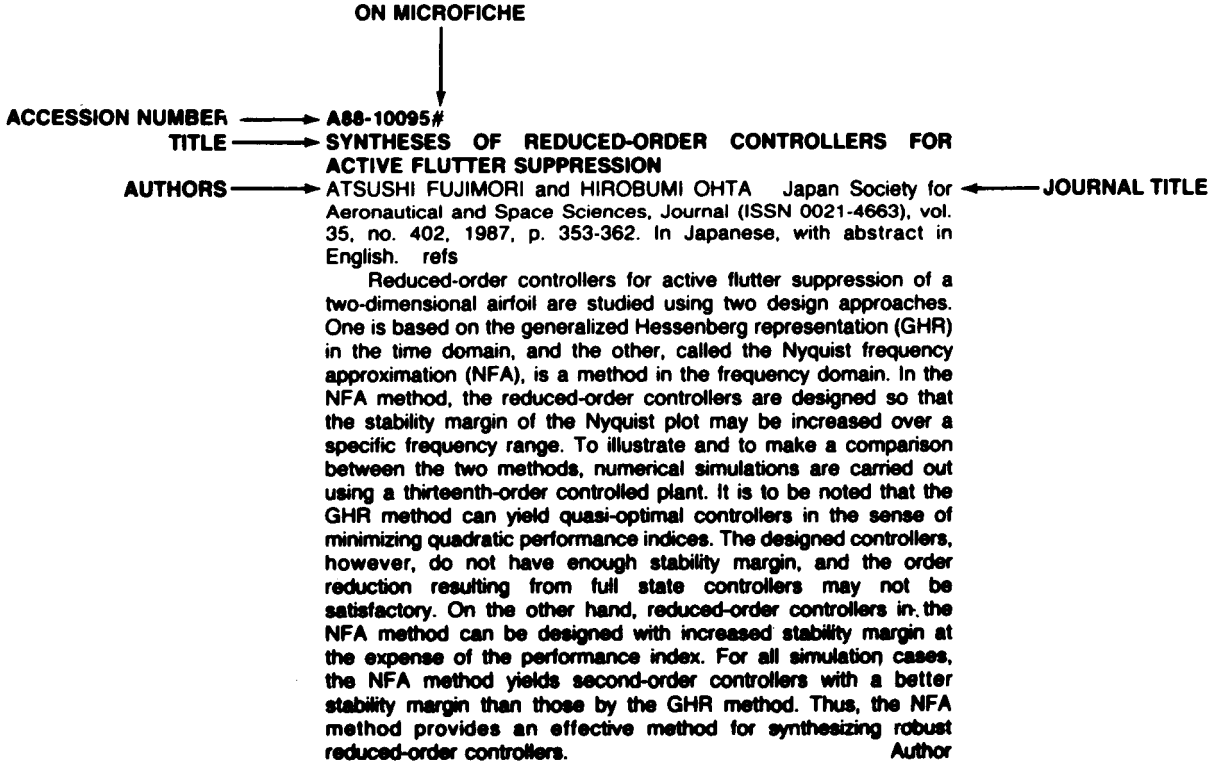


TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 226)

MAY 1988

01

AERONAUTICS (GENERAL)

A88-20706
PRODUCTION CONCEPT OF AIRBUS VERTICAL STABILIZER SPAR BOXES IN CARBON-FIBER COMPOSITE MATERIALS
WOLFGANG STRATMANN (Messerschmitt-Boelkow-Blohm GmbH, Stade, Federal Republic of Germany) IN: Looking ahead for materials and processes; Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 18-21, 1987 . Amsterdam, Elsevier, 1987, p. 53-61.

The highly automated composite airframe structure tooling and production methods used by a prominent manufacturer are presented. Structures of this type, such as CFRP vertical stabilizer spar boxes for the Airbus A320, yield weight savings of the order of 23 percent over the original metallic structure, as well as a 90-percent reduction in the number of detailed parts. The most important single piece of tooling, a 'module', is used to build up the I-section of reinforcing beams. Prepreg cutting and tape-laying onto the module are integrated and fully automated, with several positioning and translation steps being accomplished robotically. O.C.

A88-20715
ADHESION AND FLEXIBILITY OF PRETREATMENTS AND PRIMERS FOR AIRCRAFT
ROGER W. BLACKFORD (Imperial Chemical Industries, PLC, London, England) IN: Looking ahead for materials and processes; Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 18-21, 1987 . Amsterdam, Elsevier, 1987, p. 203-211.

The interrelationship of metal claddding, pretreatment, paint and temporary protective coats, as solutions to the anticorrosive protection of aluminum alloy in an aircraft structure is reviewed. The performance of these treatments is compared with particular reference to the occurrence of a structural metal crack. The properties of adhesion and flexibility are shown to have a significant effect upon the eventual behavior of the coating system as to whether and in what manner it cracks. Other types of cracking are also examined and test methods to evaluate coating performance in relation to adhesion and flexibility are discussed. Author

A88-20717
HOW TO BUILD THE MIRAGE 2000 RADOME
ROBERT CARBONE (Direction des Constructions et Armes Navales, Toulon, France) IN: Looking ahead for materials and processes; Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 18-21, 1987 . Amsterdam, Elsevier, 1987, p. 219-228.

An account is given of the robotic method by which the composite radome of the Mirage 2000 is being conducted. This novel method requires one operator, rather than three, and allows the fabrication of the radome to be achieved in a single step in place of two, as in the manual draping of the radome preform. Quality improvements are derived through precise reproducibility in the robotic positioning cycles, the achievement of identical surface temperatures, and superior compaction. Operator working conditions are also improved. O.C.

A88-20800
THE AIRBUS RUDDER ASSEMBLY - AN EXAMPLE OF NEW MANUFACTURING TECHNOLOGIES [DAS AIRBUS-SEITEN-LEITWERK - EIN BEISPIEL NEUER FERTIGUNGSTECHNOLOGIEN]
GOTTHARD MENZE and WOLFGANG STRATMANN (Messerschmitt-Boelkow-Blohm GmbH, Stade, Federal Republic of Germany) VDI-Z (ISSN 0042-1766), vol. 129, no. 11, Nov. 1987, p. 17-19. In German.

The fabrication of the CFRP rudder unit for the A-320 is described and illustrated with drawings and photographs. The advantages of CFRP construction over a conventional Al-alloy rudder unit are reviewed, including a 23.6-percent weight savings, a three times longer service life, 200 instead of 2000 structural parts, and 5800 instead of 60,000 fasteners. The design of the A-320 tail shells is based on a double-T construction wound with +/-45-deg prepregs and hardened at 125 C. The units are fabricated in an almost fully automated computer-controlled production facility; particular attention is given to the cutting and layup of the prepregs, the tape winding, the autoclave equipment, the CNC machining equipment, the ultrasonic and X-ray test procedures, and final assembly. T.K.

A88-22067*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
BUILDING A 1903 WRIGHT 'FLYER' - BY COMMITTEE
F. E. C. CULICK (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 53 p. Research supported by the California Institute of Technology. refs
(AIAA PAPER 88-0094)

This is a summary of a progress report of the Los Angeles AIAA Section Wright Flyer Project. Begun in late 1978, the project is devoted chiefly to construction of two replicas of the 1903 Wright 'Flyer'. The first, now being covered, is an exact replica intended for full-scale wind tunnel tests. The second will be a flying replica, incorporating minimal modifications to produce a less unstable aircraft. Considerable attention has been given to the aerodynamics, stability, and control of the 1903 'Flyer'. Wind-tunnel tests have been conducted with a 1/6 flexible model, and a 1/8 scale steel model tested at full-scale Reynolds numbers. The data have provided the basis for analyzing both the closed-loop and open-loop performance of the aircraft. Consideration is also given to aeronautical history both before and after 1903, to provide a better appreciation for the Wrights' achievements and a clearer perspective of their work in the context of aeronautical progress. Author

A88-22726
AHS, ANNUAL FORUM, 43RD, SAINT LOUIS, MO, MAY 18-20, 1987, PROCEEDINGS. VOLUMES 1 & 2
Forum sponsored by AHS. Alexandria, VA, American Helicopter Society, 1987, p. Vol. 1, 483 p.; vol. 2, 581 p. 1064 p. For individual items see A88-22727 to A88-22793, A88-22795 to A88-22799.

The present conference on helicopter aerodynamics, avionics, dynamics, military operations, design, testing and evaluation, structures, and acoustics, gives attention to such topics as circulation-control airfoils in unsteady flow, oscillating jet flaps, pilot workload estimation, V-22 military effectiveness, helicopter air-to-air engagements, automated helicopter mission management, and advanced digital flight control systems. Also discussed are FEM aeroelastic modeling of swept-tip rotor blades, rotor aerodynamic optimization for high speed tilt-rotors, rotor performance optimization, FEM analyses of drivetrain planetary gears, damage tolerance in civil helicopters, rotor noise prediction and validation, and the prediction of blade-vortex interaction noise. O.C.

A88-22734
HELICOPTER WIRING SYSTEM BATTLE DAMAGE REPAIR
JAMES A. BLEAKNEY (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT), MING-LEUNG LAU (U.S. Army, Applied Aviation Technology Directorate, Fort Eustis, VA), and CHARLES BRADY (U.S. Army, Aviation Logistics School, Fort Eustis, VA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 103-110.

The purpose of this paper is to discuss recent U.S. Army activities in the repair of combat damaged helicopter wiring systems as part of the Army's Aircraft Combat Maintenance/Battle Damage Repair (ACM/BDR) program, and in particular, the development program of a prototype ACM/BDR Wiring Repair Set for use on present inventory helicopters. Wiring repair set development program topics discussed include: the program philosophy, objectives/goals, hardware and software concepts, set development, effectiveness of repairs and the attainment of repair capability goals by helicopter type. Also discussed are the 'lessons learned' for considerations during the design of future helicopter wiring systems. Author

A88-22735
TILTROTOR EVOLUTION LEADS TO EFFECTIVENESS REVOLUTION
J. H. SCHAEFER (U.S. Marine Corps, Washington, DC), RICHARD F. SPIVEY, DONALD J. BARBOUR, and C. DONALD ATKINS (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 111-124.

This paper describes the development of the tiltrotor aircraft, the present status of the V-22 tiltrotor program, and anticipated uses for the tiltrotor. It discusses specific missions that the U.S. armed forces have found for the V-22, as well as the military potential of an RPV tiltrotor. Finally, it shows ways in which the tiltrotor aircraft can serve civil aviation. Author

A88-22793
IMPLEMENTATION OF THE FLIGHT SAFETY PARTS PROGRAM
JAMES A. RAY (U.S. Army, Aviation Systems Command, Saint Louis, MO) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 915-924.

The U.S. Army Aviation Systems Command has been implementing a Flight Safety Parts Program in conjunction with all Army prime helicopter manufacturers during this past year. This program is designed to provide for improved life cycle management of aircraft parts whose integrity is essential to flight safety. As such, a new approach to enhance quality assurance of the parts has been implemented to cover all phases including manufacturing, transportation, storage, maintenance, operational usage, and overhaul/repair. In addition, the overall safety and functional relibility is being enhanced by direct surveillance analyses and testing of new/used parts on a recurring basis. The purpose of this paper is to define the overall program and to describe the specific details/status of its implementation. Author

A88-22800#
APPLICATION OF AN INTEGRATED INTERCONNECTION SYSTEM IN HELICOPTER WIRING
RICHARD W. GOHMAN (McDonnell Douglas Helicopter Co., Mesa, AZ) AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Paper. 11 p.

A representative integrated interconnection system (I2S) wiring design was prepared for the AH-64A helicopter and compared to the existing wiring design to quantify the production cost savings and the technical risks involved in the design concept. Experiments in EMI/EMC performance and fabrication of a test harness were combined with the analytical evaluation effort. The conclusions drawn from this study indicated that the I2S is not effective as a concept to design replacements for existing harness assemblies, but it does present sufficient production cost saving in a new wiring design effort to be seriously considered in the design trade evaluation. Author

A88-23195#
AN OVERVIEW ON THE IMPLEMENTATION OF RELIABILITY-CENTERED MAINTENANCE
SHIHUA HU (Air Force, Beijing Military Area Command, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Aug. 1987, p. B416-B421. In Chinese, with abstract in English.

This paper discusses the basis, kernel, key points, and guarantee of reliability-centered maintenance, and shows that to explore deeper these four aspects, is important. Moreover, it is pointed out that, in order to bring into play positive factors in every aspect of design, manufacture, operation, and maintenance, (to improve the aircraft maintenance level), the structure of the maintenance system should be reformed by the use of principles and approaches of system engineering and by keeping the whole aircraft engineering system in mind. Author

A88-23259
COMPUTER APPLICATIONS IN AIRCRAFT DESIGN AND OPERATION; PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON COMPUTER AIDED DESIGN, MANUFACTURE AND OPERATION IN THE AERONAUTICS AND SPACE INDUSTRIES, PARIS, FRANCE, JUNE 16-18, 1987
T. K. S. MURTHY, ED. (Computational Mechanics Institute, Southampton, England) and J. P. FIELDING, ED. (Cranfield Institute of Technology, England) Conference organized by the Computational Mechanics Institute; Supported by the U.S. Air Force. Billerica, MA, Computational Mechanics Publications, 1987, 251 p. For individual items see A23260 to A23274.

Various papers on computer applications in aircraft design and operation are presented. The topics addressed include: teaching of aircraft design computer applications, CAD system for airplane configuration, progress towards international standards for finite element systems, analysis and design of aerospace components using the boundary element analysis system, computer systems in future advanced air traffic management, use of 4-D FMS in a complex terminal area in the pre-data link era, computer-assisted aircraft arrivals management using speed control, and computer-aided flight envelope expansion for an advanced technology fighter. Also discussed are: computer-aided dynamic analysis of electrohydraulic actuators, application of CAD in the electrical design and drawing offices of a flight simulator manufacturer, systems architecture approach to systems integration, CAD/CAM of aircraft engine strut structure, research in computational fluid dynamics at NAL in Japan, a database-oriented system for the support of flight tests, and progress towards an aircraft design expert system. C.D.

A88-23863
DEVELOPMENT TIME SCALES: THEIR ESTIMATION AND CONTROL; PROCEEDINGS OF THE SYMPOSIUM, LONDON, ENGLAND, FEB. 12, 1987
Symposium sponsored by the Royal Aeronautical Society. London, Royal Aeronautical Society, 1987, 173 p. For individual items see A88-23864 to A88-23869.

The present conference discusses development time-scales for aircraft and guided weapon systems, methods for reducing the cost of aircraft engine research and development, and the planning of risk in defense-related development projects. Also discussed are techniques for the prediction and evaluation of development schedules, the experience of program planning and management from a customer's viewpoint, aerospace corporate and project management, and the features of an experimental aircraft development program. O.C.

A88-23870
AVIONIC SYSTEMS FOR CIVIL HELICOPTERS; PROCEEDINGS OF THE SYMPOSIUM, LONDON, ENGLAND, FEB. 18, 1987
Symposium sponsored by the Royal Aeronautical Society. London, Royal Aeronautical Society, 1987, 87 p. For individual items see A88-23871 to A88-23874.

The conference presents papers on black boxes and the North Sea pilot, the corporate operator's viewpoint, and advanced radar for civil helicopters. Other topics include lightweight and cost effective displays, and automatic flight control systems for the Anglo-Italian EH101 helicopter. Consideration is also given to the experience of operations with search and rescue systems. K.K.

A88-23871
AVIONIC SYSTEMS FOR CIVIL HELICOPTERS - KEYNOTE PAPER
P. J. G. HARPER (Civil Aviation Authority, London, England) IN: Avionic systems for civil helicopters; Proceedings of the Symposium, London, England, Feb. 18, 1987 . London, Royal Aeronautical Society, 1987, p. 1-9.

The concept of avionics systems is defined and helicopter operations in the United Kingdom are described with attention given to offshore oil exploration and support, onshore passenger carrying operations, and operations involving tasks other than straight transportation. Current avionic equipment includes duplicated AFCS systems with coupled flight directors, area navigation systems, an automatic voice alerting device, cockpit voice recorders, and emergency transmitters. Motives for further avionics development are discussed as well as recent activity, new airworthiness requirements for helicopters, and future developments. K.K.

N88-14924# Naval Postgraduate School, Monterey, Calif.
DEVELOPMENT OF A PROTOTYPE H-46 HELICOPTER DIAGNOSTIC EXPERT SYSTEM M.S. Thesis
THOMAS J. GADZALA Sep. 1987 125 p
(AD-A186077) Avail: NTIS HC A06/MF A01 CSCL 01C

This study was undertaken to demonstrate the feasibility of applying expert system technology to the Navy's H-46 helicopter maintenance process. A microcomputer based prototype known as a computer-aided diagnostic system (CADS) was developed for this purpose. Given a helicopter electrical or hydraulic system discrepancy, the troubleshooter interacts with CADS to find the cause. The prototype CADS was developed utilizing the M.1 knowledge-based system development tool by knowledge, Inc. The complexity of helicopter systems diagnosis, and inadequacies of the maintenance manuals, often result in unnecessary removal of system components. The prototype CADS is intended to demonstrate that a fully developed system, containing all the formal and heuristic knowledge of H-46 diagnostic information, could eliminate these problems. Also, such a diagnostic system could provide a comprehensive, stable diagnostic knowledge base, regardless of personnel turnover. This study includes a description of current helicopter maintenance procedures and how the integration of CADS could improve this process. Also included are descriptions of expert systems and the M.1 knowledge-based system development tool; how they work, and their applicability to structured selection problem-solving. The development and testing strategies used for CADS are discussed in detail. Results, conclusions, and recommendations for further study are provided. GRA

N88-14925# Netherlands Agency for Aerospace Programs, Delft.
ACTIVITIES REPORT IN AIRCRAFT DESIGN AND ASTRONAUTICS Annual Report, 1985 [VERSLAG VAN DE WERKZAAMHEDEN 1985]
1985 35 p In DUTCH
(ETN-88-90618) Avail: NTIS HC A03/MF A01

Contributions to the design of the F28, Fokker 50, Fokker 100, Airbus, Shorts SD 330/360 aircraft, and to the development of measuring, registration, and processing systems and aircraft technology are outlined. Activities in aerospace technology programs, solar panels, and ESA progams (telecommunication, Earth observation, Meteosat, rocket vehicle development, Spacelab, EURECA, microgravity, Columbus) are described. ESA

N88-15759# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Systems and Logistics.
SUPPORTABILITY IN AIRCRAFT SYSTEMS THROUGH TECHNOLOGY AND ACQUISITION STRATEGY APPLICATIONS M.S. Thesis
DEBRA L. HALEY Sep. 1987 82 p
(AD-A186465; AFIT/GLM/LSM/87S-30) Avail: NTIS HC A05/MF A01 CSCL 15E

The importance of high reliability systems in the national defense strategy of force multiplier is paramount. Currently, the Air Force has adopted Reliability and Maintainability (R&M) 2000 as a management policy to achieve high reliabilities. However, there are few methods being implemented which can improve the measures of reliability. One method used with success by satellite systems is the use of expensive, but highly reliable class S electronic parts as opposed to the class B parts used in avionics and ground electronic systems. A method for determining the improvement of systems' Mean Time Between Failure (MTBF) was developed. Additionally, the impact of improved system MTBF along with higher acquisition costs as a result of using class S parts was analyzed in a life cycle cost model. Results obtained in this research indicate that class S parts have the potential of significantly increase MTBF while actually lowering life cycle costs. Recommendations for follow-on research are given. GRA

02

AERODYNAMICS

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

A88-20782#
COMPARISON OF THEORY AND EXPERIMENT FOR PROPFAN INLETS
VICTOR LYMAN and JOHN P. HANCOCK (Lockheed-Georgia Co., Marietta) Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, Nov.-Dec. 1987, p. 534-541. Previously cited in issue 20, p. 2916, Accession no. A86-42761. refs

A88-20845* Arizona State Univ., Tempe.
WAVE INTERACTIONS IN SWEPT-WING FLOWS
HELEN L. REED (Arizona State University, Tempe) Physics of Fluids (ISSN 0031-9171), vol. 30, Nov. 1987, p. 3419-3426. refs (Contract NAG1-402)

The leading-edge region of swept wings is dominated by the crossflow instability, resulting in vortices that all rotate in the same sense. The effect of these vortices on the behavior of other disturbances is examined and an interaction between these and

disturbances of half the dominating crossflow wavelength is predicted. According to theory, the interaction is of crossflow-crossflow type. The effect explains the anomalies found in the experimental observations of Saric and Yeates (1985). Visually Saric and Yeates observe vortices at the wavelength predicted by linear theory; however, in their hot-wire measurements they find that the second harmonic dominates disturbance growth, with eventually three times the amplitude of the primary wave. In this case, the usual transition-prediction methods would fail, clearly indicating the importance of studying interactions of this sort.
Author

A88-20938*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NLF TECHNOLOGY IS READY TO GO
BRUCE J. HOLMES (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 26, Jan. 1988, p. 16, 19, 20.

Natural laminar flow (NLF) can reduce drag on aircraft developed using modern structural design methods. Modern metal and composite construction methods can meet NLF requirements for subsonic commuter and business airframes. NLF research at NASA concentrates on expanding the practical application of NLF drag reduction technology; payoffs include progress with liquid-crystal flow visualization, NLF on three-dimensional bodies, and the effects of acoustics on laminar stability. Fuel savings from 2 to 4 percent are expected if laminar flow could be achieved over the forward 50 percent of engine nacelles on large transports depending on the configuration. It is concluded that the skill required to use NLF for drag reduction depends on understanding the conservative design corridors within which laminar flow is durable and reliable. B.J.

A88-20939*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LAMINAR FLOW CONTROL IS MATURING
RICHARD D. WAGNER, DENNIS W. BARTLETT, and DAL V. MADDALON (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 26, Jan. 1988, p. 20, 22, 24.

Recent research demonstrates that laminar flow (LF) can be reliable in flight and that the support system need not be complex. Shaping produces favorable pressure gradients for maintaining natural laminar flow (NLF), and laminar flow control (LFC) techniques such as full chord suction promise a fuel-saving payoff of up to 30 percent on long-range missions. For large aircraft, current research is concentrated on hybrid LFC concepts which combine suction and pressure-gradient control. At NASA Ames, an F-14 with variable wing sweep has been flight tested with smooth surface gloves on the wings; preliminary results indicate high transition Reynolds numbers to sweep angles as large as 25 deg. In addition, a 757 was flight tested with an NLF glove on the right wing just outboard of the engine pylon; and the LF was found to be suprisingly robust. B.J.

A88-20940*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE FIX FOR TOUGH SPOTS
JOHN B. ANDERS, MICHAEL J. WALSH, and DENNIS M. BUSHNELL (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 26, Jan. 1988, p. 24, 26, 27.

Modern turbulence-control techniques are discussed. Particular atention is given to retrofit techniques such as riblets and large-eddy breakup (LEBU) devices which use passive elements suitable for a variety of existing vehicles with minimum added complexity. Riblets are small flow-aligned grooves in the aircraft skin that damp turbulence and reduce skin friction; the mechanism of riblet drag reduction derives from the enhancement of turbulence-altering, transverse viscous forces by strong spanwise surface geometry gradients. LEBUs are thin plates or ribbons suspended in a turbulent boundary layer to sever or break up the large vortices that form the convoluted outer edge of the layer. Other turbulence-control techniques are discussed, including one that involves the injection of control vortices into the turbulent boundary layer to modify or substitute for large-eddy structures. B.J.

A88-20946
LIFTING SYMMETRIC SUPERCRITICAL AIRFOILS FOR WING DESIGN OF COMBAT AIRCRAFT
M. NANDANAN and M. A. RAMASWAMY (National Aeronautical Laboratory, Bangalore, India) Communications in Applied Numerical Methods (ISSN 0748-8025), vol. 3, Nov.-Dec. 1987, p. 463-468. refs

This paper deals with the use of lifting symmetric supercritical airfoils in the wing design of a combat aircraft. For transonic combat aircraft requiring supersonic acceleration, the usual supercritical airfoil which invariably has camber is not suitable because of the supersonic wave drag penalty arising from the camber. Therefore, lifting symmetric supercritical airfoils which overcome this disadvantage were developed by the authors, and their beneficial effects in the two-dimensional case were demonstrated earlier. The objective of this paper is to illustrate that, even when an unsophisticated approach is used for adopting such a lifting symmetric supercritical airfoil to the wing of a particular combat aircraft configuration, the theoretical analysis indicates some benefits. It is therefore felt that the use of lifting symmetric supercritical airfoils in the design of wings of combat aircraft usiing more sophisticated design techniques may be worth considering.
Author

A88-20951
A STUDY ON MATCHING PROBLEMS OF SUPERSONIC TWO-DIMENSIONAL AIR INLETS
I. A. FAKHRY and T. G. PAI (Alfateh University, Tripoli, Libya) Rozprawy Inzynierskie (ISSN 0035-9408), vol. 35, no. 2, 1987, p. 217-227. refs

In order to ensure a uniform and stable compressor face flow, maximum total pressure recovery and minimum pre-entry drag for an Air Inlet of a supersonic aircraft of flight Mach numbers above 2, over its entire flight range and variable geometry, are a necessity. The variable multiramp external compression two-dimensional Air Inlet is one of the most attractive solutions for this case, where variable geometry may be easier to engineer. In this paper, two computer programs (GMTRY and CRIT) are presented. Oswahtsch (1947) optimum ramp angles are used to determine the geometrical shape of the three ramp variable deflection Air Inlet, and the exact solution of the shock wave equation is utilized to determine a number of parameters relevant to the Air Inlet performance at design and critical operational conditions. Flow shape and flow pattern at critical, subcritical, and Ferri limits of the air inlet under study are presented. Author

A88-21723
CALCULATION OF SUBSONIC SEPARATED FLOW OF A GAS PAST THE SYSTEM WING-BODY [RASCHET OTRYVNOGO OBTEKANIIA SISTEMY KRYLO - FIUZELIAZH DOZVUKOVYM POTOKOM GAZA]
A. V. VOEVODIN and G. G. SUDAKOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Sept.-Oct. 1987, p. 122-126. In Russian. refs

The problem of subsonic separated flow past the wing-body combination is investigated using the method of matched asymptotic expansions. A solution algorithm is developed which is equally applicable to all the regions. As an example the aerodynamic characteristics of separated flow are calculated for the combinations delta wing-body and strake-wing-body, and the results obtained are compared with experimental data. V.L.

A88-21884
A VERSION OF THE TWO-DIMENSIONAL THEORY OF AXISYMMETRIC PARACHUTES [OB ODNOM VARIANTE DVUMERNOI TEORII OSESIMMETRICHNYKH PARASHIUTOV]
R. KHUDAIBERDIEV (Tashkentskii Politekhnicheskii Institut, Tashkent, Uzbek SSR) Akademiia Nauk Uzbekskoi SSR, Doklady (ISSN 0134-4307), no. 8, 1987, p. 17-19. In Russian.

The stresses and strains in a parachute canopy are analyzed numerically on the basis of a new three-dimensional theory for axisymmetric parachutes which allows for the structure of the canopy material. The problem is reduced to that of solving Keppler-Rakhmatulin equations and complex transcendental equations whose coefficients depend on the size and deformation properties of the fabric filaments, meridional cross section shape, and filament arrangement in the canopy. The equations are solved using a model version of the structural development method. V.L.

A88-21886
A CLASS OF IMPULSIVE STRUCTURAL EVOLUTION SYSTEMS [OB ODNOM KLASSE SISTEM IMPUL'SIVNOGO STRUKTURNOGO RAZVITIIA]
R. KHUDAIBERDIEV (Tashkentskii Politekhnicheskii Institut, Tashkent, Uzbek SSR) Akademiia Nauk Uzbekskoi SSR, Doklady (ISSN 0134-4307), no. 9, 1987, p. 17-19. In Russian.

The concept of an impulsive structural evolution system is defined, and it is shown that impulsive structural evolution is a controllable process. The conditions and criteria of structural evolution are derived from an analysis of systems of differential equations. An analysis is presented for the system aircraft-parachute, as an example of an impulsive structural evolution and perturbation system. V.L.

A88-21979#
VORTEX ROLL-UP FROM AN ELLIPTIC WING AT MODERATELY LOW REYNOLDS NUMBERS
HIROSHI HIGUCHI, JOSE C. QUADRELLI, and CESAR FARELL (Minnesota, University, Minneapolis) AIAA Journal (ISSN 0001-1452), vol. 25, Dec. 1987, p. 1537-1542. Navy-supported research. Previously cited in issue 07, p. 837, Accession no. A86-19951. refs

A88-21985#
BLOCK-STRUCTURED SOLUTION OF EULER EQUATIONS FOR TRANSONIC FLOWS
AKIN ECER, JOHN T. SPYROPOULOS, and VLADIMIR RUBEK (Purdue University, Indianapolis, IN) AIAA Journal (ISSN 0001-1452), vol. 25, Dec. 1987, p. 1570-1576. Previously cited in issue 17, p. 2468, Accession no. A86-38443. refs

A88-21987#
NAVIER-STOKES SIMULATIONS OF TRANSONIC FLOWS OVER A WING-FUSELAGE COMBINATION
KOZO FUJII (National Aerospace Laboratory, Tokyo, Japan) and SHIGERU OBAYASHI AIAA Journal (ISSN 0001-1452), vol. 25, Dec. 1987, p. 1587-1596. Previously cited in issue 24, p. 3535, Accession no. A86-49589. refs

A88-21991#
A MODEL FOR VORTEX BREAKDOWN ON SLENDER WINGS
JOSHUA ASHENBERG (Rafael Armament Development Authority, Haifa, Israel) AIAA Journal (ISSN 0001-1452), vol. 25, Dec. 1987, p. 1622-1624. refs

A new theoretical model is presented for evaluating the effect of vortex breakdown on the aerodynamics of slender wings. The model proposed here represents the vortex breakdown phenomenon by a distribution of sources and is applicable to simple slender wings with two concentrated vortices. With reference to a specific example, it is shown that the influence of the breakdown on lift predicted by the model is qualitatively in good agreement with the measured results, particularly for the lift curve slope. V.L.

A88-22005*# California Univ., Santa Barbara.
APPLICATION OF TRANSONIC SLENDER BODY THEORY TO BODIES OF VARYING COMPLEXITY
KARUNAMURTHY RAJAGOPAL, WILBERT J. LICK (California, University, Santa Barbara), and NORMAN D. MALMUTH (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(Contract NAS9-14000)
(AIAA PAPER 88-0005)

Transonic flows over several bodies of varying complexity including a simple wing-body combination and the Shuttle Orbiter have been modeled with the use of slender body theory. Flows with various angles of attack have been considered. Also some off-body flow calculations were conducted. For attached flows, the calculations predicted the pressure results with good accuracy. Author

A88-22006*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
FINITE VOLUME COMPUTATION OF UNSTEADY INVISCID ROTATIONAL TRANSONIC FLOWS PAST AIRFOILS IN RIGID BODY MOTION
MURALI DAMODARAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 26 p. refs
(Contract NAG2-218)
(AIAA PAPER 88-0006)

Unsteady inviscid transonic flow over airfoils in arbitrary rigid body motion is analyzed numerically by solving the two-dimensional unsteady Euler equations in integral form using a finite volume scheme. The solution procedure is based on an explicit Runge-Kutta time-stepping scheme wherein the spatial terms are central-differenced and a combination of second- and fourth-differences in the flow variables are used to form the numerical dissipation terms to stabilize the scheme. Unsteady calculations are started from converged steady-state solutions as initial conditions. Nonreflective boundary conditions are imposed on the far-field boundaries. Results are presented and, where possible, validated against available numerical and experimental data for airfoils subjected to a step change in angle of attack, airfoils oscillating and plunging in transonic flow, and airfoils immersed in a time-varying free stream. Author

A88-22007*# West Virginia Univ., Morgantown.
TRANSONIC LOW ASPECT RATIO WING-WINGLET DESIGNS
JOHN M. KUHLMAN, MICHAEL J. CERNEY, and PAUL LIAW (West Virginia University, Morgantown) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(Contract NAG1-625)
(AIAA PAPER 88-0007)

A numerical design study has been conducted to ascertain the potential of winglets as a drag-reducing measure at high subsonic Mach numbers for low aspect ratio wings. The four variants of the winglet concept studied are a 'detuned' winglet with decreased incidence at the wing-winglet juncture; a steerable winglet; more gradual pressure recovery at the wing and winglet trailing edges; and the application of supercritical airfoil technology. A further study is conducted to assess the accuracy of the numerical code's predicted pressure drag values. O.C.

A88-22008*# High Technology Corp., Hampton, Va.
ANALYSIS OF WIND-TUNNEL BOUNDARY-LAYER TRANSITION EXPERIMENTS ON AXISYMMETRIC BODIES AT TRANSONIC SPEEDS USING COMPRESSIBLE BOUNDARY-LAYER STABILITY THEORY
P. M. H. W. VIJGEN (High Technology Corp., Hampton, VA), S. S. DODBELE (Vigyan Research Associates, Inc., Hampton, VA), W. PFENNINGER (Analytical Services and Materials, Inc., Hampton, VA), and B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 16 p. refs
(Contract NAG1-345; NAS1-17919; NAS1-18235)
(AIAA PAPER 88-0008)

The design of laminar flow fuselages and advanced swept wings at high-subsonic compressible speeds can benefit from a correlation of compressible transition experiments with the e exp n transition-prediction method. A computational analysis has been conducted to investigate the detailed transition measurements obtained by Boltz et al. (1956, 1960) for two bodies-of-revolution. Nonadiabatic wall conditions were included in the analysis when wall-temperature measurements were available. O.C.

A88-22009#
EULER TRANSONIC SOLUTIONS OVER FINITE WINGS
S. AGRAWAL, A. VERHOFF, R. B. LOWRIE (McDonnell Aircraft Co., Saint Louis, MO), and R. E. VERMELAND (Cray Research, Inc., Mendota Heights, MN) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. Research supported by the McDonnell Douglas Independent Research and Development Program. refs
(AIAA PAPER 88-0009)

The QAZ1D Euler formulation, which differs from many others in that it expresses the Euler equations in terms of extended Riemann variables in a natural streamline coordinate system at each point of an arbitrary computational grid, is presently applied to the numerical solution of transonic flow over a finite wing geometry. The computer code designated ET1 solves these equations on the basis of a finite-difference scheme. Convergence is improved by the use of local maximum time-step, as well as a checkerboard scheme in conjunction with a simple multigrid method. Results obtained for the ONERA M6 wing in subsonic and transonic flow with strong shocks compare well with experimental data. O.C.

A88-22023#
INSTABILITIES IN THE FREE SHEAR LAYER FORMED BY TWO SUPERSONIC STREAMS
SAAD A. RAGAB (Virginia Polytechnic Institute and State University, Blacksburg) and J. L. WU AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(Contract N00014-87-K-0168)
(AIAA PAPER 88-0038)

Linear instability waves in supersonic shear layers have been analyzed. Both viscous and inviscid disturbances are considered. The basic state is obtained by solving the compressible laminar boundary layer equations or is specified by the hyperbolic tangent profile. The effects of the velocity ratio and temperature ratio have been determined. The maximum growth rate depends nonlinearly on the velocity ratio. The obtained results also substantiate the convective Mach number as a compressibility parameter. Two-dimensional disturbances correlate with experimental data for convective Mach numbers less than 0.8, and oblique waves improves the correlation for higher Mach numbers. Finally, the nonparallel effects are negligible for the laminar mixing layers. Author

A88-22028#
AN INVESTIGATION OF EXCITATION EFFECTS ON A ROW OF IMPINGING JETS USING LARGE-EDDY SIMULATIONS
MAGDI H. RIZK and SURESH MENON (Flow Research Co., Kent, WA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 20 p. refs
(Contract F49620-85-C-0084)
(AIAA PAPER 88-0043)

Numerical simulations of a row of impinging jets are performed. The problem considered contains the essential features of twin jets impinging on the ground, simulating the hovering configuration of a vertical takeoff and landing (VTOL) aircraft. The flow is assumed to be governed by the time-dependent, incompressible Navier-Stokes equations. The large-eddy simulation approach is followed. The response of the fountain, generated due to the collision of the wall jets, to various azimuthal and axisymmetric excitations applied at the exists of its neighboring jets, is investigated. Distinct fountain characteristics are shared among the cases in which azimuthal perturbations are applied at both jet exits in the same direction. These include a high fountain spreading rate, strong lateral interaction with the neighboring jets and weak lift-off effects. A strong similarity in fountain characteristics also exists for the cases of axisymmetric forcing and azimuthal forcing in opposite directions at the two jet exits. The similar characteristics here include a low fountain spreading rate and high lift-off effects. Author

A88-22029*# Boeing Helicopter Co., Philadelphia, Pa.
TWO-DIMENSIONAL INTERACTION OF VORTICES WITH A BLADE
DAVID R. POLING (Boeing Helicopter Co., Philadelphia, PA), DEMETRI P. TELIONIS (Virginia Polytechnic Institute and State University, Blacksburg), and MICHAEL C. WILDER AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. Research supported by the Boeing Vertol Co. and NASA. refs
(AIAA PAPER 88-0044)

The problem of blade-vortex interaction is studied experimentally and numerically. Vortices are generated in the laboratory by pitching an airfoil upstream of the model. LDV measurements are obtained in the neighborhood of the leading edge of the airfoil. Ensemble-averaged velocity vector fields and vorticity contours are thus constructed. A vortex is modeled numerically by a cloud of discrete ideal point vortices. The problem is solved via a Joukowski transformation. The interaction of distributed vorticity with the leading edge of the airfoil is examined. Author

A88-22030*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AN EXPERIMENTAL STUDY OF ROTOR-VORTEX INTERACTIONS
F. X. CARADONNA, J. LAUTENSCHLAGER, and M. SILVA (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(AIAA PAPER 88-0045)

A scheme for investigating general blade/vortex interactions (BVIs) has been used to obtain an unusual body of data. The scheme involves locating a vortex generator upstream of a nonlifting rotor so that the vortex interacts with the rotor at any desired forward azimuth. Parallel BVIs produced by this external vortex generator are shown to be nearly identical to those produced by the rotor alone operating in a normal descent mode. The test delineates various generic features of parallel and oblique BVIs. However, the dominant feature is the leading-edge pressure pulse. The effects of blade/vortex angle, and proximity (including head-on interactions) on this pulse are discussed. The effect of Mach number on the leading edge pressure variation is shown to be small even for supercritical interactions. Author

A88-22031*# Sterling Software, Palo Alto, Calif.
NUMERICAL SIMULATION OF HELICOPTER MULTI-BLADED ROTOR FLOW
C. L. CHEN (Sterling Software, Palo Alto, CA) and W. J. MCCROSKEY (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0046)

A numerical method for solving the Euler equations for multiblade rotors has been developed. The computed results, including one nonlifting forward-flight and several lifting hovering cases, are compared with experimental data. For forward-flight case, the unsteady growth and decay of the shock agree well with experimental results. For hovering case, at low and moderate transonic tip speed, the results show good agreement with experimental data in the tip region. The near-wake effects can be captured without wake modeling. Author

A88-22032#
MEASUREMENT AND COMPUTATION OF THE FLOW AROUND THE TIP OF A LIFTING ROTOR BLADE IN HOVER
L. N. SANKAR and N. M. KOMERATH (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. refs
(Contract DAAG29-82-K-0084)
(AIAA PAPER 88-0047)

The incompressible flow field near the tip of a single-bladed rotor in hover has been studied using a 3-D unsteady Navier-Stokes code, and using laser velocimeter measurements. The computer code has been previously used to study steady and unsteady viscous flow past rotor blades. The flow field predictions close to the blade agree well with the velocity measurements, but there are some differences near the leading edge off the blade tip. Measured velocity profiles across the tip vortex core reveal secondary features attributable to the difference in sense of rotation of the tip vortex and the trailing vortex sheet. Author

A88-22040#
FLOW UNSTEADINESS CONSIDERATIONS IN HIGH ALPHA TESTING
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0057)

High performance aircraft and missiles are maneuvering at high angles of attack, where the aerodynamics are dominated by separated flow effects. Associated with flow separation is flow unsteadiness of two basic types; one is motion-independent, generating the buffet-type of vehicle response; the other type of flow unsteadiness is highly motion-dependent, often generating negative aerodynamic damping. In a static high-alpha test the motion-independent unsteadiness of the slender forebody vortices will generate a time-average (static) side force that is of lesser magnitude than the instantaneous (maximum) side force. In a high-alpha flight maneuver, on the other hand, the motion-dependent unsteadiness can cause the vortex-induced side force to stay at its maximum value for an extended period of time. The problem this presents for the vehicle designer is the topic of the present paper. Author

A88-22072*# Old Dominion Univ., Norfolk, Va.
UNSTEADY VISCOUS CALCULATIONS OF SUPERSONIC FLOWS PAST DEEP AND SHALLOW THREE-DIMENSIONAL CAVITIES
O. BAYSAL, S. SRINIVASAN (Old Dominion University, Norfolk, VA), and R. L. STALLINGS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. refs
(Contract NAG1-664)
(AIAA PAPER 88-0101)

Computational simulations were performed for supersonic, turbulent flows over deep and shallow three-dimensional cavities. The width and the depth of these cavities were fixed at 2.5 in. and 0.5 in., respectively. Length-to-depth ratio of the deep cavity was 6 and that of the shallow cavity was 16. Freestream values of Mach number and Reynolds number were 1.50 and 2.0 x 10 to the 6th/ft., respectively, at a total temperature of 585 R. The thickness of the turbulent boundary layer at the front lip of the cavity was 0.2 in. Simulations of these oscillatory flows were generated through time-accurate solutions of Reynolds-averaged full Navier-Stokes equations using the explicit MacCormack scheme. The solutions are validated through comparisons with experimental data. The features of open and closed cavity flows and effects of the third dimension are illustrated through computational graphics. Author

A88-22073*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NAVIER-STOKES SOLUTIONS FOR TRANSONIC FLOW OVER A WING MOUNTED IN A TUNNEL
V. N. VATSA (NASA, Langley Research Center, Hampton, VA) and B. W. WEDEN (Vigyan Research Associates, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(AIAA PAPER 88-0102)

Three-dimensional viscous flow calculations are performed for a swept, NACA 0012 wing mounted inside a wind tunnel for which detailed experimental data is available. A Runge-Kutta time-stepping scheme is used for obtaining steady-state solutions to the thin-layer Navier-Stokes equations. Free-air comptuations are also performed to assess the wall-interference effects. The effects of grid density and artificial dissipation on the accuracy of numerical results are included. The effect of the wind-tunnel sidewall boundary layer on the flow pattern over the wing surface, particularly in the vicinity of the wing/wall juncture is found to be significant. Author

A88-22074#
MULTIZONE NAVIER-STOKES COMPUTATIONS OF VISCOUS TRANSONIC FLOWS AROUND AIRFOILS
JOHN S. CHAN (Boeing Aerospace Co., Seattle, WA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. Research supported by the Boeing Independent Research and Development Program. refs
(AIAA PAPER 88-0103)

A new multizone Navier-Stokes solution code, using the MacCormack finite volume explicit algorithm, has recently been used to simulate viscous transonic airfoil flows. The multizone approach simplifies the boundary condition application across the wake. The steady state solutions of the Reynolds-averaged Navier-Stokes equations about three different airfoils at various flow conditions were generated using the time-marching algorithm and the Baldwin-Lomax turbulence model. The three airfoils used in the computations are: the RAE 2822 airfoil, the DSMA 523 airfoil and a new Integrated Technology (IT) airfoil. Wind tunnel test data, wherever available, were used to verify the computed results. The overall results are in excellent agreement with experimental data. Author

A88-22076#
NAVIER-STOKES CALCULATIONS OF THE FLOWFIELD OF A HELICOPTER ROTOR IN HOVER
RAMESH K. AGARWAL (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0106)

Aerodynamic loads on a multibladed helicopter rotor in hovering flight are calculated by solving the three-dimensional thin-layer Reynolds-averaged Navier-Stokes equations in a rotating coordinate system on body-conforming curvilinear grids around the blades. The thin-layer Navier-Stokes equations are recast in the absolute-flow variables so that the absolute flow in the far field is uniform but the relative flow is nonuniform. Equations are solved for the absolute-flow variables by employing Jameson's finite-volume explicit Runge-Kutta time-stepping scheme.

Rotor-wake effects are modeled in the form of a correction applied to the geometric angle of attack along the blades. This correction is obtained by computing the local induced downwash with a free-wake analysis program. The calculations are performed on a Cray-2 for a model helicopter rotor in hover at various collective pitch angles. The results are compared with experimental data.
Author

A88-22078*# California State Univ., Long Beach.
THE CALCULATION OF FLOW OVER ICED AIRFOILS
TUNCER CEBECI (California State University, Long Beach) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(Contract NAG3-601)
(AIAA PAPER 88-0112)

Progress toward the development of a method for predicting the flowfield of an iced airfoil is described and shown to offer the prospect of a priori calculations of the effects of ice accretion and roughness on airfoil performance. The approach is based on interaction of inviscid flow solutions obtained by a panel method and improved upon by a finite-difference boundary-layer method which, operating in an inverse mode, incorporates viscous effects including those associated with separated flows. Results are presented for smooth, rough and iced airfoils as a function of angle of attack. Those for smooth and rough airfoils confirm the accuracy of the method and its applicability to surfaces with roughness similar to that associated with insect deposition and some forms of ice. Two procedures have been developed to deal with large ice accretion and their performance is examined and shown to be appropriate to the engineering requirements.
Author

A88-22084#
EFFECTS OF MACH NUMBER AND REYNOLDS NUMBER ON LEADING-EDGE VORTICES AT HIGH ANGLE-OF-ATTACK
KARL F. SCHRADER, GREGORY A. REYNOLDS, and CHARLES J. NOVAK (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. refs
(AIAA PAPER 88-0122)

The flowfield above a 63-degree leading-edge-sweep delta wing is studied for high angles-of-attack. Reynolds number variations were found to result in changes in the vortex structure and to have only little influence on the aerodynamic forces. Increasing Mach number was found to diminish the lift that was generated by the lee-side vortices. The flowfield of the leading-edge vortices showed a strong asymmetry for certain angles-of-attack in the compressible regime. The present results suggest a nonconical shock pattern where curved vortices are generated above the primary vortices. Increasing the angle-of-attack would result in shocks moving toward the centerline, eventually merging into a centerline shock.
R.R.

A88-22086#
NUMERICAL SIMULATION OF SHOCK INTERACTION WITH CYLINDRICAL CAVITIES
JOSEPH D. BAUM (U. S. Navy, Naval Research Laboratory, Washington, DC) and SHMUEL EIDELMAN (Science Applications International Corp., McLean, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p.
(AIAA PAPER 88-0124)

The time-dependent three-dimensional compressible Euler equations for air are solved using the leapfrog Flux-Corrected Transport code FAST3D in order to numerically investigate the time evolution of a shock wave transversing a cylindrical cavity imbedded in the solid surface of a flight vehicle. The results demonstrate shock focusing and diffraction effects. It is suggested that the semiperiodic behavior found in the three-dimensional solution resulted from focusing of the flow in the transverse direction toward the 180 degree point and the increased pressure amplitude behind the reflected shock. This in turn is hypothesized to have caused the shock to propagate upstream and to increase the pressure near the upstream wall, reestablishing the oblique shock wave.
R.R.

A88-22087#
A NUMERICAL STUDY OF THREE-DIMENSIONAL SEPARATED FLOWS AROUND A SWEPTBACK BLUNT FIN
D. L. MCMASTER and J. S. SHANG (USAF, Flight Dynamics Laboratory, Wright Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0125)

A series of numerical simulations was carried out for supersonic flow past a blunt fin mounted on a flat plate with progressively increasing leading edge sweepback. The numerical result for zero degree sweep (vertical fin) was first validated with a known numerical solution and experimental data at Mach 2.95 and unit Reynolds number of 64 million per meter. The upstream condition of the interacting region was characterized by a fully developed turbulent boundary layer with a thickness identical to that of the fin diameter. The upstream and spanwise influence of the fin decreased significantly with increasing sweepback. Under the given flow conditions, the bifurcation of the phase portrait of the surface shear-stress vector was observed between the sweepback angles of 60 to 68 degrees.
Author

A88-22088*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SOLUTIONS FOR HYPERSONIC VISCOUS FLOW OVER DELTA WINGS
STEPHEN M. RUFFIN (NASA, Ames Research Center, Moffett Field, CA) and EARLL M. MURMAN (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 17 p. refs
(Contract NAG1-507)
(AIAA PAPER 88-0126)

A conical Navier-Stokes solver is developed to study hypersonic flow over delta wings. The differencing scheme used is van Leer flux vector splitting with MUSCL differencing. A flux limiter which involves a second difference in pressure was found to provide sharp, nonoscillatory shocks in windward and leeward flow regions. The governing equations are cast in finite-volume form and are solved using an explicit multistage method. A von Neumann stability analysis of a one-dimensional flux split model is used to predict the stability characteristics of the conical solver. The stability behavior of the scheme is found to strongly depend on the stage coefficients of the multistage scheme and on the order of accuracy of the upwind discretization.
Author

A88-22091*# Textron Bell Helicopter, Fort Worth, Tex.
NONLINEAR AERODYNAMICS OF TWO-DIMENSIONAL AIRFOILS IN SEVERE MANEUVER
MATTHEW T. SCOTT (Bell Helicopter Textron, Fort Worth, TX) and JAMES E. MCCUNE (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(Contract AF-AFOSR-86-157; NAG1-658)
(AIAA PAPER 88-0129)

This paper presents a nonlinear theory of forces and moment acting on a two-dimensional airfoil in unsteady potential flow. Results are obtained for cases of both large and small amplitude motion. The analysis, which is based on an extension of Wagner's integral equation to the nonlinear regime, takes full advantage of the trailing wake's tendency to deform under local velocities. Interactive computational results are presented that show examples of wake-induced lift and moment augmentation on the order of 20 percent of quasi-static values. The expandability and flexibility of the present computational method are noted, as well as the relative speed with which solutions are obtained.
Author

A88-22092#
VISCOUS AERODYNAMIC ANALYSIS OF AN OSCILLATING FLAT PLATE AIRFOIL WITH A LOCALLY ANALYTICAL SOLUTION
LINDA M. SCHROEDER and SANFORD FLEETER (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. USAF-sponsored research. refs
(AIAA PAPER 88-0130)

A mathematical model is developed to predict the unsteady aerodynamics of a flat plate airfoil executing harmonic torsional motion in an incompressible laminar flow at moderate values of the Reynolds numbers. The unsteady viscous flow is assumed to be a small perturbation to the steady viscous flow described by the Navier-Stokes equations. Solutions for both the steady and the unsteady viscous flow fields are obtained by developing a locally analytical solution. This model is then utilized to demonstrate the effects of Reynolds number, mean flow incidence angle, and reduced frequency on the complex unsteady airfoil surface pressure distributions as well as airfoil stability. Author

A88-22093*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A NATURAL LOW FREQUENCY OSCILLATION IN THE WAKE OF AN AIRFOIL NEAR STALLING CONDITIONS
K. B. M. Q. ZAMAN and D. J. MCKINZIE (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. Previously announced in STAR as N88-10779. refs
(AIAA PAPER 88-0131)

An unusually low frequency oscillation in the flow over an airfoil was explored experimentally. Wind tunnel measurements were carried out with a two dimensional airfoil model at a chord Reynolds number of 100,000. During deep stall the usual bluff-body shedding occurred at a Strouhal number. But at the onset of stall a low frequency periodic oscillation occurred, the corresponding Strouhal number being an order of magnitude lower. The phenomenon occurred in relatively unclean flow when the freestream turbulence was raised to 0.4 percent, but did not in the cleaner flow with turbulence intensity of 0.1 percent. It could also be produced by certain high frequency acoustic excitation. Details of the flow field are compared between a case of low frequency oscillation at alpha = 15 deg and a case of bluff-body shedding at alpha = 22.5 deg. The origin of the low frequency oscillation traces to the upper surface of the airfoil and is seemingly associated with the periodic formation and breakdown of a large separation bubble. The intense flow fluctuations impart significant unsteady forces to the airfoil but diminish rapidly within a distance of one chord from the trailing edge. Author

A88-22094#
EFFECT OF COMPRESSIBILITY ON DYNAMIC STALL OF A PITCHING AIRFOIL
MIGUEL R. VISBAL (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 17 p. refs
(AIAA PAPER 88-0132)

A computational study is presented for the dynamic stall of an airfoil which is pitched at a constant rate from zero incidence to a high angle of attack. The unsteady flow is simulated employing the mass-averaged Navier-Stokes equations and an algebraic turbulent eddy viscosity model. The approach is first validated by comparison of computed and experimental results for a pitching airfoil at low freestream Mach numbers. The computed dynamic stall events, as well as the computed effects of pitch rate and axis location are found in qualitative agreement with experimental observations. The effect of compressibility on dynamic stall is investigated. As the freestream Mach number increases, the appearance of a supersonic region provides, through the shock/boundary layer interaction, an additional mechanism in the dynamic stall process. The main effects of compressibility are found to be: (1) a change from trailing-edge stall to leading-edge stall and (2) a reduction of the stall delay and of the attained maximum lift. Author

A88-22096*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A LOW-DRAG NOSE-BODY
P. R. BANDYOPADHYAY (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. refs
(Contract NAS1-18235)
(AIAA PAPER 88-0135)

In the present investigation of the application of convex-curvature viscous drag reduction to an axisymmetric body, the qualification of a modified mixing-length formulation in several complex two-dimensional and axisymmetric turbulent boundary layers that are primarily curved is followed by the design of a low-drag nose-body for low drag at high subsonic speeds. The longitudinal distribution of the cross-sectional area ratio is found to be critical to boundary layer separation, requiring implementation not over a single long span of curvature but over three short spans. The possibility of a 'net' drag reduction is examined in relation to 'equivalent' nose-bodies. O.C.

A88-22102*# Flow Research, Inc., Kent, Wash.
A PROCEDURE BASED ON THE EULER EQUATIONS FOR CORRECTING TRANSONIC WIND TUNNEL WALL INTERFERENCE
MAGDI H. RIZK, DONALD R. LOVELL (Flow Research Co., Kent, WA), and TIMOTHY J. BAKER (Princeton University, NJ) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 21 p. refs
(Contract NAS2-12157)
(AIAA PAPER 88-0141)

Based on an optimization formulation, a procedure has been developed to evaluate Mach number and angle-of-attack corrections. The Euler equations are assumed to be the flow governing equations. To obtain efficient solutions for the optimization problem, the iterative solutions for the flow variables and the design parameters are simultaneously updated. In addition to the model lift and geometry, the procedure requires pressure measurements near the tunnel walls. The accuracy and efficiency of several optimization techniques are investigated. The effect of perturbing certain test conditions on the residual interference is investigated. Author

A88-22126#
TIME SERIES ANALYSIS OF SHOCK-INDUCED PRESSURE FLUCTUATIONS IN SUPERSONIC INTERACTIVE FLOW
HANS A. BAADE AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. NASA-Navy-sponsored research. refs
(Contract AF-AFOSR-86-0112)
(AIAA PAPER 88-0176)

Fluctuating surface pressures were measured upstream of separation in a shock wave-turbulent boundary layer interaction in a Mach 5 flow. The interaction was generated by placing a semiinfinite unswept cylinder in the turbulent boundary layer on a flat plate. Signals from two streamwise-mounted pressure transducers were conditionally sampled and then cross correlated. From the cross correlation and an analysis of model signals, estimates of maximum upstream and downstream speeds of the separation shock were determined to be approximately 10 percent of the freestream velocity and 20 percent of the convection velocity of the turbulence structures in the incoming turbulent boundary layer. Author

A88-22133*# Texas A&M Univ., College Station.
3-D LDA STUDY OF A RECTANGULAR JET
GERALD L. MORRISON, GARY B. TATTERSON (Texas A & M University, College Station), and DAVID H. SWAN AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(Contract NAG1-630)
(AIAA PAPER 88-0183)

The flow field of a rectangular jet with a 2:1 aspect ratio was studied at an axial Reynolds number of 100,000 (Mach number 0.09) using three-dimensional laser Doppler velocimetry. The flow field survey resulted in mean velocity vector field plots and contour plots of the Reynolds stress tensor components. This paper presents contour plots in the planes of the jet minor and major axes at different axial locations. These data contribute substantially to currently available data of jet flow fields and will provide a valuable database for three-dimensional modeling. Author

A88-22135#
PREDICTION OF THREE-DIMENSIONAL TURBULENT FLOWS IN A DUMP DIFFUSER
YASUNORI ANDO, MASAFUMI KAWAI (Ishikawajima-Harima Heavy Industries Co., Ltd., Research Institute, Yokohama, Japan), YUKINORI SATO, and HIDEMI TOH (Ishikawajima-Harima Heavy Industries Co., Ltd., Research and Development Dept., Tokyo, Japan) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. refs
(AIAA PAPER 88-0185)

A finite volume method for the solution of three-dimensional incompressible steady Navier-Stokes equations based on a general curvilinear coordinate system was employed to study the characteristics of turbulent flow in dump diffuser of gas-turbine combustor. The standard k-epsilon turbulence model is used to characterize the effect of turbulence. In order to achieve a saving in CPU time for calculation, present calculation was performed by lending itself to vector computer architecture of the FACOM VP-50 supercomputer. This method is applied to prediction of turbulent flow in a three-dimensional dump diffuser with and without the fuel nozzle. The calculated resutls are compared with the corresponding experimental data obtained in this work. General features of the flow pattern are adequately predicted, although discrepancies in detail seem to indicate deficiencies in the turbulence model used in present study. Author

A88-22139*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OBSERVATION OF AIRPLANE FLOW FIELDS BY NATURAL CONDENSATION EFFECTS
JAMES F. CAMPBELL, JOSEPH R. CHAMBERS, and CHRISTOPHER L. RUMSEY (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 26 p. refs
(AIAA PAPER 88-0191)

In-flight condensation patterns can illustrate a variety of airplane flow fields, such as attached and separated flows, vortex flows, and expansion and shock waves. These patterns are a unique source of flow visualization that has not been utilized previously. Condensation patterns at full-scale Reynolds number can provide useful information for researchers experimenting in subscale tunnels. It is also shown that computed values of relative humidity in the local flow field provide an inexpensive way to analyze the qualitative features of the condensation pattern, although a more complete theoretical modeling is necessary to obtain details of the condensation process. Furthermore, the analysis revealed that relative humidity is more sensitive to changes in local static temperature than to changes in pressure. Author

A88-22143*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN AND EXPERIMENTAL VERIFICATION OF AN EQUIVALENT FOREBODY TO PRODUCE DISTURBANCES EQUIVALENT TO THOSE OF A FOREBODY WITH FLOWING INLETS
DAVY A. HAYNES, DAVID S. MILLER (NASA, Langley Research Center, Hampton, VA), JOHN R. KLEIN, and CHECK M. LOUIE (McDonnell Aircraft Co., Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0195)

A method by which a simple equivalent faired body can be designed to replace a more complex body with flowing inlets has been demonstrated for supersonic flow. An analytically defined, geometrically simple faired inlet forebody has been designed using a linear potential code to generate flow perturbations equivalent to those produced by a much more complex forebody with inlets. An equivalent forebody wind-tunnel model was fabricated and a test was conducted in NASA Langley Research Center's Unitary Plan Wind Tunnel. The test Mach number range was 1.60 to 2.16 for angles of attack of -4 to 16 deg. Test results indicate that, for the purposes considered here, the equivalent forebody simulates the original flowfield disturbances to an acceptable degree of accuracy. Author

A88-22144#
INVESTIGATIONS OF LOW-SPEED NOZZLE/AFTERBODY PERFORMANCE FOR A GENERIC HYPERSONIC CONFIGURATION
CHARLES J. NOVAK and KENNETH C. CORNELIUS (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(AIAA PAPER 88-0196)

In this study the nozzle/afterbody flowfield of a generic hypersonic cruise configuration has been investigated using several modern wind tunnel test techniques to provide both CFD correlation data and an understanding of the flow physics. A wind tunnel model with three different upswept afterbodies and simulated propulsion effects was designed, fabricated and tested at transonic and low supersonic conditions to explore the effects of Mach number and Reynolds number variation. The model was then tested again at low subsonic speeds using a 3-D laser velocimeter to quantify the turbulent behavior of the jet-freestream mixing region. For all three afterbodies tested, it was found that a high jet-to-freestream velocity ratio promoted jet attachment to the nozzle surface. In addition, the low-speed laser velocimeter data, when reduced and analyzed using a wake integration technique, showed that the crossflow velocities generated by the half-nozzle flow contribute heavily to the thrust losses. Further, the amount of thrust vectored by this propulsion integration concept also indicates that similar configurations may share common penalties in loss of thrust recovery. Author

A88-22167#
A HYBRID FINITE VOLUME APPROACH TO EULER SOLUTIONS FOR SUPERSONIC FLOWS
M. J. SICLARI and P. DEL GUIDICE (Grumman Corporate Research Center, Bethpage, NY) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0225)

A new efficient numerical scheme is presented to solve the Euler equations about three-dimensional surfaces for supersonic flows. The approach utilizes a node-centered, physical space, finite volume, central difference scheme with added dissipation which is applied to the crossflow plane terms of the Euler equations. The discretized unsteady Euler equations are then solved by multistage Runge-Kutta integration with local time stepping and residual smoothing to accelerate convergence to a steady state. Three-dimensional flows are treated using an upwind finite difference scheme for the nonconical terms within the context of a fully implicit marching technique on spherical surfaces. Results for both conical and three-dimensional flows are presented. Author

A88-22168*# California Univ., Davis.
CALCULATIONS OF TRANSONIC FLOWS WITH SHOCKS USING NEWTON'S METHOD AND DIRECT SOLVER. II - SOLUTION OF EULER EQUATIONS
M. HAFEZ, S. PALANISWAMY, and P. MARIANI (California, University, Davis) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 40 p. NASA-supported research. refs
(AIAA PAPER 88-0226)

Transonic flows with shocks are simulated using steady Euler equations and by simultaneously solving the resulting nonlinear algebraic equations using Newton's method. At each iteration, a direct solver computes the corrections and the process is repeated until convergence is achieved. The corrections and errors are reduced quadratically with the present method, allowing solutions of machine accuracy to be obtained in a few steps. Nonunique inviscid solutions and nonunique solutions of the Navier Stokes equations for quasi-one-dimensional flows in nozzles are presented. Calculations are also presented for steady two-dimensional inviscid flows around a cylinder in the transonic regime. R.R.

A88-22169#
A FLUX-VECTOR SPLIT, FINITE-VOLUME METHOD FOR EULER'S EQUATIONS ON NON-MAPPED GRIDS
B. GROSSMAN (Virginia Polytechnic Institute and State University, Blacksburg) and S. K. CHOI AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0227)

A numerical procedure has been developed for the computation of high-speed inviscid flows over arbitrary, complex two-dimensional geometries. The Euler equations are solved using a finite-volume method with a non-body-fitted Cartesian grid. A new numerical formulation for the complicated body geometries is developed in conjunction with implicit flux-split schemes. Computations for blunt bodies, scramjet inlets, and airfoils show good agreement with exact solutions or existing solutions with body-fitted grids. The method is shown to be accurate, efficient and robust and should prove to be particularly useful in a preliminary design mode, where a wide variety of complex geometries can be computed without complicated grid-generation procedures. Author

A88-22172*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN HISTORICAL PERSPECTIVE ON HYPERSONIC AERODYNAMIC RESEARCH AT THE LANGLEY RESEARCH CENTER
PATRICK J. JOHNSTON and WALLACE C. SAWYER (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(AIAA PAPER 88-0230)

The 40-year history of hypersonic technology is reviewed from a technical perspective. A broad overview is first given of the major accomplishments of hypersonic flight projects and systems studies that have been conducted over the last 40-odd years. Then, the history of major supersonic and hypersonic ground facilities at the NASA Langley and Ames Research Centers is traced, and some of the research conducted in them over the past 40 years is reviewed. C.D.

A88-22173#
THE COMPUTATION OF THE BOUNDARY REGION USING THE THIN-LAYER NAVIER-STOKES EQUATIONS
F. MARCONI (Grumman Corporate Research Center, Bethpage, NY) and G. WILSON AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0231)

The ability of the thin-layer Navier-Stokes equations to predict the flow near the lee plane of bodies at angle of attack (i.e., the boundary region) is investigated. The high super/hypersonic flow about cones on varying angles of attack is considered. The effects of including crossflow diffusion and eliminating artificial dissipation are studied in detail. Author

A88-22174*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
COMPUTATION OF HYPERSONIC FLOW THROUGH A NARROW EXPANSION SLOT
CHING-MAO HUNG and TIMOTHY J. BARTH (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(AIAA PAPER 88-0232)

The compressible Navier-Stokes equations are numerically solved for hypersonic flow over a three-dimensional ramp with a narrow expansion slot. In a two-dimensional test case, it is shown that a higher order scheme is needed to avoid too much numerical dissipation and hence too much total-pressure loss. The calculation demonstrates the role of viscosity in the expansion process of hypersonic flow through the narrow slot. Cases with various wall temperatures and slot widths are studied. Calculations show that wall cooling reduces the thickness of boundary layer, and hence increases the flow expansion substantially. In the lower portion of the slot, inviscidly, the flow is dominated by a highly expanded low density fluid, and viscously, by a viscous layer. As a direct consequence, as soon as the wedge angle is large enough, the mass flux through the slot is almost constant. Author

A88-22175*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
VISCOUS HYPERSONIC SHOCK-ON-SHOCK INTERACTION ON BLUNT COWL LIPS
G. H. KLOPFER (NEAR, Inc., Mountain View, CA) and H. C. YEE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 20 p. refs
(Contract N00014-87-C-0483)
(AIAA PAPER 88-0233)

The effects of impinging ramp shocks on a two-dimensional viscous inlet cowl of the National Aerospace Plane (NASP) or blunt body flow fields for various impingement locations are numerically simulated by a recently developed second-order implicit total variation diminishing (TVD) algorithm. The results demonstrate that accurate computation of heat transfer rate is crucially dependent on adequate normal grid resolution at the wall. The various numerical results are compared with recent experimental data. Due to the complex flow patterns that occur for the shock-on-shock flows, adaptive grid procedures are utilized. Author

A88-22198#
EXPERIMENTAL MEASUREMENTS OF THE FLOW IN A SCRAMJET INLET AT MACH 4
WILLIAM J. YANTA, ARNOLD S. COLLIER, CHARLES W. SPRING, III, CHRISTOPHER F. BOYD (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD), and J. CRAIG MCARTHUR (North Carolina State University, Raleigh) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 16 p. refs
(Contract NAVY TASK RR-023-02)
(AIAA PAPER 88-0271)

Wind tunnel measurements have been carried out in a scramjet inlet model at a freestream Mach number of 4. Measurements included velocity profiles using a two-dimensional Laser Doppler Velocimeter (LDV), Mach number surveys, skin friction measurements with Preston probes, wall static pressure distributions, density profiles with a laser holographic interferometer and qualitative shadowgraph photography. The effect of boundary layer bleed on the viscous flow entering the inlet was also investigated. It was determined that bleeding off the boundary layer increased the inlet efficiency substantially. Author

A88-22199#
AN EXPERIMENTAL INVESTIGATION OF SHOCK WAVES AND TURBULENT BOUNDARY LAYER INTERACTIONS IN A SUPERSONIC FLOWFIELD THROUGH AN ANNULAR DUCT
RICHARD D. STOCKBRIDGE (Johns Hopkins University, Laurel, MD) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(Contract N00039-87-C-5301)
(AIAA PAPER 88-0272)

In the present study of supersonic flow compression fields in an axisymmetric annular duct through the overexpansion of compressed air, an attempt is made to acquire and evaluate data on hypersonic inlet performance for a dual combustion ramjet engine. This ramjet configuration's precombustion shock train must be physically isolated from the external compression field of the air inlet, in order to prevent undesirable combustor/inlet interactions. The effect of test variable changes on the position of the compression field is evaluated. O.C.

A88-22200#
THE APPLICATION OF EULER AND NAVIER-STOKES METHODOLOGY TO 2-D AND 3-D NOZZLE-AFTERBODY FLOWFIELDS
B. K. BERGMAN and D. A. TREIBER (Northrop Corp., Aircraft Div., Hawthorne, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 20 p. refs
(AIAA PAPER 88-0274)

The application of Euler and Navier-Stokes methodology is demonstrated for nozzle-afterbody configurations. A major emphasis is placed on the utilization of inviscid three-dimensional Euler methodology for analyzing realistic geometries. Two-dimensional comparisons of various nozzle calculations generated by a modified version of the ARC2D Euler/Navier-Stokes solver will be made to determine the importance of three-dimensional and viscous effects. Three-dimensional analysis using a modified version of the FLO57 Euler solver will be made on a choked exit single expansion ramp nozzle (SERN) and compared to available test data. Three-dimensional grid generation and adaption are also discussed. Author

A88-22224*# Rutgers Univ., New Brunswick, N. J.
SUPERSONIC TURBULENT FLOW PAST A SWEPT COMPRESSION CORNER AT MACH 3. II
DOYLE D. KNIGHT (Rutgers University, New Brunswick, NJ), C. C. HORSTMAN (NASA, Ames Research Center, Moffett Field, CA), SEYMOUR BOGDONOFF (Princeton University, NJ), DENISE RAUFER, and ANDREW KETCHUM AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 18 p. NSF-supported research. refs
(Contract AF-AFOSR-86-0266; F49620-86-C-0094)
(AIAA PAPER 88-0310)

The three-dimensional Mach 3.0 shock wave-turbulent boundary layer interaction generated by a swept compression corner whose geometry is characterized by the angle of streamwise compression angle alpha and the angle of sweep lambda is presently treated by the Baldwin-Lomax (1978) algebraic turbulent eddy viscosity model. The results obtained, and those previously derived by means of Cebeci and Smith (1974) and Jones and Launder (1972) models, are compared with experimental measurements. The rate of change of the mean kinetic energy along a streamline is investigated, and evidence is obtained that the flowfield structure is rotational and inviscid. O.C.

A88-22226#
MULTI-BLOCK MULTIGRID CALCULATIONS OF A SYSTEM OF ELLIPTIC GRID GENERATORS
C. J. WOAN (Rockwell International Corp., Los Angeles, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. Research supported by the Rockwell International Independent Research and Development Program. refs
(AIAA PAPER 88-0312)

A multiblock multigrid iterative procedure is presented for calculations of a system of elliptic grid generators including surface and 3-dimensional grid generators. In the present multiblock multigrid algorithm, the multrigrid solution blocks are decoupled from the input data blocks and constructed during solution to make the most efficient use of the multigrid method within the computer memory size limitations. Example calculations include grids of 0-type for an airfoil on a circular-cylinder surface, a grid in between two circles on a patched surface, and 3-dimensional grids of O-H type for an ONERA M6 wing. Numerical results indicate that solution convergence can be greatly accelerated by the multigrid method. Author

A88-22227#
AN ADAPTIVE GRID GENERATION TECHNIQUE FOR VISCOUS TRANSONIC FLOW PROBLEMS
C. W. REED (System Dynamics, Inc., Gainesville, FL), C. C. HSU (Florida, University, Gainesville), and N. H. SHIAU AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. USAF-sponsored research. refs
(AIAA PAPER 88-0313)

An adaptive grid generation procedure is developed for viscous flow problems. The equations governing the adaptation are derived using a variational statement resulting in a set of elliptic equations in which adaptation can occur independently in each coordinate direction. The equations allow for explicit control of adaptation and orthogonality while smoothness is inherent in the elliptic equations. They retain a simple relationship between the control functions and the grid point spacing, the minimum and maximum grid point spacing may be specified and the method is capable of providing the extremely refined mesh in the boundary layer regions. The adaptive grid generation technique has been used with a TVD scheme to solve a transonic projectile flow problem. The results indicate that the adaptive grid generation procedure can reliably provide good adaptive grid networks provided proper choices are made for the control functions. Author

A88-22230*# Old Dominion Univ., Norfolk, Va.
UNSTEADY VORTEX-DOMINATED FLOWS AROUND MANEUVERING WINGS OVER A WIDE RANGE OF MACH NUMBERS
OSAMA A. KANDIL and H. ANDREW CHUANG (Old Dominion University, Norfolk, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(Contract NAG1-648)
(AIAA PAPER 88-0317)

The problem of unsteady flow around maneuvering wings is solved using the unsteady Euler equations. The unsteady conservative Euler equations are derived for the flow relative motion with respect to a moving (translating and rotating) frame of reference. The resulting equations can handle the most general case for unsteady three-dimensional flow around maneuvering wings or wing-body configurations undergoing six degrees of freedom motion; three translations and three rotations. The equations are solved using two computational schemes; an explicit multistage finite-volume scheme and an implicit approximately factored finite-volume scheme. The computational applications cover two cases. The first case is for a locally conical supersonic flow of rolling oscillation of a sharp-edged delta wing at zero angle of attack. The second case is for a pitching oscillation around a mean angle of attack of a NACA 0012 airfoil in transonic flow. Author

A88-22233*# Massachusetts Inst. of Tech., Cambridge.
SLENDER WING THEORY INCLUDING REGIONS OF EMBEDDED TOTAL PRESSURE LOSS
JAMES E. MCCUNE, T. SEAN TAVARES, NORMAN K. W. LEE, and DAVID WEISSBEIN (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(Contract AF-AFOSR-86-157; NAG1-658)
(AIAA PAPER 88-0320)

An aerodynamic theory of the flow about slender delta wings is described. The theory includes a treatment of the self-consistent development of the vortex wake patterns above the wing necessary to maintain smooth flow at the wing edges. The paper focuses

especially on the formation within the wake of vortex 'cores' as embedded regions of total pressure loss, fed and maintained by umbilical vortex sheets emanating from the wing edges. Criteria are developed for determining the growing size and location of these cores, as well as the distribution and strength of the vorticity within them. In this paper, however, the possibility of vortex breakup is omitted. The aerodynamic consequences of the presence and evolution of the cores and the associated wake structure are illustrated and discussed. It is noted that wake history effects can have substantial influence on the distribution of normal force on the wing as well as on its magnitude. Author

A88-22234#
A HYBRID VORTEX METHOD FOR PARACHUTE AERODYNAMIC PREDICTIONS
HUGH MCCOY (U.S. Navy, Naval Weapons Center, China Lake, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0322)

The unsteady aerodynamics of constant geometry axisymmetric parachutes has been simulated by using a hybrid vortex method. This hybrid method combines a vortex panel method that models the flow along the parachute surface and a cloud-in-cell method that transports vorticity through the flow field. Asymptotic solutions have been derived that eliminate the singularities associated with near-field problems such as the vortex panel self-induced velocity. The basic transport equations are stated in the theoretical background. The vortex panel and cloud-in-cell methods are discussed as well as the boundary conditions for mutual implementation. Some of the steps taken to verify the performance of the code are presented. The unsteady flow around a ribbon parachute is then simulated using this hybrid method. Author

A88-22235#
PROPULSIVE VORTICAL SIGNATURES OF PLUNGING AND PITCHING AIRFOILS
PETER FREYMUTH (Colorado, University, Boulder) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(Contract F49620-84-C-0065)
(AIAA PAPER 88-0323)

The propulsive vortical signatures behind periodically plunging and pitching airfoils are visualized and identified. These signatures are vortex streets with opposite sense of rotation as the drag indicating Karman vortex street. The signature is most easily identified at high frequencies. At low frequencies visual thrust indication is lost in the wake of the airfoil which also produces drag. Author

A88-22236#
FORCED INTERNAL UNSTEADY AERODYNAMICS
ERIC J. STEPHEN, JOHN M. WALKER, MICHAEL C. ROBINSON (USAF, Frank J. Seiler Research Laboratory, Colorado Springs, CO), RODOLFO LLOBET, and BRUCE LA CHARITE (U.S. Air Force Academy, Colorado Springs, CO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0324)

A model of two cascaded pitching NACA 0015 airfoils was tested in the wind tunnel using different separation distances between the airfoils and different nondimensional pitch rates, alpha(+). The separations varied from .3 chord to 1.0 chord and the alpha(+) varied from .05 to .2. Results indicated that the presence of an additional airfoil has little effect on flow about the exterior surfaces of the airfoils when compared to single airfoil results. The flow between the airfoils was affected by both the separation distance and the nondimensional pitch rate. Increasing alpha(+) delayed the dynamic stall vortex formation on the lower airfoil and decreased the size of the vortex in a similar fashion to a single pitching airfoil. Decreasing the separation distance dramatically affected the formation and convection of the dynamic stall vortex. Author

A88-22237#
UNSTEADY SEPARATED FLOW STRUCTURE - EXTENDED K RANGE AND OSCILLATIONS THROUGH ZERO PITCH ANGLE
MARVIN W. LUTTGES (Colorado, University, Boulder) and SCOTT J. SCHRECK AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(Contract F49620-84-C-0065)
(AIAA PAPER 88-0325)

Unsteady separated flow structures generated by a flat plate undergoing sinusoidal pitching were examined using different mean pitch angles and a broad range of reduced frequency parameters. Multiple-exposure photography phase-locked to plate oscillation phase angles yielded smoke visualization of the flow. The physical development and interactions between unsteady flow structures were carefully assessed spatially and temporally. The oscillating parameters of the plate strongly influenced the initiation, growth and convection rate of the vortex structures. Detailed data reductions were employed to fully evaluate the characteristics of both vortex and ancillary flow structures. These analysis details provided the bases for beginning to evolve a physical model for vortex initiation, development and shedding dynamics. Author

A88-22238#
AN EXPERIMENTAL STUDY OF FLOW DEVELOPMENT OVER AN AIRFOIL IN IMPULSIVE AND ACCELERATING STARTING MOTIONS
F. FINALSH and D. S. MCCOLLUM (Colorado, University, Boulder) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(Contract F49620-84-C-0065)
(AIAA PAPER 88-0326)

A comparative study of two-dimensional vortex patterns developed over an airfoil in impulsive and accelerating starting flows was conducted. A new experimental system that generates and visualizes impulsive and accelerating starting air flows was employed to visualize the flow developments over a NACA0015 airfoil. The visualization sequences survey the flow over a range of angles of attack between 20 and 90 deg and for a chord Reynolds number of 1000. In addition to the qualitative results of flow visualizations, the photographic sequences utilized to extract quantitative information characterize the important features of the flow developments. The comparison of impulsive starting flow and accelerating starting flow over the airfoil shows the similarities and the differences of flow developments, revealing new information on vortex patterns of dynamic separation. Author

A88-22239#
UNSTEADY SURFACE PRESSURE MEASUREMENTS ON A PITCHING RECTANGULAR WING
MICHAEL C. ROBINSON (USAF, Frank J. Seiler Research Laboratory, Colorado Springs, CO) and JOHN B. WISSLER (U.S. Air Force Academy, Colorado Springs, CO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. USAF-sponsored research. refs
(AIAA PAPER 88-0328)

Transient pressure measurements collected at three different span locations documented the forced unsteady flow separation from a pitching rectangular wing. The separated flow was dominated by the development of both a leading edge and wingtip vortex. Pressure signatures from the vortex-wing interaction provided an indication of the dynamic vortex behavior along the span. Inboard, away from the wingtip, vortex initiation and development proceeded two-dimensionally, duplicating previous airfoil results. Near the tip, vortex-vortex interactions prolonged vortex residence times and enhanced the sectional lift coefficient values. The magnitude and duration of these enhancements were directly dependent upon the wing pitch rate. These findings suggest that previous two-dimensional airfoil results should provide a good indication of three-dimensional wing performance. Author

A88-22240*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SOME NUMERICAL AND PHYSICAL ASPECTS OF UNSTEADY NAVIER-STOKES COMPUTATIONS OVER AIRFOILS USING DYNAMIC MESHES
CHRISTOPHER L. RUMSEY and W. KYLE ANDERSON (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(AIAA PAPER 88-0329)

An upwind-biased implicit approximate factorization algorithm is applied to several unsteady flows on dynamic meshes. The thin-layer form of the compressible Navier-Stokes equations is used to solve both laminar and turbulent flows over airfoils pitching about the quarter chord. Numerical aspects of the solutions are investigated, including grid and time step effects. Two methods for determining fluxes - flux-vector splitting and flux-difference splitting - are compared. Flux-difference splitting predicts results more accurately than flux-vector splitting on a coarse mesh, but both methods agree on a fine mesh. Physical aspects of the computations are also examined. An equilibrium turbulent boundary layer model computes generally better unsteady results in comparison with experiment than a nonequilibrium model for the transonic case analyzed. Also, the size and location of the primary shed vortex for an airfoil pitching up at a constant rate is calculated in good agreement with experiment for two pitch rates. Author

A88-22244*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CAVITY DOOR EFFECTS ON AERODYNAMIC LOADINGS OF COMPRESSED-CARRIAGE STORE CONFIGURATIONS SEPARATING FROM CAVITIES AT SUPERSONIC SPEEDS
A. B. BLAIR, JR. and R. L. STALLINGS, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p. refs
(AIAA PAPER 88-0333)

An experimental wind-tunnel investigation has been conducted at supersonic Mach numbers to determine the effects of cavity doors on the aerodynamic characteristics of compressed-carriage store configurations during separation from a shallow box cavity (closed cavity flow) located in a simulated generic parent aircraft. The tests were conducted in the Langley Unitary Plan Wind Tunnel at free-stream Mach numbers of 1.70, 2.00, and 2.65 for a constant Reynolds number per foot of two million. Results are summarized to show the effects of cavity door opening angles, vertical door height, folded and unfolded tail fins, and Mach number on the near-field aerodynamic separation characteristics of a single missile-type store with in-line cruciform wings and tail fins.
Author

A88-22266#
COMPUTATION OF CASCADE FLOWS AT HIGH REYNOLDS NUMBER BY NUMERICAL SOLUTION OF THE NAVIER-STOKES EQUATIONS
L. CAMBIER and J. P. VEUILLOT (ONERA, Chatillon-sous-Bagneux, France) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. DRET-supported research. refs
(AIAA PAPER 88-0364)

The paper deals with the numerical simulation of two-dimensional turbulent flows by solution of the Reynolds averaged Navier-Stokes equations with a mixing-length turbulence model. The equations are solved in a pseudo-unsteady formulation with constant total enthalpy, by means of an explicit one-step centered finite difference scheme with a multigrid convergence acceleration. A subdomain decomposition technique with viscous and inviscid subdomains is implemented. Characteristic relations are used for subdomain matching as well as for the boundary condition treatment. Numerical results related to high Reynolds number flows through a rotating supersonic compressor cascade are in good agreement with experimental measurements. Author

A88-22267#
EXPERIMENTAL INVESTIGATION OF LOADING EFFECTS ON SIMULATED COMPRESSOR AIRFOIL TRAILING-EDGE FLOWFIELDS
DUANE C. MCCORMICK, ROBERT W. PATERSON (United Technologies Research Center, East Hartford, CT), and HARRIS D. WEINGOLD (United Technologies Corp., Pratt and Whitney, East Hartford, CT) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 18 p. refs
(Contract N00014-83-C-0434)
(AIAA PAPER 88-0365)

Flowfield development in the trailing-edge region of a simulated compressor airfoil having pressure-to-suction surface loading is experimentally investigated at both nominal design condition and higher-loading, off-design condition. In the former, the airfoil boundary layer separated at the trailing edge; at the latter, separation occurred on the suction surface upstream of the trailing edge. Pressure loading was found to alter the trailing edge time mean velocity field from that observed in previous, unloaded airfoil experiments. Increased loading induced greater cascade exit flow deviation from the exit metal angle, thereby reducing the relative cascade flow turning. O.C.

A88-22269#
A COMPARISON OF NUMERICAL SIMULATION AND EXPERIMENTAL MEASUREMENTS OF FLOW THROUGH PROPELLERS
W. J. USAB, JR., K. H. LEE, and J. P. SULLIVAN (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(AIAA PAPER 88-0367)

In the present study two existing inviscid propeller flow solution schemes, a 3-D Euler method and a Vortex Lattice Method, are applied to a simple low speed propeller configuration for which a large amount of experimental data is available. A special mesh is constructed for the 3-D Euler method in an effort to accurately resolve the blade wake and tip vortex downstream of the propeller. Detailed comparisons are made between the two numerical solutions and LDV measurements at selected axial planes upstream and downstream of the propeller. While the propeller performance parameters predicted by both methods were in good agreement with the experimental data, distinct differences were found in the solutions downstream of the propeller. Author

A88-22272#
HYPERSONIC FOREBODY PERFORMANCE SENSITIVITIES BASED ON 3-D EQUILIBRIUM NAVIER-STOKES CALCULATIONS
W. H. DAVIS (Grumman Corp., Aircraft Systems Div., Bethpage, NY) and G. J. WILSON AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 20 p. refs
(AIAA PAPER 88-0370)

Hypersonic computational fluid dynamics development and its applications to vehicle design are addressed. A time-dependent, thin-layer Navier-Stokes code modified for equilibrium high-temperature effects is used for the flowfield solution. Verification cases show favorable comparisons with experimental data and support the code's ability to predict surface pressures, L/D ratios, heat transfers, and boundary layer features at hypersonic speeds. The code is then used to investigate a series of sharp-nosed forebodies of varying cross-sectional shape and longitudinal camber and to study the variation of flow characteristics associated with aerodynamic and propulsion-coupled design parameters. C.D.

A88-22273#
CONE-DERIVED WAVERIDERS WITH COMBINED TRANSVERSE AND LONGITUDINAL CURVATURE
MAURICE L. RASMUSSEN (Oklahoma, University, Norman) and SHEAM-CHYUN LIN AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0371)

Lifting-body waverider configurations with combined transverse and longitudinal curvature are derived by means of known flow fields past ogival bodies with noncircular cross sections. The flow fields are generated by means of perturbations of the hypersonic flow past a circular cone. Approximate analytic solutions for the shock-layer flow field are found within the framework of hypersonic small-disturbance theory. Waverider shapes derived from the perturbed flow fields can produce reduced drag and increased lift-to-drag ratios. They provide a systematic means for studying more efficient volume distribution related to packaging of guidance, propulsion, and payload units. Author

A88-22292*# Nielsen Engineering and Research, Inc., Mountain View, Calif.
NUMERICAL SIMULATION OF WING LIFT AUGMENTATION WITH SPANWISE TIP BLOWING
S. C. CARUSO, M. R. MENDENHALL, and R. E. CHILDS (Nielsen Engineering and Research, Inc., Mountain View, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. NASA-supported research. refs
(Contract F33615-83-C-3033)
(AIAA PAPER 88-0396)

Navier-Stokes simulations are used to study the phenomena of wing lift augmentation with spanwise tip blowing. Flowfields calculated for varying blowing conditions are analyzed to determine the mechanisms responsible for providing lift augmentation. It is found that both viscous and inviscid effects are important. Author

A88-22293*# Tennessee Univ., Tullahoma.
A SCALAR/VECTOR POTENTIAL FORMULATION OF AN AIRFOIL IN NONUNIFORM STREAM
J. C. A. WANG and WALTER FROST (Tennessee, University, Tullahoma) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. NASA-supported research. refs
(AIAA PAPER 88-0397)

A recent innovation in aerodynamic calculation techniques is the formulation based upon scalar and vector potentials (Stokes-Helmholtz decomposition) for the velocity field. This technique is presented: an implementation involving classical panel method is studied. The application of interest is to two-dimensional airfoils moving into a nonuniform approach flow. Comparisons with theoretical and numerical results are included. Furthermore the variations of lift and moment coefficients of quasi-steady simulated flight of an airfoil through microburst wind shear data are studied. Author

A88-22294#
EULER SOLUTION OF FLOW OVER WING WITH A FULL-SPAN CONTROL SURFACE AT SUBSONIC SPEED
S. Y. RUO, R. I. KREIS, W. A. STEVENS (Lockheed Aeronautical Systems Co., Marietta, GA), and L. N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(AIAA PAPER 88-0398)

A three-dimensional Euler solver has been used to analyze flows over wings with deflected control surfaces. Results are presented for: (1) a C-130 vertical tail at Mach=0.1, yaw angles of 0, 5 and 15 degrees, and rudder deflections of 0 and 10 degrees; and (2) a two-dimensional wing at Mach=0.5, zero angle of attack with a 3 degree deflected flap. The theoretical results compare favorably with the experimental data; however, some numerical problems still exist near the trailing edge. Author

A88-22295*# San Diego State Univ., Calif.
NUMERICAL SIMULATION OF AIRCRAFT ROTARY AERODYNAMICS
JOSEPH KATZ (San Diego State University, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p. refs
(Contract NCC2-458)
(AIAA PAPER 88-0399)

A potential-flow based panel method was used to compute the aerodynamic loads along a three-dimensional flight path. Comparisons were made with rotary rig tests of an airplane performing a coning motion and found to compare well with the main components of the aerodynamic forces. The effect of the sting-type wind tunnel mounting of the model on the measured loads was briefly investigated, and the possible benefits of using this method combined with wind tunnel experiments were highlighted. Author

A88-22298*# Old Dominion Univ., Norfolk, Va.
EVOLUTION OF RESONANT WAVE TRIADS IN THREE-DIMENSIONAL BOUNDARY LAYERS
NABIL M. EL-HADY (Old Dominion University, Norfolk, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 16 p. refs
(Contract NAG1-729)
(AIAA PAPER 88-0405)

An analysis is presented that examines the modulation of different instability modes satisfying the triad resonance condition in time and space in a three-dimensional boundary-layer flow. Detuning parameters are used for the wavenumbers and the frequencies. The nonparallelism of the mean flow is taken into account in the analysis. At the leading-edge region of an infinite swept wing, different resonant triads are investigated that are comprised of traveling crossflow, stationary crossflow, vertical vorticity, and Tollmien-Schlichting modes. The spatial evolution of the resonating triad components are studied. Author

A88-22303*# High Technology Corp., Hampton, Va.
COMPARISON OF BOUNDARY-LAYER TRANSITION ON A CONE AND FLAT PLATE AT MACH 3.5
F.-J. CHEN, M. R. MALIK (High Technology Corp., Hampton, VA), and I. E. BECKWITH (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(AIAA PAPER 88-0411)

NASA-Langley's Pilot Low-Disturbance Tunnel has been used to obtain boundary layer transition data on a cone and flat plate at Mach 3.5. The transition Reynolds numbers measured under these low noise conditions are higher than those in conventional noisy tunnels by a factor of 3 in the case of the cone and of seven in that of the flat plate. Transition predictions based on compressible linear stability theory and the e exp N method, for N=10, are in excellent agreement with the measured locations with transition onset for both the cone and flat plate under these low noise conditions. O.C.

A88-22305*# Analytical Services and Materials, Inc., Hampton, Va.
NEWTON SOLUTION OF INVISCID AND VISCOUS PROBLEMS
V. VENKATAKRISHNAN (Analytical Services and Materials, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. NASA-supported research. refs
(AIAA PAPER 88-0413)

The application of Newton iteration to inviscid and viscous airfoil calculations is examined. Spatial discretization is performed using upwind differences with split fluxes. The system of linear equations which arises as a result of linearization in time is solved directly using either a banded matrix solver or a sparse matrix solver. In the latter case, the solver is used in conjunction with the nested dissection strategy, whose implementation for airfoil calculations is discussed. The boundary conditions are also implemented in a fully implicit manner, thus yielding quadratic convergence. Complexities such as the ordering of cell nodes and the use of a far field vortex to correct freestream for a lifting airfoil are

addressed. Various methods to accelerate convergence and improve computational efficiency while using Newton iteration are discussed. Results are presented for inviscid, transonic nonlifting and lifting airfoils and also for laminar viscous cases. Author

A88-22311#
AN EQUILIBRIUM AIR NAVIER-STOKES CODE FOR HYPERSONIC FLOWS
DALE K. OTA, SUKUMAR R. CHAKRAVARTHY, and JILL C. DARLING (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 16 p. refs
(AIAA PAPER 88-0419)

A new 2-D/axisymmetric turbulent Navier-Stokes code has been developed with an equilibrium air equation of state. This code has been validated against three hypersonic experiments. The code has the versatility to be run either in a space-marching mode or a time-dependent mode. Features such as the high accuracy TVD (Total Variation Diminishing) formulation of the convective terms to avoid numerical oscillations, the use of Riemann solvers to construct the numerical fluxes for following signal propagation properties, and multizone capability for complex geometries exist as before from previous perfect gas versions. Verification runs for three cases are presented. The three cases are a hypersonic ramp (2-D), hypersonic inlet (2-D), and a hypersonic hyperboloid (axisymmetric). The two 2-D cases compare well with experimental data and the axisymmetric case compares well with computational data. The versatility of the code to be run either in a time-dependent or space-marching mode is very powerful, allowing both for attached type flows for space-marching and fully separated flow for time-dependent computations without having to use two different codes. Author

A88-22350#
HYPERSONIC VEHICLE PROPULSION - A CFD APPLICATION CASE STUDY
THOMAS J. BARBER (United Technologies Research Center, East Hartford, CT) and G. B. COX, JR. (United Technologies Corp., Pratt and Whitney, West Palm Beach, FL) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. USAF-supported research. refs
(AIAA PAPER 88-0475)

The Mach number and Re number typical of hypersonic flight envelopes, and the high degree of vehicle/propulsion system integration of the vehicle configurations envisioned, preclude the use of traditional aerodynamic design methodologies; CFD techniques are accordingly being employed as a design tool over portions of the envelope where experimental data cannot be economically or feasibly obtained. Existing codes are applied where possible, and improved physical and numerical models are incorporated where dictated by the geometry and flow regime in question. Validation calculations are then conducted to determine applicability, accuracy, and efficiency. O.C.

A88-22351#
DESCRIPTION OF NONEQUILIBRIUM EFFECTS ON SIMULATION OF FLOWS ABOUT HYPERSONIC VEHICLES
J. A. LORDI, D. W. BOYER, M. G. DUNN, K. K. SMOLAREK, and C. E. WITTLIFF (Calspan Corp., Buffalo, NY) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 17 p. refs
(AIAA PAPER 88-0476)

An account is given of the design of hypersonic shock-tunnel experiments aimed at the measurement of RF propagation through the ionized flow around blunted slender vehicles as well as for the study of H2-burning scramjet combustors. The computation of ionized flowfields around blunted slender vehicles, in both ionized freestream test and flight conditions, are used to demonstrate that simulation of the flight shock layer profiles is possible for selected conditions of interest. The effects of shock tunnel freestream nonequilibrium on scramjet combustor experiments are unimportant, if the shock-tunnel test conditions are properly selected. O.C.

A88-22354#
THE EVALUATION OF FOREBODY COMPRESSION AT HYPERSONIC MACH NUMBERS
C. F. NEWBERRY, H. S. DRESSER, J. W. BYERLY, and W. T. RIBA (Rockwell International Corp., Space Transportation Systems Div., Downey, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. refs
(AIAA PAPER 88-0479)

Future hypersonic aircraft can be expected to use bow wave (forebody) compression to increase the efficiency of the propulsion system. A computational fluid dynamics (CFD) Euler code external flow field solution for a hypersonic entry research vehicle (ERV) is shown to be useful for determining the location of scramjet engine modules. A gray shading (color) graphics display of the Euler code solution is used to illustrate both the magnitude and spatial gradients of the local external flow Mach number, pressure, density, and bow wave compression efficiency (total pressure recovery, process efficiency, and kinetic energy efficiency). The usefulness of the Euler code in determining the location of scramjet engine modules enhances the vehicle design decision-making process. This enhanced design process should result in a reduction of both wind tunnel test time and expense and thereby contribute to a reduction in the overall design lead time. Author

A88-22355*# PRC Kentron, Inc., Hampton, Va.
A FULL-POTENTIAL THEORY ANALYSIS OF THE SUPERSONIC AERODYNAMICS OF A 60-DEG DELTA WING-BODY CONFIGURATION
O. C. ROSE (PRC Kentron, Inc., Hampton, VA), DAVID S. MILLER, JAMES L. PITTMAN (NASA, Langley Research Center, Hampton, VA), P. R. ASHILL, and J. L. FULKER (Royal Aircraft Establishment, Bedford, England) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(AIAA PAPER 88-0480)

Experimental spanwise pressure distributions for a 60-deg delta wing/body of approximate fineness ratio 7.6 have been obtained and compared to predictions using full-potential theory. Analysis was performed at Mach 1.6 for angles of attack in the range 0.8 to 10 deg, and for Mach numbers ranging from 1.4 to 1.8 at lift coefficients 0.3 and 0.4. The intent of the study was to examine an attached flow approach for maneuver wing design in the presence of a fuselage. For the Mach number, angle-of-attack conditions considered, the full-potential theory accurately modeled the pressure distributions provided the flow remained attached. By combining the full-potential theory results with an empirical shock-induced separation criterion, it was found that the onset of shock-induced separation can be predicted. The investigation showed that, if an attached-flow approach is used with an empirical method of indicating shock-induced separation, the full-potential method is capable of being used as an effective tool for designing maneuver wings. Author

A88-22356*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EVALUATION OF A THREE-DIMENSIONAL EMPIRICALLY DERIVED WING AT SUPERSONIC SPEEDS
RICHARD M. WOOD and STEVEN X. S. BAUER (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0481)

A novel wing design concept is introduced which takes advantage of the existence of conical flow at supersonic speeds. The present wing design concept is to create a near conical wing geometry by redistributing airfoils in a spanwise direction. In addition, a set of graphs which review the supersonic aerodynamics of delta wings have been employed to select a design wing sweep and Mach number. An iteration through the wing design logic resulted in the selection of a 65 deg swept delta wing and a design Mach number of 1.62. Theoretical analysis was performed with a nonlinear full-potential analysis method to assess the merits of the wing design approach. The analysis showed large reductions in drag due to lift compared to delta wings configured with traditional thickness and airfoil distributions. Author

A88-22359#
HIGH ANGLE OF ATTACK NON-LINEAR VORTEX LATTICE CALCULATIONS OF CANARD-WING
J. ROM and R. GORDON (Technion - Israel Institute of Technology, Haifa) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0484)

The aerodynamic characteristics of closely coupled canard-wing configurations at moderately high angles of attack are investigated, using the Non-Linear Vortex Lattice Method (NLVLM). The effects of the canard deflection angles on the aerodynamic coefficients at various horizontal and vertical positions, relative to the main wing position are presented. It is found that using the canard-wing configuration improves the overall lift to drag ratio over that of the wing alone, by an amount depending on the angle of attack, deflection angle and the canard position while the total lift is the same for both configurations. This is in addition to the beneficial effect of the canard of delaying the vortex breakdown and increasing the angle of attack before stall. Author

A88-22360*# Old Dominion Univ., Norfolk, Va.
COMPUTATIONS OF VORTICAL SUPERSONIC FLOWS OVER A BLUNT-NOSE-CYLINDER AT HIGH ANGLES OF ATTACK
O. BAYSAL, K. FOULADI (Old Dominion University, Norfolk, VA), and D. S. MILLER (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(Contract NAG1-664)
(AIAA PAPER 88-0485)

Three-dimensional, viscous, and separated flows over a blunt-nose-cylinder at 20, 32, and 44-deg attack angles were computed. The approaching freestream was at a Mach number of 1.6 and a unit Reynolds number of 2 x 10 to the 6th/ft with a total temperature of 585 R. The cylinder used for the computations had a length-to-diameter ratio of 6.67 with a base diameter of 3 in. The flowfield was dominated by large-scale and multiple vortices generated by crossflow separation. The effect of turbulence on the flow structure of one case was modeled algebraically with modifications to correct the length and velocity scales in the regions of separation. The mass averaged Navier-Stokes equations were solved by an approximately factored, upwind-biased, implicit, finite volume scheme. The initialization of the flows was enhanced by a mesh sequencing strategy applied to the diagonalized form of the discretized equations. The convergence to steady-state was accelerated by a multigrid algorithm and using the block inversions for the discretized equations. Calculations were compared with experimental results. Author

A88-22364*# Pennsylvania State Univ., University Park.
SKIN FRICTION MEASUREMENTS BY LASER INTERFEROMETRY IN SWEPT SHOCK WAVE/TURBULENT BOUNDARY-LAYER INTERACTIONS
KWANG-SOO KIM and GARY S. SETTLES (Pennsylvania State University, University Park) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(Contract AF-AFOSR-86-0082; NAG3-527)
(AIAA PAPER 88-0497)

The laser interferometric skin friction meter was used to measure wall shear stress distributions in two interactions of fin-generated swept shock waves with turbulent boundary layers. The basic research configuration was an unswept sharp-leading-edge fin of variable angle mounted on a flatplate. The results indicate that such measurements are practical in high-speed interacting flows, and that a repeatability of + or - 6 percent or better is possible. Marked increases in wall shear were observed in both swept interactions tested. K.K.

A88-22371*# Notre Dame Univ., Ind.
CONTROL OF LEADING EDGE VORTEX BREAKDOWN BY BLOWING
K. D. VISSER, K. P. IWANSKI, R. C. NELSON, and T. T. NG (Notre Dame, University, IN) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(Contract NCA2-162)
(AIAA PAPER 88-0504)

An investigation into the effects of using a jet of air to control the vortex breakdown position on a 70 degree delta wing is presented. The specific objectives focused on optimizing the blowing positions in terms of maximum lift increments obtained for minimum blowing rates. The tests were conducted at chord Reynolds numbers of 150,000, 200,000, and 250,000 at angles of incidence of 30 and 35 degrees. Visualization and force data is presented to show the effect of the jet on the wing aerodynamic characteristics. The results indicate a jet position located at and aligned parallel to the leading edge to be the optimum. Nearness to the apex and tangency to the upper surface were also crucial factors. The influence of the jet on the leading edge vortex structure was examined using laser Doppler anemometry. Velocity surveys through the vortex showed that at high blowing rates the parallel velocity in the outer swirling region of the vortex increased and the normal velocity decreased. This resulted in a decrease in the swirling angle in the outer region. The peak core velocity was reduced and the vortex breakdown was delayed. Author

A88-22378#
NUMERICAL SIMULATIONS OF NON-EQUILIBRIUM HYPERSONIC FLOW PAST BLUNT BODIES
J. S. SHANG and ESWAR JOSYULA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0512)

Nonequilibrium hypersonic flows past axisymmetric blunt bodies at zero incidence have been numerically simulated by the Navier-Stokes equations with finite rate chemical kinetics. The high temperature air mixture was described by the nonequilibrium Lighthill's dissociation gas model including the equilibrium vibrational excitation of diatomic gas molecules. The numerical results reproduced the detailed physics and the rate of heat transfer that agreed very well with the classic theories and experimental measurements. Author

A88-22380#
NONEQUILIBRIUM REACTING HYPERSONIC FLOW ABOUT BLUNT BODIES - NUMERICAL PREDICTION
NICOLA BOTTA, MAURIZIO PANDOLFI, and MASSIMO GERMANO (Torino, Politecnico, Turin, Italy) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0514)

Hypersonic flows about blunt bodies are investigated. The flow is modeled on the basis of the Euler equations modified by the terms related to the nonequilibrium chemical effects due to the high temperatures. A five components model, widely known in the literature, is assumed for describing the chemical kinetic. The numerics is founded upon an upwind formulation (lambda) and on the explicit treatment of the bow shock as a discontinuity. The solution is achieved in the spirit of a time-dependent technique, by carrying out the integration of the Euler equations together with the equations of the production of the chemical species. Examples are shown for a wide range of the Damkoehler number, where the attention is focused on the interpretation of the physics on the basis of the numerical results. Author

A88-22392#
NANC, A NONAXISYMMETRIC BODY, SUPERSONIC AEROPREDICTION CODE
LEROY DEVAN (U.S. Navy, Naval Surface Warfare Center, Dahlgren, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. Navy-USAF-supported research. refs
(AIAA PAPER 88-0526)

The capabilities of a supersonic inviscid model, developed earlier, are outlined. Approximate viscous component estimates are presented for the pitch plane aerodynamic coefficients. Axial force coefficient is estimated as a superposition of wave drag, skin friction, and base contributions. Normal force and pitching moment contributions are given as a superposition of inviscid and simple crossflow contributions. Computational comparisons with data are presented. Author

A88-22422#
APPLICATION OF FORCED UNSTEADY AERODYNAMICS TO A FORWARD SWEPT WING X-29 MODEL
J. ASHWORTH, T. MOUCH, and M. LUTTGES (U.S. Air Force Academy, Colorado Springs, CO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. refs
(Contract F49620-83-K-0009)
(AIAA PAPER 88-0563)

An experimental study is reported which was designed to verify the hypothesis (proposed by previous studies) that controlled unsteady separated flows can be utilized for lift enhancement on high-performance aircraft. A 1/10 scale reflection-plane model of the X-29 aircraft was tested in a low-turbulence wind tunnel. Orthogonal-view flow-visualization data were collected with variation of the model angle of attack betwen 0 and 10 deg, and the canard angle of attack, with respect to the model centerline, between +40 and -40 deg. The oscillation canard tests demonstrated aerodynamically the reduction of canard stall tendencies and the decrease of the effective angles of attack of the root area of the forward swept wing. In addition, three-dimensional dynamic interactions were observed between the canard-generated leading-edge vortices and the unsteady canard tip vortex patterns. These complex flows convect downstream and impinge upon the tandem forward swept wing. I.S.

A88-22426#
PROSPECTS OF COMPUTATIONAL FLUID DYNAMICS APPLIED TO POST-STALL MANEUVERING
ROBERT L. ROACH (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 24 p. refs
(AIAA PAPER 88-0567)

The purpose of the present paper is to review the more recent literature applicable to the numerical computation of flow fields likely to be encountered in unsteady, high speed, high angle-of-attack flight. A description of novel control devices and the nature of flow in the vicinity of poststall maneuvering aircraft is reviewed. Thus the major part of this work is to assess the applicability of the various numerical flow computations to the proper characterization of these flows. Author

A88-22427#
UNSTEADY SUPERSONIC FLOW CALCULATIONS FOR WING-BODY COMBINATIONS USING HARMONIC GRADIENT METHOD
PABLO GARCIA-FOGEDA, D. D. LIU (Arizona State University, Tempe), and P. C. CHEN AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. Sponsorship: Army-suported research. refs
(AIAA PAPER 88-0568)

The harmonic gradient method (HGM) developed for nonplanar wings in unsteady supersonic flow is generalized to include asymmetric bodies and wing-body combinations. The HGM model is incorporated with a newly developed bundled triplet method (BTM) for treatment of arbitrary bodies. The present method is an effective one in handling unsteady wing-body interference. In particular, the BTM has proven to be computationally more efficient than the surface panel method. Numerical studies for various configurations include: pressures on asymmetric conical bodies, generalized forces on cylindrical panels and stability derivatives for bodies and wing-body combinations. All computed results are in good agreement with existing theoretical results and measured data. Author

A88-22428#
VISUALIZATION OF UNSTEADY SEPARATED FLOW PRODUCED BY MECHANICALLY DRIVEN DRAGONFLY WING KINEMATICS MODEL
DANIEL SAHARON and MARVIN W. LUTTGES (Colorado, University, Boulder) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 24 p. refs
(Contract F49620-84-C-0065; N00014-85-K-0053)
(AIAA PAPER 88-0569)

Three-dimensional unsteady separated flow closely resembling that of live dragonflies has been visualized on the basis of a mechanical modeling of dragonfly tandem-wing kinematics. Vortex structures generated by the mechanically modeled wings, with eight major vortex structures per beat cycle, are noted to be very similar to those of tethered dragonflies subjected to wind tunnel testing. The multioscillating wing beat cycle may constitute a comprehensive model of the unsteady separated flow-based lift enhancement mechanisms employed by many insects. O.C.

A88-22437*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE EFFECT OF SPATIAL WIND GRADIENTS ON AIRPLANE AERODYNAMICS
DAN D. VICROY and ROLAND L. BOWLES (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(AIAA PAPER 88-0579)

An account is given of the results of recent studies of the effect of a spatially sheared wind field on airplane aerodynamics; the wind shear was computed by a modified vortex-lattice computer program, and characterized through the formulation of wind shear aerodynamic coefficients. The magnitude of the aerodynamic effect was demonstrated by computing the change in conventional wing/tail configuration aerodynamics for a fixed flight path through a simulated microburst. A substantial portion of the control authority of the aircraft may be required to counteract the wind shear-induced forces and moments in the microburst environment; both aperiodic and oscillatory instabilities may be generated by shear-dependent dynamic modes. O.C.

A88-22445#
ACOUSTIC VORTICAL INTERACTION IN A COMPLEX TURBULENT FLOW
J. A. DAVIS and W. C. STRAHLE (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(Contract N00014-84-K-0293)
(AIAA PAPER 88-0595)

This investigation is concerned with the interaction between vortical structures and an externally applied acoustic field in a complex turbulent flow field. The flow field is produced by a flow of air over a backward facing step in a rectangular cross section duct. The purposes of this investigation are to: (1) demonstrate the existence of somewhat organized vortical structures in the shear layer, (2) demonstrate that the vortical structures are influenced (organized) by an applied acoustic field, and (3) determine if the vortical structures in turn affect the applied acoustic field. By anemometry and acoustic pressure measurement, together with aeroacoustic theory, the first two demonstrations are made. However, in the flow field used, without strong downstream constrictions, there is no discernable feedback into the acoustic field. The results obtained have application to ramjet type flow fields. Author

A88-22447#
NUMERICAL SIMULATION OF VORTICITY-ACOUSTICS INTERACTIONS WITHIN DUMP COMBUSTORS
W. TANG, L. N. SANKAR, and W. C. STRAHLE (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(Contract N00014-84-K-0293)
(AIAA PAPER 88-0597)

The behavior of free shear layers within ramjet dump combustors is studied through the numerical solution of unsteady compressible Navier-Stokes equations. Three configurations are considered: (a) a short combustor with an open downstream boundary, (b) a long combustor with an open downstream boundary, and (c) a short combustor with a partially blocked downstream boundary. Vorticity contours of the computed flow fields in all three cases reveal oscillations of the shear layer, roll up and shedding of organized vortices. A Fourier analysis of the computed flow fields indicates that the natural acoustic frequency of the system, and the natural shear layer instability frequency are the two dominant frequencies of the flow field. It is also observed that the boundary conditions play a crucial role in the behavior of the combustor flow field. Author

A88-22451#
R. THOMAS DAVIS: HIS CONTRIBUTIONS TO NUMERICAL SIMULATION OF VISCOUS FLOWS. II - TECHNICAL PERSPECTIVES
M. J. WERLE (United Technologies Research Center, East Hartford, CT) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(AIAA PAPER 88-0602)

Attention is given to the contributions of R. Thomas Davis to the numerical simulation of viscous flows, especially for high Reynolds number conditions. Davis' interest centered on solution techniques for the full Navier-Stokes equations by identifying the dominating physics of fluid processes and tailoring solution methodologies accordingly. A review will be given of his work covering the spectrum from incompressible to hypersonic speeds, from low to high Reynolds numbers, for two-dimensional, three-dimensional and unsteady conditions. This overview will highlight a common thread woven throughout his work - that of embedding theoretical fluid dynamic concepts into viscous flow numerical methodology in order to enhance computational efficiency and algorithm robustness, accelerate iterative convergence, and reduce truncation errors. Author

A88-22453#
THE CALCULATION OF LAMINAR SEPARATION BUBBLES IN THE WAKE INFLATION/DEFLATION REGIME
ALRIC P. ROTHMAYER (Iowa State University of Science and Technology, Ames) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. Research supported by the United Technologies Corp. refs
(AIAA PAPER 88-0605)

A new interacting boundary-layer method is developed for calculating two-dimensional incompressible laminar separation bubbles. The method relies on a completely consistent mixed boundary value treatment of the outer inviscid flow. For attached flows, the new method is found to converge as fast as the classical Cauchy-Hilbert method, and to yield the same solution. For separated flows, the new method is found to converge two to three times faster than a comparable Cauchy-Hilbert method. The physical asymptotic theories which underlie this new numerical method will be discussed, in so far as they motivate the method. Numerical results are presented and qualitatively compared with a previously suggested asymptotic model of high Reynolds number laminar separation. Author

A88-22455*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PERFORMANCE CHARACTERISTICS FROM WIND-TUNNEL TESTS OF A LOW-REYNOLDS-NUMBER AIRFOIL
ROBERT J. MCGHEE (NASA, Langley Research Center, Hampton, VA), GREGORY S. JONES (Complere, Inc., Palo Alto, CA), and REMI JOUTY (Ministere de la Defense, Paris, France) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(AIAA PAPER 88-0607)

Wind tunnel lift and pitching-moment data have been obtained from pressure measurements, and drag data from wake surveys, for an Eppler 387 low Reynolds number airfoil over the Re range of 60,000 to 460,000; oil flow visualizations were also used to determine laminar separation and turbulent reattachment locations. Airfoil performance is found to be dominated by laminar separation bubbles below Re 200,000, and two flow regimes, namely laminar separations with and without turbulent reattachment, were observed at the same angle-of-attack for an Re of 60,000. O.C.

A88-22461*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TURBULENT SEPARATED FLOW IN THE VICINITY OF A SINGLE-SLOTTED AIRFOIL FLAP
DESMOND ADAIR and W. CLIFTON HORNE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(AIAA PAPER 88-0613)

Detailed measurements of pressure and velocity characteristics are presented and analyzed for flow over and downstream of a NACA 4412 airfoil equipped with a NACA 4415 single-slotted flap at high angle of attack and close to maximum lift. The flow remained attached over the main element while a large region of recirculating flow occurred over the aft 61 percent of the flap. The airfoil configuration was tested at a Mach number of 0.09 and chord based Reynolds number of 1.8 x 10 to the 6th in the NASA Ames Research Center 7- by 10-Foot Wind Tunnel. Measurements of mean and fluctuating velocities were obtained in the region of recirculation and high turbulence intensity using three-dimensional laser velocimetry. In regions where the flow had a preferred direction and relatively low turbulence intensity hot-wire anemometry was used. Emphasis was placed on obtaining flow characteristics in the confluent boundary layer, the region of recirculating flow and in the downstream wake. Surface pressure measurements were made on the main airfoil, flap, wind tunnel roof, and wind tunnel floor. In addition to the presentation of pressure and velocity characteristics, the near wall results inside the separated region are analyzed as are the relative importance of terms in the momentum and turbulence kinetic energy equations in the confluent separated boundary layer and the recirculating region of the near wake. Author

A88-22462*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLOW CONTROL IN A WING/FUSELAGE-TYPE JUNCTURE
L. R. KUBENDRAN, A. BAR-SEVER, and W. D. HARVEY (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(Contract NAS1-18235)
(AIAA PAPER 88-0614)

The laminar flow around a juncture formed by an unswept wing and a flat plate has been studied using a combination of smoke flow visualization, and velocity and pressure measurements. The effectiveness of swept leading-edge fillets in controlling the juncture flow field has been evaluated. Flow separation upstream of the wing leading edge is confined to a small region near the plate. This separation results in periodic shedding of horseshoe type vortices. The pressure gradient measured upstream of the leading edge in this laminar juncture is steeper than that of the turbulent flow case. The use of fillets eliminates the leading-edge flow separation and reduces the size of juncture wake, as observed from flow visualization. For one of the filleted cases, there is a

significant increase in the extent of laminar flow in the juncture region, and a sizable reduction in the juncture drag. Author

A88-22463#
NUMERICAL INVESTIGATION ON THE EFFECT OF FAIRING ON THE VORTEX FLOWS AROUND AIRFOIL/FLAT-PLATE JUNCTURES
CHAO-HO SUNG and CHENG-WEN LIN (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. Navy-supported research. refs
(AIAA PAPER 88-0615)

Numerical solutions of the incompressible Reynolds-averaged Navier-Stokes equations supplemented by the Baldwin-Lomax turbulence model have been applied to investigate the effect of fairing on the vortex flows around airfoil/flat-plate junctures. It has been found that the leading edge fairing is quite effective in reducing the nonuniformity of the wake velocity profile and the addition of the trailing edge fairing can contribute further improvement. The effect of fairing on the drag reduction is less significant in the geometry considered since the decrease in the drag due to the pressure is compensated by the increase in the drag due to the skin friction. Author

A88-22465*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NUMERICAL INVESTIGATION OF THREE-DIMENSIONAL FLOW SEPARATION USING THE BOUNDARY LAYER EQUATIONS
YONG-SUN WIE (NASA, Langley Research Center, Hampton, VA; North Carolina State University, Raleigh) and FRED R. DEJARNETTE (North Carolina State University, Raleigh) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(Contract N00167-85-K-0158)
(AIAA PAPER 88-0617)

The steady, incompressible, three-dimensional laminar and turbulent boundary-layer equations are solved in a streamline coordinate system and in a self-adaptive grid system using Matsuno's finite difference method. Techniques are described for calculating laminar and turbulent separation using the boundary-layer equations. Any type (bubble type or free vortex-layer type) of major separation line can be calculated at an angle of attack on ellipsoids of revolution by this boundary layer code. Results are presented for ellipsoids of revolution at angles of attack up to 45 degrees. Agreements with other numerical and experimental results are very good for laminar flows. Turbulent flows are also investigated with algebraic turbulence models proposed by Rotta and Cebeci and Smith. Good agreement with experimental results was obtained at a small angle of attack (10 degrees) but only qualitative agreement was obtained at a high angle of attack (30 degrees) for turbulent flow on a 6:1 ellipsoid of revolution. Author

A88-22466#
APPLICATION OF THE HYPERSONIC ANALOGY FOR VALIDATION OF THE NUMERICAL SIMULATIONS
SHMUEL EIDELMAN (Science Applications Internationl Corp., McLean, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0618)

The paper presents a family of the self-similar solutions for hypersonic flow over a flat plate with a blunt leading edge. These solutions are derived, based on the principle of the hypersonic similitude, from the solutions of the point blast problems and include modeling of the energy release (or absorption) behind the main shock front. The developed analytical solutions are of particular interest as test problems for the numerical simulations of the hypersonic flow. An example of this application is shown for the hypersonic flow with M = 32 over the flat plate 0.025 m thick. The numerical simulations were done using the first and second order accurate Godunov methods on a succession of grids covering the computational domain with increased density. Author

A88-22494*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A MULTI-ELEMENT VORTEX LATTICE METHOD FOR CALCULATING THE GEOMETRY AND EFFECTS OF A HELICOPTER ROTOR WAKE IN FORWARD FLIGHT
JOHN D. BERRY (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0664)

A method is described for the analysis of the unsteady, incompressible potential flow associated with a helicopter rotor and it's wake in forward flight. This method is particularly useful in low advance ratio flight due to the major contribution, in the near field, of the deformed wake. The rotor geometry is prescribed and the unsteady wake geometry is computed from the local flow perturbation velocities. The wake is modeled as a full vortex lattice. The rotor geometry is arbitrary and several rotor blades can be represented. The unsteady airloads on the rotor blades are computed in the presence of the deformed rotor wake by a time-stepping technique. Solution for the load distribution on the blade surfaces is found by prescribing boundary conditions in a reference system which rotates with the blade tips. Transformation tensors are used to describe the contribution of the wake in the inertial system to the rotor in the rotating reference system. The effects of blade cyclic pitch variation are computed using a rotation tensor. The deformation of the wake is computed in the inertial frame. The wake is started impulsively from rest, allowing a natural convection of the wake with time. Author

A88-22495*# Purdue Univ., West Lafayette, Ind.
AERODYNAMIC INTERACTION BETWEEN PROPELLERS AND WINGS
DAVID WITKOWSKI, ALEX K. H. LEE, and JOHN P. SULLIVAN (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. refs
(Contract NSG-3134)
(AIAA PAPER 88-0665)

A combined computational/experimental investigation has been conducted to determine the time-averaged interactive performance of a propeller and wing in tractor configuration at Mach 0.1 and Re=470,000, based on a wind tunnel model wing chord of 8 in. Wing angle-of-attack was varied from 0 to +13 deg, and propeller advance ratio ranged from 2.4 (windmilling) to 1.1 (maximum power). Both a semiempirical model and a vortex lattice simulation were used in the computational analysis. Good agreement has been obtained between theory and experiment. O.C.

A88-22498#
A THEORETICAL AND EXPERIMENTAL STUDY OF THE SNAP-THROUGH AIRFOIL AND ITS POTENTIAL AS A HIGHER HARMONIC CONTROL DEVICE
ROBERT E. DUFFY (Rensselaer Polytechnic Institute, Troy, NY), JOSEPH NICKERSON (Boeing Helicopter Co., Philadelphia, PA), JOHN COLASANTE (Grumman Aerospace Corp., Bethpage, NY), and JAMES DUBBEN AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. Army-sponsored research. refs
(AIAA PAPER 88-0668)

The steady and unsteady lift and moment characteristics of a snap-through airfoil, obtained by modifying a section from an existing rotor blade, have been theoretically and experimentally studied in order to evaluate the potential of such an airfoil as a helicopter harmonic control device. The effect of the increased lift and pitching moment on the elastic twist of a sample rotor blade is evaluated for the forward flight case. In all the cases considered, the effect of the snapping at points along the blade is to increase the local node down aerodynamic pitching moment, reducing the overall blade lift. It is demonstrated that the snap-through airfoil can reduce the magnitude of the 1P vertical shear fluctuations on a blade by about 60 percent. R.R.

A88-22527#
EXPERIMENTAL AND ANALYTICAL INVESTIGATIONS OF SUPERSONIC MIXING LAYERS
J. P. RENIE, J. C. DUTTON, H. KRIER (Illinois, University, Urbana), N. L. MESSERSMITH, S. G. GOEBEL et al. AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(Contract N00014-86-K-0434)
(AIAA PAPER 88-0702)

A newly constructed, dual stream supersonic wind tunnel has been designed to provide long run times for investigations into the characteristics of reactive and nonreactive, planar two-dimensional supersonic free shear layers. The flow facility currently operates with Mach 1.95 and Mach 1.33 air streams, and can generate heterogeneous mixing layers, since control of the stagnation temperatures enables the density ratio of the two streams to be varied. Preliminary schlieren photography and Laser Doppler Velocimetry have been used to measure the incoming boundary layers and subsequent compressible mixing layer growth rate for a density ratio of 0.77. This ratio corresponds to a convective Mach number of 0.20. The spatial shear layer growth rate was measured to be 0.022, corresponding to a shear layer spreading parameter of 90. A general analysis of the convective Mach number concept is presented along with a technique to predict compressible free shear layer growth rates. Author

A88-22528#
NUMERICAL STUDY OF TWO-DIMENSIONAL IMPINGING JET FLOWFIELDS
C. J. HWANG (National Cheng Kung University, Tainan, Republic of China) and J. L. LIU AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0703)

The Euler/Reynolds-averaged compressible Navier-Stokes, continuity and energy equations are solved in conjunction with a two-equation (K - epsilon) turbulence model for two-dimensional impinging jet flowfields relevant to VTOL aircraft. Two physical domains, impingement region with free upper boundary and planar jet with upper flat surface, are investigated. For the impingement region, the inviscid fluid and viscous, turbulent flow are studied numerically. To suppress the numerical oscillation, the explicit fourth-order and implicit second-order dissipation terms are employed. In order to confirm the accuracy and reliability of the present solution procedure, computed flowfield properties are presented and comparisons are made with experimental and related numerical results. Author

A88-22529#
MEASUREMENTS OF HIGHLY ASYMMETRIC TRAILING-EDGE FLOW
N. ALEMDAROGLU (California State University, Long Beach) and A. NAKAYAMA (Douglas Aircraft Co., Long Beach, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p. refs
(Contract NSF MEA-80-18565)
(AIAA PAPER 88-0704)

A highly asymmetric two dimensional wake was generated using a flexible plate in a low speed wind tunnel and the mean-flow and turbulence fields were measured using pilot-tube, hot-wire probes and a laser Doppler velocimeter. The flow was found to resemble closely the mean wake flows of airfoils at high angles of attack, with thick and separated shear layers from the upper surface and very thin boundary layers from the lower surface merging to create the highly asymmetric wake. The results were used to study the detailed properties of airfoil trailing-edge flows and are useful for developing and verifying computational methods. Author

A88-22530#
MULTIGRID SOLUTION OF THE NAVIER-STOKES EQUATIONS FOR FLOW OVER WINGS
ANTONY JAMESON (Princeton University, NJ) and MOHAN JAYARAM (IBM, Kingston, NY) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(AIAA PAPER 88-0705)

An accurate and efficient method for solving the three-dimensional Navier-Stokes equations is presented. The time-dependent conservation equations are spatially discretized using a finite volume approach. This offers flexibility in treating arbitrary geometries. The time integration is done by using an explicit hybrid multistage scheme. Convergence to a steady state is accelerated dramatically by using local time-stepping, implicit residual averaging and an effective multigrid strategy. Turbulence closure is achieved by using the Baldwin-Lomax turbulence modal. Computed results are presented for laminar as well as high Reynolds number attached and separated flows over an airplane wing. They compare very well with the experimental data. Comparison with the corresponding inviscid solution is also provided. Author

A88-22531#
NAVIER-STOKES SOLUTION FOR A THICK SUPERCRITICAL AIRFOIL WITH STRONG SHOCKS AND MASSIVELY SEPARATED FLOW
D. W. KINSEY (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and F. E. EASTEP (Dayton, University, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0706)

This report describes a numerical solution for flow over a thick supercritical airfoil with strong shock-induced separation on both the upper and lower surfaces. The separated flow region extends from the shock (approximately 50 percent chord) to the trailing edge on both surfaces. The solution algorithm employed was an explicit predictor-corrector method. An algebraic turbulence model was used to describe the turbulent Reynolds stresses. The treatment of the eddy-viscosity behavior through the shock, in the separated regions over the airfoil and in the near wake, was the critical step for a successful solution. Author

A88-22532#
CALCULATION OF TRANSONIC FLOWS WITH SEPARATION PAST ARBITRARY INLETS AT INCIDENCE
ARVIN SHMILOVICH (Douglas Aircraft Co., Long Beach, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 16 p. refs
(AIAA PAPER 88-0707)

A method for calculating transonic separated flows past arbitrary inlets at incidence and yaw is presented. The inviscid flow solver is based on the transonic potential equation which is approximated and solved numerically on a boundary-conforming coordinate system. The multigrid finite-volume method is used to solve the flow equation. The inviscid flow technique is coupled with an interactive boundary layer method that uses an inverse formulation in order to calculate shock-induced separated flows. Experimental results obtained for several nacelle configurations are used to evaluate the accuracy of the method in predicting flow fields for a wide range of operational conditions. Separated flow cases on both internal and external inlet surfaces are computed. Slotted and perforated wind-tunnel wall boundary conditions are implemented to account for discrepancies between experimental data and free-air calculations for nearly supersonic freestream velocities. Author

A88-22533#
NUMERICAL SOLUTION OF VISCOUS FLOWS OVER CASCADES WITH SIDEWALLS
KOJI MORINISHI and NOBUYUKI SATOFUKA (Kyoto Institute of Technology, Matsugasaki, Japan) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0708)

Numerical solution of viscous transonic flows through cascades with sidewalls is obtained. The RRK scheme used in the previous two-dimensional study has been extended to the three-dimensional version. The algebraic two-layer eddy-viscosity model proposed by Baldwin and Lomax with a modified distance is used to simulate viscous turbulent flows. The preliminary calculation are carried out for the flow through the plane NACA 65-(12)10 compressor cascade with sidewalls. Three cases with different aspect ratios of 1, 2, and 3 are calculated. For each case, a large separated flow region is found on the suction surface near sidewalls, which indicates strong effect of sidewalls on the flow fields. The results are compared with those of the previous two-dimensional code and experiments. The results obtained for the aspect ratio 3 qualitatively agree with the experimental data taken without sidewall boundary-layer removal and porous endwall suction, while the previous results agree with those taken with endwall suction.
Author

A88-22535*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATION OF A NONISENTROPIC FULL POTENTIAL METHOD TO AGARD STANDARD AIRFOILS
WOODROW WHITLOW, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(AIAA PAPER 88-0710)

An entropy-correction method for the unsteady full potential equation is presented. The unsteady potential equation is modified to model the entropy jumps across shock waves. The conservative form of the modified equation is solved in generalized coordinates using an implicit, approximate factorization method. A flux-biasing differencing method, which generates the proper amounts of artificial viscosity in supersonic regions, is used to discretize the flow equations in space. Calculated results are presented for the NLR 7301, NACA 0012, and NACA 64A010A airfoils. Comparisons of the present method and solutions of the Euler equations are presented for the NLR 7301 airfoil, and comparisons of the present method and experimental data are presented for all three airfoils. The comparisons show that the present method more accurately models solutions of the Euler equations and experiment than does the isentropic potential formulation. In addition, it is shown that modeling shock-generated entropy extends the range of validity of the full potential method.
Author

A88-22539*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
A LONGITUDINALLY-PATCHED GRID APPROACH WITH APPLICATIONS TO HIGH SPEED FLOWS
R. W. WALTERS, T. REU, W. D. MCGRORY (Virginia Polytechnic Institute and State University, Blacksburg), J. L. THOMAS, and P. F. RICHARDSON (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(Contract NAG1-776; NAS1-18106)
(AIAA PAPER 88-0715)

The combined use of an implicit, upwind finite-volume scheme with an 'equivalent' gamma formulation (for real gas effects) and with a three-dimensional conservative patched grid formulation is discussed. Results are presented over a wide Mach number range on both single and patched grids.
Author

A88-22585#
COMPUTATION OF UNSTEADY PHENOMENA IN TRANSONIC TURBINES AND COMPRESSORS
A. FOURMAUX and A. LE MEUR (ONERA, Chatillon-sous-Bagneux, France) (Symposium on Unsteady Aerodynamics and Aeroelasticity of Turbomachines and Propellers, 4th, Aachen, West Germany, Sept. 6-10, 1987) ONERA, TP, no. 1987-131, 1987, 22 p. refs
(ONERA, TP NO. 1987-131)

The purpose of this paper is to describe two- and three-dimensional calculation methods for compressible flow in a complete stage of a turbomachine, where two wheels have different angular speeds. The Euler equations are solved in physical space by a finite difference method using the MacCormack explicit predictor-corrector scheme. These methods make possible a better knowledge of the two blade-row interaction for the description of unsteady phenomena as well as for the steady blade-row fitting. The potential of these methods for a detailed flow analysis is emphasized by computational results in a complete turbine stage.
Author

A88-22590*# Office National d'Etudes et de Recherches Aerospatiales, Leclerc (France).
COMPUTATION OF TRANSONIC POTENTIAL FLOW ON HELICOPTER ROTOR BLADES
M. COSTES (ONERA, Chatillon-sous-Bagneux, France) and H. E. JONES (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) ONERA, TP, no. 1987-136, 1987, 17 p. refs
(ONERA, TP NO. 1987-136)

Two computer codes, the full-potential three-dimensional (FP3D) code and the full-potential rotor (FPR) code have recently been developed. Both of these codes solve the three-dimensional conservative formulation of the full potential equation. The FPR code was developed at the U.S. Army Aeroflightdynamics Directorate (AFDD) while the FP3D code was a joint development by ONERA and AFDD. Both of these codes were used to predict the nonlifting, unsteady flow over a rotor operating at high advance ratio and tip speed. Three different rotor tip planform shapes were studied: a rectangular tip, a 30 deg aft swept tip and a 30 deg forward swept tip. Results of these computations are compared to results obtained using an earlier small-disturbances code. Also, the lifting flow over a rectangular tip operating at a slightly different condition was computed. These results are also compared with the small disturbances computations and with experimental results.
Author

A88-22591#
A STUDY OF TURBULENCE MODELLING IN TRANSONIC SHOCK-WAVE/BOUNDARY-LAYER INTERACTIONS
R. BENAY, M.-C. COET, and J. DELERY (ONERA, Chatillon-sous-Bagneux, France) (Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987) ONERA, TP, no. 1987-137, 1987, 7 p. refs
(ONERA, TP NO. 1987-137)

An inverse boundary-layer approach has been used to test six turbulence models applied to transonic shock-wave/boundary-layer interactions. It was found that nonequilibrium models give a poor prediction both of the mean and turbulent flow properties, especially in strong interactions leading to separation. Introduction of a history effect by means of transport equations improves sensibly the prediction of the mean flow. However, deficiencies subsist in the calculation of the turbulent properties.
Author

A88-22598#
WAKE MODELLING FOR HELICOPTER FUSELAGE
T. H. LE, J. RYAN, and G. FALEMPIN (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1987-145, 1987, 13 p. refs
(ONERA, TP NO. 1987-145)

Within the framework of potential inviscid flow, a wake model for helicopter fuselages has been developed that provides accurate pressure values at the aft contraction, downstream of the

separation line. The model has been implemented in an existing three-dimensional panel code and applied to a helicopter fuselage with a sharp aft contraction. The results show the influence of the wake not only over the whole rear part but also upstream of the aft contraction. The cylindrical wake topology found can explain the high velocities on the side of the tailboom and the discrepancy of the pressure values at the end of the lower symmetry line. R.R.

A88-22600#
EFFECT OF AN ANHEDRAL SWEPTBACK TIP ON THE PERFORMANCE OF A HELICOPTER ROTOR
A. DESOPPER, P. LAFON, J. J. PHILIPPE, and J. PRIEUR (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1987-147, 1987, 16 p. refs
(ONERA, TP NO. 1987-147)

Experimental results were obtained with a rig without cyclic pitch control for a rectangular blade, a blade with a parabolic sweptback tip, and a blade combining an evolutive anhedral shape with the same parabolic sweptback tip in order to study the local aerodynamics of helicopter rotor blades in high-speed forward flight. The results demonstrate the advantages of combining anhedral and sweep effects in designing blade tip shapes. Results obtained using a rotor test rig with a cyclic pitch device indicate that the piloting law of the rotor has a significant effect on the local flow over the blade, particularly for the transonic flow development on the advancing blade side. R.R.

A88-22728
ROTOR WAKE MODELING FOR HIGH SPEED APPLICATIONS
DONALD B. BLISS (Duke University, Durham, NC), LEO DADONE (Boeing Vertol Co., Philadelphia, PA), and DANIEL A. WACHSPRESS (Continuum Dynamics, Inc., Princeton, NJ) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 17-33. refs

An evaluation is made of results for the effect of various wake models on the prediction of helicopter rotor vibratory air loading in high speed flight. Attention is given to the flight conditions under which multiple filament kinematic wake models perform adequately, and to the development of a novel multifilament full-span free-wake analysis employing curved vortex elements whose representation of the wake directly accounts for both trailed and shed vorticity components. Both the advanced kinematic wakes and the novel free wake show substantial agreement with data for higher-harmonic air loading. O.C.

A88-22729
CIRCULATION CONTROL AIRFOILS IN UNSTEADY FLOW
V. RAGHAVAN, INDERJIT CHOPRA (Maryland, University, College Park), and SHIH-I PAI IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 35-48. refs

A numerical method is developed to study the unsteady circulation control aerodynamics of two-dimensional circular cylinders and elliptic airfoils. Two cases of unsteady flow are considered; unsteady freestream and unsteady blowing momentum from a spanwise slot. A simple solution for the potential flow is obtained using conformal mapping and including the wake effects by distributing source panels in the separation region. The potential flow and the boundary layer and wall jet calculations are combined in an iterative process to determine the aerodynamic forces under given jet momentum and freestream conditions. Satisfactory correlation of predicted results with experimental data (wind tunnel) is achieved for steady lift over circular cylinders as well as elliptic airfoils. Substantial unsteady effects are observed for thick airfoils at large blowing and reduced frequencies. Author

A88-22730
AIRFOIL DESIGN, TEST, AND EVALUATION FOR THE V-22 TILT ROTOR VEHICLE
J. C. NARRAMORE (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 49-60. refs

An extensive airfoil design, analysis, test, and evaluation effort to develop new rotor and wing airfoils for the V-22 tilt rotor vehicle has been conducted. State-of-the-art analysis and design computer programs were used to produce airfoils designed to meet specific aerodynamic and geometric design goals and constraints on the wing section and four radial stations on the blade. Two-dimensional, large-scale rotor and airframe aerodynamic wind tunnel tests were conducted on these new sections. The test results confirm that the new airfoils satisfy the design goals and provide significant improvements in the aerodynamic characteristics at tilt rotor flight conditions. Author

A88-22731
THE AERODYNAMICS OF AN OSCILLATING JET FLAP
PETER F. LORBER, FRANKLIN O. CARTA (United Technologies Research Center, East Hartford, CT), and RAYMOND G. CARLSON (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 61-71. Research supported by United Technologies Corp. refs

The aerodynamics of an oscillating jet flap have been studied experimentally using an SC1094-R8 airfoil section that was modified to incorporate a Coanda surface at the blade trailing edge. Wind tunnel tests were conducted at Mach numbers of 0.4 and 0.7, at airfoil angles of attack of 0, 4, and 7 deg, and with a jet momentum coefficient that oscillated between 0 and a maximum value of .002, .004, and .007 at frequencies between 0 and 25 Hz. Unsteady pressures were measured using 24 miniature pressure transducers at the airfoil centerline. The variations of the integrated mean and oscillatory normal force and pitching moment with jet momentum, jet frequency, airfoil angle of attack, and incoming Mach number are described. The oscillatory pitching moment coefficient had an approximately linear dependence on the jet momentum coefficient, and showed little phase variation. These results are in general agreement with quasi-steady predictions, and provide an initial demonstration of the feasibility of generating blade pitching moments of the correct amplitude for helicopter higher harmonic vibration control. Author

A88-22784* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PREDICTION OF UNSTEADY TRANSONIC ROTOR LOADS WITH A FULL-POTENTIAL ROTOR CODE
ROGER C. STRAWN and CHEE TUNG (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 795-805. refs

A new version of the full-potential rotor code (FPR) is described. This revised version contains improvements in code structure, algorithm implementation, and input/output options over the earlier version. The FPR code is coupled to a rotor-wake and trim model and the resulting combined code is used to predict surface pressures for three experimentally tested helicopter rotors. Generally good agreement is seen between computed and experimental results. Author

A88-22785* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AERODYNAMIC INTERACTION BETWEEN VORTICAL WAKES AND LIFTING TWO-DIMENSIONAL BODIES
PAUL M. STREMEL (NASA, Ames Research Center, Moffett Field, CA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 807-823. refs

Unsteady rotor wake interactions with the empenage, tail boom, and other aerodynamic surfaces of a helicopter have a significant influence on its aerodynamic performance, the ride quality, and amount of vibration. A numerical method for computing the aerodynamic interaction between an interacting vortex wake and the viscous flow about arbitrary two-dimensional bodies has been developed to address this helicopter problem. The method solves for the flow field velocities on a body-fitted computational mesh using finite-difference techniques. The interaction of a rotor wake with the flow about a 4:1 elliptic cylinder at 45-deg incidence was calculated for a Reynolds number of 3000. Author

A88-22786
TOWING TANK FLOW VISUALIZATION TEST OF A SCALE MODEL H-34 ROTOR
MARK JENKS, SR., LEO LADONE (Boeing Vertol Co., Philadelphia, PA), and MOHAMED GAD-EL-HAK (Notre Dame, University, IN) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 825-838. refs

A towing tank flow visualization test of a scale model H-34 rotor has been conducted in order to aid in understanding the characteristics of high-advance-ratio rotor wakes. The test provided a comprehensive qualitative record of helicopter rotor wake characteristics in high-speed forward flight. It was shown that the load reversal on the advancing tip gives rise to a discrete, rolled-up tip vortex of 'negative' sense (opposite to the conventional 'positive' tip vortex). More generally, it has been demonstrated that high-advance-ratio rotor flow field visualization is practical and that a wealth of detailed qualitative information can be gained from the visualization methods employed. Author

A88-22787
A CLOSED-FORM UNSTEADY AERODYNAMIC THEORY FOR LIFTING ROTORS IN HOVER AND FORWARD LIGHT
DAVID A. PETERS and CHENG JIAN HE (Georgia Institute of Technology, Atlanta) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 839-865. refs

A theory of unsteady aerodynamics (i.e., of induced flow) is offered for a lifting rotor in hover and forward flight. The induced flow is expressed azimuthally by a Fourier series and radically by Legendre functions. In a nonlifting climb with quasi-steady aerodynamics, the theory gives results almost identical to those of Loewy theory but with improved values of the wake apparent mass. The theory implicitly includes both dynamic-inflow theory and the near-wake approximation to the Theodorsen function. Author

A88-22788* Tennessee Univ., Tullahoma.
FREE WAKE ANALYSIS OF HELICOPTER ROTOR BLADES IN HOVER USING A FINITE VOLUME TECHNIQUE
K. RAMACHANDRAN, JOHN STEINHOFF (Tennessee, University, Tullahoma), and C. TUNG (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 867-877. Army-supported research. refs

A fully compressible method for determining helicopter rotor wake effects is described which computes the wake without requiring external specification of the wake, or separate computations for the wake and blade region. The method is a modification of a compressible finite volume Potential Flow technique, and it has been implemented in a program, HELIX I, for computing compressible rotor flow fields in hover with free wakes. Wake positions in substantial agreement with experiment have been calculated for cases including subsonic and transonic flows, high and low aspect ratios, and two- and four-bladed rotors. R.R.

A88-22789* Advanced Rotorcraft Technology, Inc., Mountain View, Calif.
A FREE-WAKE ROTOR ANALYSIS INCLUDING GROUND EFFECT
H. A. SABERI (Advanced Rotorcraft Technology, Inc., Mountain View, CA) and M. D. MAISEL (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 879-889. refs

The objective of this work is to develop a computer program which analytically estimates the wake geometry, vorticity, and velocity distribution over a rotor and in the neighboring airflow for a variety of conditions in and out of ground effect. The resulting wake is used to provide an assessment of the blade loading distribution for various hover and low speed flight conditions. The computer program is based on a lifting line free wake model and provides stable solutions for a variety of steady state conditions, including ground effect and forward flight. The wake program was validated by comparing the computed wake geometry and experimental test data for two different rotors. Author

A88-23102
INVESTIGATION OF THE TURBULENT BOUNDARY LAYER ON A SYMMETRICAL AEROFOIL WITHIN A WIDE RANGE OF INCIDENCES AT DIFFERENT FREE-STREAM TURBULENCE
JAROMIR PRIHODA (Ceskoslovenska Akademie Ved, Ustav Termomechaniky, Prague, Czechoslovakia) Acta Technica CSAV (ISSN 0001-7043), vol. 32, no. 5, 1987, p. 621-635. refs

Flows with variations in free-stream turbulence are used to study the turbulent boundary layer on a symmetrical airfoil, and measured boundary layer parameters for the attached flow region are compared with those predicted using an integral method. An increase in free-stream turbulence is found to result in a delay of separation on the upper side of the airoil and in increases in the maximum loft coefficient and the critical angle of attack. It is shown that the minimum drag coefficient increases with increasing tubulence level in a manner similar to the drag behavior of a flat plate. R.R.

A88-23148
A DESIGN METHOD FOR TWO-DIMENSIONAL CASCADES OF TURBOMACHINERY BLADES
M. HART and D. S. WHITEHEAD (Cambridge University, England) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 7, Dec. 1987, p. 1363-1381. refs

A design method for two-dimensional cascades of turbomachinery blades is presented. A finite element potential flow program is extended to allow fluid to transpire through the blade surface, the displaced surface streamline defining a new blade geometry. The potential changes are related linearly to the transpired flow rates. New surface velocities may then be specified as a function of surface distance, in accordance with boundary layer considerations. Closure and smoothness of the new blade are successfully achieved, while large changes in the blade geometry are possible. Author

A88-23176#
AN ENGINEERING APPROACH FOR NEARLY SHOCK-FREE WING DESIGN
ZIQIANG ZHU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) and H. SOBIECZKY (DFVLR, Cologne, Federal Republic of Germany) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, July 1987, p. A327-A334. In Chinese, with abstract in English. refs

A method is presented that is able to systematically alter given transonic cruise speed wing shapes, on the basis of the 'elliptic continuation' method, to arrive at virtually shock-free flows with

substantially reduced drag. A reliable transonic analysis algorithm with an analytic fictitious gas model is used to arrive at a simplified version of this design method, foregoing exactly shock-free flows in order to arrive at those with only weak shocks; the transpiration velocity boundary condition, rather than the space-marching procedure, is employed to simulate surface deformation. O.C.

A88-23178#
NON-ISENTROPIC POTENTIAL APPROACH AND ITS APPLICATION TO NUMERICAL COMPUTATION OF TRANSONIC FLOWS IN TURBOMACHINERY
JIANZHONG XU (Chinese Academy of Sciences, Institute of Engineering Thermophysics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, July 1987, p. A342-A348. In Chinese, with abstract in English. refs

A88-23183#
APPLICATION OF A METHOD OF MATCHED ASYMPTOTIC EXPANSIONS TO THE ANALYSIS OF TRANSONIC FLOWS OVER THIN AIRFOILS WITH BLUNT NOSES
YIZHAO WU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, July 1987, p. A392-A397. In Chinese, with abstract in English.

A method is developed for obtaining uniformly valid solutions about thin airfoils with blunt noses in transonic flows. The method, based on the principles of singular perturbation theory, is applied to nonlifting problems. The method corrects transonic small perturbation theory, which is invalid in the nose region. The first-order potential equation, applicable to inner (nose) region, and the analytic solution of this equation are given for the first time. A composite solution, which is uniformly valid, is constructed. Application of the method is presented for the NACA0012 airfoil. A comparison of the results with those of the full potential equation shows good agreement. Author

A88-23208#
AF-2 ITERATION COMPUTATIONS FOR PLANE STEADY TRANSONIC POTENTIAL FLOWS OVER AIRFOILS WITH CHORDWISE LARGE DISTURBANCE
XIUYING LI, SAIJIN MIN (Changsha Institute of Technology, People's Republic of China), and SHIJUN LUO (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Sept. 1987, p. A518-A523. In Chinese, with abstract in English. refs

The plane steady potential flow over a NACA 0012 airfoil with a large disturbance in the x direction and a small disturbance in the y direction at freestream Mach number 0.8-0.9 and angle of attack 0-4 deg is investigated analytically. The performance of the AF-2 implicit approximate-factorization scheme of Ballhaus et al. (1978) and the SLOR method (cf Wong et al., 1985) in solving the governing equations is compared, and von Neumann stability analysis is applied to the AF-2 method. An expression for the linearized stability condition at subsonic points is derived, and the convergence of AF-2 is shown to be about 13 times faster than that of SLOR. T.K.

A88-24123*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ALGEBRAIC GRID GENERATION ABOUT WING-FUSELAGE BODIES
R.E. SMITH, R. A. KUDLINSKI, E. L. EVERTON (NASA, Langley Research Center, Hampton, VA), and M. R. WIESE (Computer Sciences Corp., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 24, Dec. 1987, p. 868-872. refs

An algebraic procedure for generating boundary-fitted grids about wing-fuselage configurations is presented. A wing-fuselage configuration consists of two aircraft components specified by cross sections and mathematically represented by Coons' patches. Several grid blocks are constructed to cover the entire region surrounding the configuration, and each grid block maps into a computational cube. Grid points are first determined on the six boundary surfaces of a block and then in the interior. Grid points on the surface of the configuration are derived from the intersection of planes with the Coons' patch definition. Approximate arc length distributions along the resulting grid curves concentrate and disperse grid points. The two-boundary technique and transfinite interpolation are used to determine grid points on the remaining boundary surfaces and block interiors. Author

A88-24124*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SUPERSONIC AIRFOIL OPTIMIZATION
JAMES L. PITTMAN (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 24, Dec. 1987, p. 873-879. Previously cited in issue 17, p. 2463, Accession no. A86-37837. refs

A88-24448#
EXPERIMENTAL INVESTIGATION AND SEMI-EMPIRICAL ESTIMATION OF AERODYNAMIC CHARACTERISTICS OF A SWEPT-FORWARD WING AT LOW SPEED AND HIGH ANGLES OF ATTACK
QINGSHENG CAI (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 5, Dec. 1987, p. 409-412. In Chinese, with abstract in English.

An investigation of aerodynamic characteristics of SFWs (swept-forward wings) at high angles of attack has been made by means of force measurements, pressure distribution measurements on the wing surface, and flow visualizations. A semiempirical method has also been established for calculating the lift of SFWs with partial wing stall. Author

A88-24508#
SHOCK WAVE/TURBULENT BOUNDARY-LAYER INTERACTIONS INDUCED BY A SEMICONE
NOBUMI SAIDA (Aoyama Gakuin University, Tokyo, Japan) and TOMONARI OOKA Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 30, Nov. 1987, p. 173-185. refs

This paper presents an experimental study of shock wave/turbulent boundary-layer interactions induced by a semicone placed on the floor of a wind tunnel. The experiments were carried out in an 8 x 10 sq cm supersonic wind tunnel at free-stream Mach numbers of 1.98 and 2.48. Corresponding unit Reynolds numbers at the test section were in both cases 3.8 x 10 to the 7th/m. Semicone models with half angles varying from 20 to 90 deg were used in this study. Surface static pressure measurements, oil flow studies, and Schlieren photographs of the flow field were made. It was found that, on a flat plate, the shape of the separation line is insensitive to the cone angle of over 40 deg. Furthermore, a secondary separation region embedded in the shock-induced primary separated flow exists along the semicone and plate junction. Author

N88-14928*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FINITE-VOLUME SCHEME FOR TRANSONIC POTENTIAL FLOW ABOUT AIRFOILS AND BODIES IN AN ARBITRARILY SHAPED CHANNEL
JERRY C. SOUTH, JR., MICHAEL L. DORIA (Valparaiso Univ., Ind.), and LAWRENCE L. GREEN *In its* Langley Symposium on Aerodynamics, Volume 1 p 25-43 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 01A

A conservative finite-volume difference scheme is developed for the potential equation to solve transonic flow about airfoils and bodies in an arbitrarily shaped channel. The scheme employs a mesh which is a nearly conformal O mesh about the airfoil and nearly orthogonal at the channel walls. The mesh extends to infinity upstream and downstream, where the mapping is singular. Special procedures are required to treat the singularities at infinity, including computation of the metrics near those points. Channels with exit areas different from inlet areas are solved; a body with a sting mount is an example of such a case. Author

N88-14934*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VISCOUS VORTEX FLOWS
R. P. WESTON, J. P. CHAMBERLAIN, C. H. LIU, and PETER-MICHAEL HARTWICH *In its* Langley Symposium on Aerodynamics, Volume 1 p 153-168 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 01A

Several computational studies are currently being pursued that focus on various aspects of representing the entire lifetime of the viscous trailing vortex wakes generated by an aircraft. The formulation and subsequent near-wing development of the leading-edge vortices formed by a delta wing are being calculated at modest Reynolds numbers using a three-dimensional, time-dependent Navier-Stokes code. Another computational code was developed to focus on the roll-up, trajectory, and mutual interaction of trailing vortices further downstream from the wing using a two-dimensional, time-dependent, Navier-Stokes algorithm. To investigate the effect of a cross-wind ground shear flow on the drift and decay of the far-field trailing vortices, a code was developed that employs Euler equations along with matched asymptotic solutions for the decaying vortex filaments. And finally, to simulate the conditions far down stream after the onset of the Crow instability in the vortex wake, a full three-dimensional, time-dependent Navier-Stokes code was developed to study the behavior of interacting vortex rings. Author

N88-14935*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A THEORY FOR THE CORE FLOW OF LEADING-EDGE VORTICES
JAMES M. LUCKRING *In its* Langley Symposium on Aerodynamics, Volume 1 p 169-185 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 01A

Separation-induced leading-edge vortices can dominate the flow about slender wings at moderate to high angles of attack, often with favorable aerodynamic effects. However, at the high angles of attack which are desirable for takeoff and landing as well as subsonic-transonic maneuver the vortices can breakdown or burst in the vicinity of the aircraft causing many adverse effects; these include lift loss, pitchup, and buffet. The flow in the core of leading-edge vortices is generally affiliated with the vortex breakdown phenomenon. A theory is presented for the flow in the core of separation-induced, leading-edge vortices at practical Reynolds numbers. The theory is based on matching inner and outer representations of the vortex. The inner representation models continuously distributed vorticity and includes an asymptotic viscous subcore. The outer representation models concentrated spiral sheets of vorticity and is fully three dimensional. A parameter is identified which closely tracks the vortex breakdown stability boundary for delta, arrow, and diamond wings. Author

N88-14946*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OVERVIEW OF THE LANGLEY VISCOUS DRAG REDUCTION PROGRAM
JERRY N. HEFNER *In its* Langley Symposium on Aerodynamics, Volume 1 p 393-399 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 01A

As a result of reductions in form drag and roughness drag, skin friction, drag, or viscous drag now represents a major contributor to the cruise drag of subsonic business and transport aircraft, and hence, is considered a barrier problem to further significant improvements in the aerodynamic efficiency of these aircraft. To meet the challenge, research in the areas of laminar-flow control and turbulence control/drag reduction was initiated at NASA Langley Research Center. The significance of this research is discussed. B.G.

N88-14948*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTATIONAL DESIGN OF NATURAL LAMINAR FLOW WINGS FOR TRANSONIC TRANSPORT APPLICATION
EDGAR G. WAGGONER, RICHARD L. CAMPBELL, PAMELA S. PHILLIPS, and JEFFREY K. VIKEN (Engineering and Science Consultants, Grafton, Va.) *In its* Langley Symposium on Aerodynamics, Volume 1 p 415-443 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 01A

Two research programs are described which directly relate to the application of natural laminar flow (NLF) technology to transonic transport-type wind planforms. Each involved using state-of-the-art computational methods to design three-dimensional wing contours which generate significant runs of favorable pressure gradients. The first program supported the Variable Sweep Transition Flight Experiment and involves design of a full-span glove which extends from the leading edge to the spoiler hinge line on the upper surface of an F-14 outer wing panel. Boundary-layer and static-pressure data will be measured on this design during the supporting wind-tunnel and flight tests. These data will then be analyzed and used to infer the relationship between crossflow and Tollmein-Schlichting disturbances on laminar boundary-layer transition. A wing was designed computationally for a corporate transport aircraft in the second program. The resulting wing design generated favorable pressure gradients from the leading edge aft to the mid-chord on both upper and lower surfaces at the cruise design point. Detailed descriptions of the computational design approach are presented along with the various constraints imposed on each of the designs. Wing surface pressure distributions, which support the design objective and were derived from transonic three-dimensional analyses codes, are also presented. Current status of each of the research programs is included in the summary. Author

N88-14958# United Technologies Research Center, East Hartford, Conn.
UNSTEADY STALL PENETRATION EXPERIMENTS AT HIGH REYNOLDS NUMBER Final Report, 14 Aug. 1984 - 14 Feb. 1987
PETER F. LORBER and FRANKLIN O. CARTA 14 Apr. 1987 204 p
(Contract F49620-84-C-0082)
(AD-A186120; UTRC/R87-956939-3; AFOSR-87-1202TR) Avail: NTIS HC A10/MF A01 CSCL 20D

An experiment was performed to examine the unsteady aerodynamics of stall penetration at constant pitch rate and high Reynolds number, in an attempt to more accurately model conditions during aircraft post-stall maneuvers and during helicopter high speed forward flight. The model spanned the 8 ft wind tunnel and consisted of a 17.3 in. chord wing with a Sikorsky SSC-AOQ airfoil section. Two forms of pitching motion were used: constant pitch rate ramps and sinusoidal oscillations. Ramp data were obtained for 36 test points at pitch rates between 0.001 and 0.020, Mach numbers between 0.2 and 0.4, and Reynolds numbers between 2 and 4 million. Sinusoidal data were obtained for an additional 9 conditions. The results demonstrate the influence of the leading edge stall vortex on the unsteady aerodynamic response during and after stall. The vortex-related unsteady increments to the lift, drag, and pitching moment increase with pitch rate; the maximum delta C sub L is 1.2 at A $=0.02$. Angular delays in stall events also increase with pitch rate. Vortex strength and propagation velocity were determined from pressures induced on the airfoil surface. The vortex is strengthened by increasing the pitch rate, and is weakened both by increasing the Mach number and by starting the motion close to the steady-state stall angle. Propogation velocity increases linearly with pitch rate. GRA

N88-14960*# Douglas Aircraft Co., Inc., Long Beach, Calif.
LAMINAR FLOW CONTROL LEADING EDGE GLOVE FLIGHT TEST ARTICLE DEVELOPMENT Final Report
W. E. PEARCE, D. E. MCNAY, and J. A. THELANDER Nov. 1984 112 p
(Contract NAS1-16220)
(NASA-CR-172137; NAS 1.26:172137) Avail: NTIS HC A06/MF A01 CSCL 01A

A laminar flow control (LFC) flight test article was designed and fabricated to fit into the right leading edge of a JetStar aircraft. The article was designed to attach to the front spar and fill in approx. 70 inches of the leading edge that are normally occupied by the large slipper fuel tank. The outer contour of the test article was constrained to align with an external fairing aft of the front spar which provided a surface pressure distribution over the test region representative of an LFC airfoil. LFC is achieved by applying suction through a finely perforated surface, which removes a small fraction of the boundary layer. The LFC test article has a retractable high lift shield to protect the laminar surface from contamination by airborne debris during takeoff and low altitude operation. The shield is designed to intercept insects and other particles that could otherwise impact the leading edge. Because the shield will intercept freezing rain and ice, a oozing glycol ice protection system is installed on the shield leading edge. In addition to the shield, a liquid freezing point depressant can be sprayed on the back of the shield. Author

N88-14962*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LIFT DISTRIBUTION AND VELOCITY FIELD MEASUREMENTS FOR A THREE-DIMENSIONAL, STEADY BLADE/VORTEX INTERACTION
STEPHEN E. DUNAGAN and THOMAS R. NORMAN Nov. 1987 39 p
(NASA-TM-100013; A-87306; NAS 1.15:100013) Avail: NTIS HC A03/MF A01 CSCL 01A

A wind tunnel experiment simulating a steady three-dimensional helicopter rotor blade/vortex interaction is reported. The experimental configuration consisted of a vertical semispan vortex-generating wing, mounted upstream of a horizontal semispan rotor blade airfoil. A three-dimensional laser velocimeter was used to measure the velocity field in the region of the blade. Sectional lift coefficients were calculated by integrating the velocity field to obtain the bound vorticity. Total lift values, obtained by using an internal strain-gauge balance, verified the laser velocimeter data. Parametric variations of vortex strength, rotor blade angle of attack, and vortex position relative to the rotor blade were explored. These data are reported (with attention to experimental limitations) to provide a dataset for the validation of analytical work. Author

N88-14965*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MODERN WING FLUTTER ANALYSIS BY COMPUTATIONAL FLUID DYNAMICS METHODS
HERBERT J. CUNNINGHAM, JOHN T. BATINA, and ROBERT M. BENNETT Jan. 1988 11 p Presented at the ASME Winter Annual Meeting, Boston, Mass. 13-18 Dec. 1987
(NASA-TM-100531; NAS 1.15:100531; ASME-PAPER-87-WA/AERO-9) Avail: NTIS HC A03/MF A01 CSCL 01A

The application and assessment of the recently developed CAP-TSD transonic small-disturbance code for flutter prediction is described. The CAP-TSD code has been developed for aeroelastic analysis of complete aircraft configurations and was previously applied to the calculation of steady and unsteady pressures with favorable results. Generalized aerodynamic forces and flutter characteristics are calculated and compared with linear theory results and with experimental data for a 45 deg sweptback wing. These results are in good agreement with the experimental flutter data which is the first step toward validating CAP-TSD for general transonic aeroelastic applications. The paper presents these results and comparisons along with general remarks regarding modern wing flutter analysis by computational fluid dynamics methods. Author

N88-14966*# Ohio State Univ., Columbus. Dept. of Aeronautical and Astronautical Engineering.
A FLOW VISUALIZATION STUDY OF THE LEADING EDGE SEPARATION BUBBLE ON A NACA 0012 AIRFOIL WITH SIMULATED GLAZE ICE Final Report M.S. Thesis
ABDOLLAH KHODADOUST Jan. 1988 91 p
(Contract NAG3-28)
(NASA-CR-180846; NAS 1.26:180846) Avail: NTIS HC A05/MF A01 CSCL 01A

As a part of the ongoing research in aircraft icing, the leading edge separation bubble on the NACA 0012 model with a 5-min simulated glaze ice was investigated. The flow visualization methods used oil, tuft, splitter plate, smoke, and liquid crystals to get reattachment line data for the leading edge separation bubble on both surfaces of the airfoil. On the upper surface, the bubble was found to grow larger with increasing negative angles of attack and reduce in size with increasing angles of attack. The separated flow fails to reattach beyond 6 deg for the upper surface and -5 deg for the lower surface. The results of this study compared well with those of other experiments and computational results. Author

N88-15760*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNSTEADY TRANSONIC ALGORITHM IMPROVEMENTS FOR REALISTIC AIRCRAFT APPLICATIONS
JOHN T. BATINA Dec. 1987 15 p Presented at the 26th AIAA Aerospace Sciences Meeting, Reno, Nev., 11-14 Jan. 1988
(NASA-TM-100516; NAS 1.15:100516; AIAA-88-0105) Avail: NTIS HC A03/MF A01 CSCL 01A

Improvements to a time-accurate approximate factorization (AF) algorithm were implemented for steady and unsteady transonic analysis of realistic aircraft configurations. These algorithm improvements were made to the CAP-TSD (Computational Aeroelasticity Program - Transonic Small Disturbance) code developed at the Langley Research Center. The code permits the aeroelastic analysis of complete aircraft in the flutter critical transonic speed range. The AF algorithm of the CAP-TSD code solves the unsteady transonic small-disturbance equation. The algorithm improvements include: an Engquist-Osher (E-O) type-dependent switch to more accurately and efficiently treat regions of supersonic flow; extension of the E-O switch for second-order spatial accuracy in these regions; nonreflecting far field boundary conditions for more accurate unsteady applications; and several modifications which accelerate convergence to steady-state. Calculations are presented for several configurations including the General Dynamics one-ninth scale F-16C aircraft model to evaluate the algorithm modifications. The modifications have significantly improved the stability of the AF algorithm and hence the reliability of the CAP-TSD code in general. Author

N88-15766*# Ohio State Univ., Columbus. Dept. of Aeronautical and Astronautical Engineering.
AN EXPERIMENTAL MAPPING OF THE FLOW FIELD BEHIND A GLAZE ICE SHAPE ON A NACA 0012 AIRFOIL M.S. Thesis Final Report
SAMUEL A. SPRING Jan. 1988 84 p
(Contract NAG3-28)
(NASA-CR-180847; NAS 1.26:180847) Avail: NTIS HC A05/MF A01 CSCL 01A

The flow field about a NACA 0012 airfoil with a simulated glaze ice shape was studied. Split hot-film anemometry was used to measure the streamwise velocity component in the upper and lower separation bubbles aft of the glaze ice horns. Velocity profiles were presented as well as the boundary layer momentum and displacement thickness distributions through the bubbles. Data were presented at angles of attack of 0, 2 and 4 deg and clearly showed the large region of reverse flow. A detailed discussion of split hot-film acquisition and data reduction, and possible sources of error has been included. Author

N88-15770# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
THREE-DIMENSIONAL UNSTEADY FLOW ELICITED BY FINITE WINGS AND COMPLEX CONFIGURATIONS Ph.D. Thesis
JEFFREY C. ASHWORTH 1987 188 p
(AD-A186464; AFIT/CI/NR-87-142D) Avail: NTIS HC A09/MF A01 CSCL 01A

Studies of 2-D unsteady separated flows demonstrate possible aerodynamic benefits of controlled unsteady flows about airfoil surfaces. However, since all applicable wings are necessarily finite, a thorough understanding of 3-D unsteady flows is essential. Any direct application or modelling of this complex 3-D phenomenon may be somewhat premature until a characteristic data base is established. The spatial and temporal transport, accumulation and dissipation of vorticity on the surface of three wings varying only in sweep angles (forward, straight and aft) were examined using flow visualization and hot wire anemometry. Identical geometric positions were tested on each wing for a variety of dynamic parameters. Each sweep geometry produced distinct, time-dependent, spanwise and chordwise sites for vorticity accumulation into large scale leading edge and wingtip vortices. The wingtip and leading edge vortex interactions produced spanwise flow patterns uncharacteristic of 2-D flows. Wing sweep is a dominant geometric parameter in analyzing the effects of unsteady wingtip flow. An initial investigation into the feasibility of unsteady flow application was performed on a model of the X-29 Forward Swept Wing Technology Demonstrator. This model geometry produces complex flow patterns but may be ideally suited for application of unsteady flow technology. GRA

03

AIR TRANSPORTATION AND SAFETY

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

A88-20699* Rice Univ., Houston, Tex.
OPTIMAL ABORT LANDING TRAJECTORIES IN THE PRESENCE OF WINDSHEAR
A. MIELE, T. WANG (Rice University, Houston, TX), W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA), and C. Y. TZENG Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 55, Nov. 1987, p. 165-202. Research supported by the Boeing Commercial Airplane Co. and Air Lines Pilots Association. refs
(Contract NAG1-516)

The abort landing problem is considered with reference to flight in a vertical plane. It is assumed that, upon sensing that the aircraft is in a windshear, the pilot increases the power setting at a constant time rate until maximum power setting is reached; afterward, the power setting is held constant. The performance index being minimized is the peak value of the altitude drop; the resulting optimization problem is a minimax or Chebyshev problem of optimal control. It is found that, for strong-to-severe windshears, the optimal trajectory includes three branches: a descending flight branch followed by a nearly horizontal flight branch, followed by an ascending flight branch after the aircraft has passed through the shear region. The peak altitude drop depends on the windshear intensity, the initial altitude, and the power setting rate; it increases as the windshear intensity increases and the initial altitude increases, and it decreases as the power setting rate increases. B.J.

A88-20718
PRACTICAL ASPECTS OF APPLYING LIGHTNING PROTECTION TO AIRCRAFT AND SPACE VEHICLES
B. J. BURROWS (U.K. Atomic Energy Authority, Culham Laboratory, Abingdon, England), C. R. JONES (British Aerospace, PLC, Preston, England), and K. G. PAYNE IN: Looking ahead for materials and processes; Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 18-21, 1987 . Amsterdam, Elsevier, 1987, p. 229-246. refs

The threat to aerospace vehicles from natural lightning is considered with particular reference to the increasing use of sensitive integrated circuitry and composite materials in flight controls and structures. Methods and materials for protection against the direct and indirect effects of lightning are reviewed and problem areas in their application considered. Examples of systems in use on a number of aircraft are briefly described and details given on some current lightning damage experience. The damage is assessed and suggestions made for the limitation of damage. Conclusions are drawn for the design of protection for electronically controlled aircraft and their composite structures. Author

A88-22079*# Massachusetts Inst. of Tech., Cambridge.
INVESTIGATION OF SURFACE WATER BEHAVIOR DURING GLAZE ICE ACCRETION
R. JOHN HANSMAN, JR. and STEPHEN R. TURNOCK (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(Contract NAG3-666; NGL-22-009-640)
(AIAA PAPER 88-0115)

Microvideo observations of glaze ice accretions on 1-in-diameter cylinders in a closed-loop refrigerated wind tunnel were obtained to study factors controlling the behavior of unfrozen surface water during glaze ice accretion. Three zones of surface water behavior were noted, each with a characteristic roughness. The effect of substrate thermal and roughness properties on ice accretions was also studied. The contact angle and hysteresis were found to increase sharply at temperatures just below 0 C, explaining the high resistance to motion of water beads observed on accreting glaze ice surfaces. Based on the results, a simple multizone modification to the current glaze ice accretion model is proposed. R.R.

A88-22080*# Ohio State Univ., Columbus.
EXPERIMENTAL MEASUREMENTS IN A LARGE SEPARATION BUBBLE DUE TO A SIMULATED GLAZE ICE SHAPE
M. B. BRAGG and A. KHODADOUST (Ohio State University, Columbus) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 16 p. NASA-supported research. refs
(AIAA PAPER 88-0116)

The effect of a simulated glaze ice accretion on the aerodynamic performance of a NACA 0012 airfoil was studied experimentally. Two ice shapes were tested, one from an experimentally measured accretion and one from an accretion predicted using a computer model given the same icing conditions. Lift, drag and moment coefficients were measured for the airfoil with both ice shapes, smooth and rough. The aerodynamic performance of the two shapes compared well at positive, but not negative, angles of attack. Split hot-film probe velocity data were presented in the upper surface boundary layer and in the wake. Boundary layer parameters were presented for the separation bubble and in the reattached turbulent boundary layer. Author

A88-22150*# Continuum Dynamics, Inc., Princeton, N. J.
PROPOSED MODIFICATIONS TO ICE ACCRETION/ICING SCALING THEORY
ALAN J. BILANIN (Continuum Dynamics, Inc., Princeton, NJ) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. Research supported by Continuum Dynamics, Inc. and FAA. refs
(Contract NAS1-18302)
(AIAA PAPER 88-0203)

The difficulty of conducting full-scale icing tests has long been appreciated. Testing in an icing wind tunnel has been undertaken for decades. While aircraft size and speeds have increased, tunnel facilities have not, thus making subscale geometric tests a necessity. Scaling laws governing these tests are almost exclusively based on analysis performed over 30 years ago and have not been rigorously validated. The following work reviews past scaling analyses and suggests revision to these analyses based on recent experimental observation. It is also suggested, based on the analysis contained herein, that current ice accretion predictive technologies, such as LEWICE when utilized in the glaze ice accretion regime, may need upgrading to more accurately estimate the rate of ice build-up on aerodynamic surfaces. Author

A88-22151#
AIRCRAFT ICING CERTIFICATION - IN PERSPECTIVE
RICHARD I. ADAMS (FAA, Washington, DC) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0204)

The process of certificating an aircraft for flight in meteorological conditions conducive to icing is a very complex and often a time-consuming and costly process. The process is always going to be complex because it deals with so many variables, but it does not necessarily have to remain difficult and expensive. The answer lies in an understanding of the requirements (the Federal Aviation Administration Regulations), the philosophy of certification, and the tools (the ice protection devices, the analytical sciences, and the design, development, and testing techniques). This process is referred to by the FAA as finding or demonstrating compliance. The applicant demonstrates compliance. The FAA finds compliance. This paper succinctly describes a philosophical approach that, if used by the applicant and the FAA, will result in the most cost-effective icing certification program that will assure flight safety. Author

A88-22152#
ENHANCED AIRCRAFT ICING DUE TO OROGRAPHIC EFFECTS
WAYNE R. SAND (National Center for Atmospheric Research, Boulder, CO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p. refs
(AIAA PAPER 88-0206)

It is known that aircraft icing is enhanced due to orographic effects. This paper is an initial examination of the potential increase in aircraft icing as a result of orography. The enhancement is calculable and could theoretically be accounted for in icing forecasts. Airways that pass along or over the crest of hills or mountains are thus prime locations for serious icing encounters. Author

A88-22288*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CLOUD-TO-GROUND STRIKES TO THE NASA F-106 AIRPLANE
VLADISLAV MAZUR, BRUCE D. FISHER, and PHILIP W. BROWN (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 16 p. NASA-supported research.
(AIAA PAPER 88-0390)

Cloud-to-ground (CG) lightning strike data on the NASA F-106B research aircraft obtained during the 1984-86 storm seasons in the vicinity of Wallops Island, Virginia, are analyzed. The results suggest that CG strikes may represent a significant portion of the total number of lightning strikes encountered by the aircraft at altitudes below 6 km. It is unlikely that an aircraft encounters the first return stroke of the CG flash. The current values of the CG strikes are not different from currents in other types of strikes. C.D.

A88-22289*# National Oceanic and Atmospheric Administration, Norman, Okla.
LIGHTNING INITIATION ON AIRCRAFT IN THUNDERSTORMS
VLADISLAV MAZUR (NOAA, National Severe Storms Laboratory, Norman, OK) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. NASA-supported research. refs
(AIAA PAPER 88-0391)

The physical model of the initiation of lightning flashes by aircraft in thunderstorms is presented. The model is based on the 'bi-directional uncharged leader' concept by Kasemir, and is verified with airborne data from lightning strikes to an instrumented airplane (NASA F-106B and FAA CV-580). The characteristics of electromagnetic processes during lightning attachment are identified by comparison with those studied in natural flashes, those triggered by wire trailing rockets, and laboratory discharges. A triggered flash starts with either a negative corona or a positive leader that depends on the ambient electric field vector and the airplane form factor. The positive leader with continuous current that increases with time is followed in a few milliseconds by the negative stepped leader with current pulses of a few kA. The two leaders develop in space simultaneously and bi-directionally from the oppositely charged extremities of the airplane. Author

A88-22290#
TRIGGERING OF LIGHTNING BY AEROSPACE VEHICLES
RODNEY A. PERALA and TERENCE H. RYDOLPH (Electro Magnetic Applications, Inc., Lakewood, CO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0393)

The triggering of lightning by in-flight vehicles is investigated. Specific attention is placed on the NASA F-106B Thunderstorm Research Aircraft and the Atlas-Centaur vehicle involved in the March 1987 AC-67 failure. Thunderstorm and vehicle parameters relevant to triggered lightning initiation are identified. A numerical simulation technique suitable for application to triggered lightning events is discussed. Results from this model's use in the F-106B program are shown and compared to measured data from actual lightning strikes to the aircraft. Issues unique to the Atlas-Centaur incident are presented. The results consist of currents and current time derivatives on the vehicle as a function of time. Derived ambient electric fields at the altitude of the lightning incident are compared with ground based electric field measurements. Finally, questions still unresolved in the physics of triggered lightning are identified. Author

A88-22291*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IMPLICATIONS OF A RECENT LIGHTNING STRIKE TO A NASA JET TRAINER
BRUCE D. FISHER (NASA, Langley Research Center, Hampton, VA), RALPH J. TAEUBER (NASA, Johnson Space Center, Houston, TX), and KEITH E. CROUCH (Lightning Technologies, Inc., Pittsfield, MA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(AIAA PAPER 88-0394)

On February 24, 1987, a NASA T-38A airplane experienced a lightning strike while approaching the Los Alamitos Army Aviation Facility in California. The airplane was landed safely at Los Alamitos with no injury to the crew members. However, the airplane suffered extensive fire damage in the center fuselage section. The NASA investigation board concluded that the airplane was struck by lightning, which resulted in an inflight explosion with subsequent fire. This paper describes the most probable cause of the incident, and the implications of this mishap to aircraft lightning protection and to the avoidance of those conditions conducive to lightning strikes to aircraft. Author

A88-22438*# Rice Univ., Houston, Tex.
OPTIMAL PENETRATION LANDING TRAJECTORIES IN THE PRESENCE OF WINDSHEAR
A. MIELE, T. WANG, W. W. MELVIN (Rice University, Houston, TX), and H. WANG AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 29 p. Research supported by the Boeing Commercial Airplane Co. and Air Line Pilots Association. refs
(Contract NAG1-516)
(AIAA PAPER 88-0580)

The present consideration of optimal windshear-penetration flight trajectories in a vertical plane gives attention to the cases of either mere angle-of-attack control, with predetermined power setting, or both angle-of-attack and power setting controls. Inequality constraints are imposed on the angle-of-attack, the power setting, and their time derivatives. The performance index being minimized measures flight trajectory deviation from a nominal trajectory. Time is free, absolute path inclination at touchdown is specified, and touchdown velocity and distance are subject to upper and lower bounds. Three power settings are investigated. O.C.

A88-22509#
AVOIDANCE OF HAZARDOUS WEATHER IN THE TERMINAL AREA
JEFFREY L. GORNEY (National Transportation Safety Board, Washington, DC) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 5 p.
(AIAA PAPER 88-0679)

The FAA's Windshear Training Aid is a package encompassing both texts and video materials that has been developed to reduce wind shear-related accidents and incidents, through the modification of flight crew behavior in light of past wind shear effects on terminal area operations during hazardous weather conditions. The Training Aid stresses that the clues concerning the presence and severity of wind shear are cumulative; if sufficient indications of hazardous conditions are present, crews should consider the delay of departure or approach. Hourly sequence reports, terminal forecasts, and Low Level Windshear Alert System data are the bases for crew judgments. O.C.

A88-22517#
OPERATIONAL HAZARDS OF WIND SHEARS
W. W. MELVIN (Air Line Pilots Association, Washington, DC) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0691)

The present assessment of the prospects for operational implementation of wind shear accident prevention measures recommends the provision of direct communications from airport towers to NWS weather radar sites. A microburst forecasting system should be developed that will warn pilots of severe microburst conditions. Pilots should be sensitized through future simulator training to the degree of severity that microburst phenomena represent, and should be made directly responsible for the expeditious reporting of suspected microwave conditions and microburst near-encounters. O.C.

A88-22717
THE NATIONAL AIR TRANSPORTATION SYSTEM - DESIGN BY CITY HALL?
E. TAZEWELL ELLETT (FAA, Washington, DC) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 53, Fall 1987, p. 1-30. refs

A background is given of the current airport-access and airport-use restriction situation in the United States. The respective roles of the federal and local goverments, the airport proprietor, and the airport user with respect to airport access and airport use restrictions are elucidated. The inadequacies of the current allocation of responsibility and authority are evaluated using restrictions designed to address an aircraft noise problem as an example. K.K.

A88-23187#
DEVELOPMENT TRENDS FOR EJECTION SEAT
ERKANG SHEN (Chinese Aeronautical Rescue Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Aug. 1987, p. B341-B347. In Chinese, with abstract in English. refs

A brief history of the development of the ejection seat is introduced. Emphasis is put on the options for improvement in safe escape in the low level and high speed mode. For providing the ejection seat with a self-adaptive control, some equipment, including microcomputer, new sensors, and controllable rocket motors should be used. Finally, three escape schemes for a high-acceleration cockpit are presented and evaluated. Author

A88-23258
HIGH SPEED COMMERCIAL FLIGHT - THE COMING ERA; PROCEEDINGS OF THE FIRST SYMPOSIUM, COLUMBUS, OH, OCT. 22, 23, 1986
JAMES P. LOOMIS, ED. (Battelle Memorial Institute, Columbus, OH) Symposium sponsored by the Battelle Memorial Institute, DOC, and Ohio Edison Program. Columbus, OH, Battelle Press, 1987, 286 p. No individual items are abstracted in this volume.

The present consideration of the near- and long-term technological and economic feasibility of supersonic and hypersonic transport aircraft gives attention to the comparative attractiveness of intensified R&D for the supersonic and hypersonic regimes. It is noted that the technology readiness base for a Mach 3-cruise SST is inadequate, and that the U.S. National Aerospace Plane (NASP) program will do little or nothing to alleviate this shortfall. The technology readiness base for a Mach 5 commercial SST is also inadequate, and the NASP is anticipated to contribute to only 30 percent of these needs. The SST market in the foreseeable future will accomodate only one such economically viable aircraft. O.C.

A88-24549
POTENTIAL CRASHWORTHINESS BENEFITS TO GENERAL AVIATION FROM INDIANAPOLIS MOTOR SPEEDWAY TECHNOLOGY
RICHARD T. JENNINGS and STANLEY R. MOHLER (Wright State University, Dayton, OH) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 59, Jan. 1988, p. 67-73. refs

General aviation crashworthiness can potentially benefit from certain advances being accomplished by the automobile industry. Progressive improvements in crash protection technology, as documented by a dramatic reduction in crash injuries and fatalities at the Indianapolis Motor Speedway, reflect improved crashworthiness.The speeds of survivable general aviation aircraft impacts are in the range of the Indianapolis Motor Speedway crashes (200-220 mph). This paper relates the declining crash death rates at Indy by decade versus the increase in speeds. The continuous rise in speeds has prompted the development of new crashworthy designs and driver protection equipment. Crashworthiness improvements include crushable surrounding structures, high-grade restraint systems, protective head gear, fire resistant clothing, break-away structural components, and a 'protective cocoon' concept. Adaptation of selected advances in crashworthiness design and operations accomplished at the Indianapolis Motor Speedway to the next generation of general aviation aircraft should provide significant dividends in survival of air crashes. Author

N88-14970*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WIND SHEAR DETECTION. FORWARD-LOOKING SENSOR TECHNOLOGY
E. M. BRACALENTE, comp. and V. E. DELNORE, comp. (PRC Kentron, Inc., Hampton, Va.) Oct. 1987 282 p Presented at the 1st Industry Review, Hampton, Va., 24-25 Feb. 1987
(NASA-CP-10004; NAS 1.55:10004; DOT/FAA/PS-87/2) Avail: NTIS HC A13/MF A01 CSCL 01C

A meeting took place at NASA Langley Research Center in February 1987 to discuss the development and eventual use of

forward-looking remote sensors for the detection and avoidance of wind shear by aircraft. The participants represented industry, academia, and government. The meeting was structured to provide first a review of the current FAA and NASA wind shear programs, then to define what really happens to the airplane, and finally to give technology updates on the various types of forward-looking sensors. This document is intended to informally record the essence of the technology updates (represented here through unedited duplication of the vugraphs used), and the floor discussion following each presentation. Also given are key issues remaining unresolved. Author

N88-15771# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
INFLUENCE OF ENVIRONMENTAL FACTORS ON AIRCRAFT WING PERFORMANCE
Feb. 1987 250 p Lecture series held in Rhode-Saint-Genese, Belgium, 16-20 Feb. 1987
(VKI-LS-1987-03; ISSN-0377-8312; ETN-88-91160) Avail: NTIS HC A11/MF A01

Characterization of meteorological phenomena influencing aircraft operations, the influence of wind shear, rain, ground frost and deicing fluids on aircraft performance, measures against wind shear and other flight hazards, and the effects of environmentally imposed roughness on airfoil performance are discussed. ESA

N88-15772# Centre National de Recherches Meteorologiques, Toulouse (France).
CHARACTERIZATION OF METEOROLOGICAL PHENOMENA INFLUENCING AIRCRAFT OPERATIONS
J. P. CHALON *In* Von Karman Inst. for Fluid Dynamics, Influence of Environmental Factors on Aircraft Wing Performance 32 p Feb. 1987
Avail: NTIS HC A11/MF A01

Phenomena associated with thunderstorms and presenting a potential hazard for aviation are discussed. The structure of thunderstorm systems, updrafts and energy involved, icing, hail, downdrafts, turbulence, and lightning are described. Difficulties in detecting potential hazards for aviation are reviewed. The deficiencies of the detection methods are pointed out. ESA

N88-15773# Technische Univ., Brunswick (West Germany). Inst. for Flight Guidance and Control.
THE INFLUENCE OF WIND SHEAR, DOWNDRAFT, AND TURBULENCE IN AIRCRAFT PERFORMANCE
MANFRED SWOLINSKY *In* Von Karman Inst. for Fluid Dynamics, Influence of Environmental Factors on Aircraft Wing Performance 59 p Feb. 1987
Avail: NTIS HC A11/MF A01

Typical aircraft responses to short scale gusts or turbulence and to large scale variations of the mean wind are discussed. The phenomena influence the flight performance and may crucially restrict flight safety, especially in takeoff and landing approach. The analysis indicates that aircraft response to wind shear and downdraft on the one hand and short scale gusts on the other hand is quite different and the operational requirements to cope with it have to discriminate between takeoff and landing approach. Adequate information about the aircraft response in wind shear and downdraft can be obtained only by onboard measurement. ESA

N88-15774*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE POTENTIAL INFLUENCE OF RAIN ON AIRFOIL PERFORMANCE
R. EARL DUNHAM, JR. *In* Von Karman Inst. for Fluid Dynamics, Influence of Environmental Factors on Aircraft Wing Performance 14 p Feb. 1987
Avail: NTIS HC A11/MF A01 CSCL 01C

The potential influence of heavy rain on airfoil performance is discussed. Experimental methods for evaluating rain effects are reviewed. Important scaling considerations for extrapolating model data are presented. It is shown that considerable additional effort, both analytical and experimental, is necessary to understand the degree of hazard associated with flight operations in rain. ESA

N88-15775# Boeing Commercial Airplane Co., Seattle, Wash.
EFFECTS OF WING SIMULATED GROUND FROST ON AIRCRAFT PERFORMANCE
THOMAS A. ZIERTEN and EUGENE G. HILL *In* Von Karman Inst. for Fluid Dynamics, Influence of Environmental Factors on Aircraft Wing Performance 36 p Feb. 1987
Avail: NTIS HC A11/MF A01

The results of flight test programs of the B737, 757, and 767 aircraft with simulated ground frost contamination are reviewed. A frost of 0.76 mm average roughness was selected as being most representative of frost encountered in service. Wind tunnel tests as well as flight tests were carried out. The results show that wing contamination can seriously reduce climb performance and lift. ESA

N88-15776# Boeing Commercial Airplane Co., Seattle, Wash.
EFFECTS OF AIRCRAFT DEICING/ANTIICING FLUIDS ON AIRFOIL CHARACTERISTICS
EUGENE G. HILL *In* Von Karman Inst. For Fluid Dynamics, Influence of Environmental Factors on Aircraft Wing Performance 18 p Feb. 1987
Avail: NTIS HC A11/MF A01

Wind tunnel tests evaluated flow behavior and aerodynamic effects of aircraft deicing and antiicing fluids, primarily ethylene glycol or glycol mixtures. The measurements and observations made during the tests show that all the fluids tested produce a rough, reticulated leading edge surface. Wave fronts of the fluid form near the leading edge and move slowly toward the trailing edge as the airspeed increases. The results justify a cautious approach to the use of these fluids. ESA

N88-15777# Boeing Commercial Airplane Co., Seattle, Wash.
LOW ALTITUDE WINDSHEAR THREAT TO COMMERCIAL AIRCRAFT
GEORGE S. HENDRICKSON and EUGENE G. HILL *In* Von Karman Inst. for Fluid Dynamics, Influence of Environmental Factors on Aircraft Wing Performance 48 p Feb. 1987
Avail: NTIS HC A11/MF A01

The efforts being made in the United States to combat the low altitude windshear threat are reviewed and the influence of windshear on airplane performance is described. Considerable attention is directed toward convective storm phenomena and to the associated flight hazards. Airports are scheduled to be better equipped with Doppler radar to enhance existing systems, providing more timely and reliable warnings of the presence of windshear. ESA

N88-15778*# Douglas Aircraft Co., Inc., Long Beach, Calif. Aircraft Configuration and Performance Dept.
EFFECTS OF ENVIROMENTALLY IMPOSED ROUGHNESS ON AIRFOIL PERFORMANCE
TUNCER CEBECI *In* Von Karman Inst. for Fluid Dynamics, Influence of Environmental Factors on Aircraft Wing Performance 43 p Feb. 1987
(Contract NAG3-601; NSF MEA-0818565)
Avail: NTIS HC A11/MF A01 CSCL 01C

The experimental evidence for the effects of rain, insects, and ice on airfoil performance are examined. The extent to which the available information can be incorporated in a calculation method in terms of change of shape and surface roughness is discussed. The methods described are based on the interactive boundary layer procedure of Cebeci or on the thin layer Navier Stokes procedure developed at NASA. Cases presented show that extensive flow separation occurs on the rough surfaces. ESA

N88-15780# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 5 OF 1986 ACCIDENTS
2 Nov. 1987 410 p
(PB87-916907; NTSB/AAB-87/07) Avail: NTIS HC A18/MF A01; also avail. paper copy, North American Continent $185.00; all others write for quote CSCL 01C

The publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1986. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The Brief Format presents the facts, conditions, circumstances, and probable cause(s) for each accident. GRA

N88-15781# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 7 OF 1986 ACCIDENTS
4 Nov. 1987 400 p
(PB87-916909; NTSB/AAB-87/09) Avail: NTIS HC A17/MF A01; also avail. on paper copy, North American Continent $185.00; all others write for quote CSCL 01C

The publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1986. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The Brief Format represents the facts, conditions, circumstances and probable cause(s) for each accident. GRA

N88-15782# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 8 OF 1986 ACCIDENTS
13 Sep. 1987 410 p
(PB87-916910; NTSB/AAB-87/10) Avail: NTIS HC A18/MF A01; also avail. paper copy, North American Continent $185.00/year; all others write for quote CSCL 01C

The publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during calendar year 1986. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The Brief Format presents the facts, conditions, circumstances, and probable cause(s) for each accident. GRA

N88-15803*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE NASA AIRCRAFT ICING RESEARCH PROGRAM
ROBERT J. SHAW and JOHN J. REINMANN *In its* Aeropropulsion '87. *Session 5: Subsonic Propulsion Technology* 27 p Nov. 1987
Avail: NTIS HC A08/MF A01 CSCL 01C

The objective of the NASA aircraft icing research program is to develop and make available to industry icing technology to support the needs and requirements for all weather aircraft designs. Research is being done for both fixed and rotary wing applications. The NASA program emphasizes technology development in two key areas: advanced ice protection concepts and icing simulation (analytical and experimental). The computer code development/validation, icing wind tunnel testing, and icing flight testing efforts which were conducted to support the icing technology development are reviewed. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A88-21600
FUTURE CIVIL AVIATION NEEDS - RECOMMENDATIONS OF RTCA SPECIAL COMMITTEE 155
WILLIAM T. HARDAKER (Radio Technical Commission for Aeronautics, Washington, DC) Navigation (ISSN 0028-1522), vol. 34, Fall 1987, p. 250-259.

In October 1983, the Radio Technical Commission for Aeronautics (RTCA) established Special Committee 155 (SC-155) on user requirements for future communications, navigation and surveillance, including space technology applications through the year 2010. This paper summarizes the assumptions, the postulated environment, the user requirements and technology forecasts upon which the resulting conclusions and recommendations are based. Author

A88-23264
COMPUTER SYSTEMS IN FUTURE ADVANCED AIR TRAFFIC MANAGEMENT
G. C. HOWELL (Civil Aviation Authority, London, England) IN: Computer applications in aircraft design and operation; Proceedings of the First International Conference on Computer Aided Design, Manufacture and Operation in the Aeronautics and Space Industries, Paris, France, June 16-18, 1987 . Billerica, MA, Computational Mechanics Publications, 1987, p. 65-84.

Some typical current ATC systems and existing areas of computer assistance to controllers are described. The role of automation and its relationship with human controllers is discussed, and a possible evolutionary route to the extensive use of automation compatible with flight safety is considered. The use of intelligent knowledge-based systems in future ATC computer systems is discussed, including plans for a U.K. research program in this area. C.D.

A88-23265
USE OF 4-D FMS IN A COMPLEX TERMINAL AREA IN THE PRE-DATA-LINK
S. A. N. MAGILL (Royal Signals and Radar Establishment, Air Traffic Control Research Div., Malvern, England) IN: Computer applications in aircraft design and operation; Proceedings of the First International Conference on Computer Aided Design, Manufacture and Operation in the Aeronautics and Space Industries, Paris, France, June 16-18, 1987 . Billerica, MA, Computational Mechanics Publications, 1987, p. 85-94.

Theoretical and practical aspects of using a four-dimensional flight management system (4-D FMS) in a complex aircraft terminal area are examined. The arrivals management problem is briefly reviewed, and the kind of computer assistance to ATC likely to come into service in the next few years is outlined. Ways to use 4-D FMS in arrivals management are summarized, and two opposing views of how to use 4-D FMS in ATC systems are presented. A method is proposed for using 4-D FMS in such a way that the controller retains full control of height and lateral position while the FMS controls speed to meet a planned time goal. The consequences of this method for FMS development are considered. C.D.

A88-23266
COMPUTER-ASSISTED AIRCRAFT ARRIVALS MANAGEMENT USING SPEED CONTROL
A. C. F. TYLER (Royal Signals and Radar Establishment, Air Traffic Control Research Div., Malvern, England) IN: Computer applications in aircraft design and operation; Proceedings of the First International Conference on Computer Aided Design, Manufacture and Operation in the Aeronautics and Space Industries, Paris, France, June 16-18, 1987 . Billerica, MA, Computational Mechanics Publications, 1987, p. 95-105. refs

This paper introduces the idea of computer assistance in ATC by describing a simple advisory aid which uses control of aircraft speed to produce an orderly flow of aircraft arriving in the terminal area. This results in delays being absorbed more efficiently. An indication is given of the potential use of computer prediction of aircraft trajectories to help controllers handle the arrivals management task in a scenario with increasing traffic flows.
C.D.

N88-14973# Computer Technology Associates, Inc., Colorado Springs, Colo.
FAA AIR TRAFFIC CONTROL OPERATIONS CONCEPTS. VOLUME 1: ATC BACKGROUND AND ANALYSIS METHODOLOGY Final Report
H. L. AMMERMAN, E. S. BECKER, G. W. JONES, W. K. TOBEY, and M. D. PHILLIPS 6 Jul. 1987 255 p
(Contract DTF-A01-85-Y-010304)
(AD-A185979; DOT/FAA/AP-87-01-VOL-1) Avail: NTIS HC A12/MF A01 CSCL 17G

The series of volumes documents the operations concepts for operational air traffic control (ATC) positions in the Advanced Automation System (AAS). AAS operational positions involve interaction with advanced radar and flight data displays, as well as other automated ATC functions, through a sector suite workstation or position console. Volume I of the series includes material common to all positions. Operations in today's facilities (pre-AAS centers, towers, and TRACONs), the automated capabilities planned for AAS, and the methodology used to analyze the operations concept for a particular ATC position are described in Volume 1. Volume 1 includes definitions of air traffic events, baseline operational scenarios, glossaries of task and element action verbs, glossary of ATC terms, and list of acronyms used in the documents.
GRA

N88-14974# Computer Technology Associates, Inc., Colorado Springs, Colo.
FAA AIR TRAFFIC CONTROL OPERATIONS CONCEPTS. VOLUME 2: ACF/ACCC (AREA CONTROL FACILITY/AREA CONTROL COMPUTER COMPLEX) TERMINAL AND EN ROUTE CONTROLL ERS Final Report
H. L. AMMERMAN, E. S. BECKER, C. A. CLAUSSEN, E. E. INMAN, and G. W. JONES 6 Jul. 1987 365 p
(Contract DTF-A01-85-Y-010304)
(AD-A185980; DOT/FAA/AP-87-01-VOL-2) Avail: NTIS HC A16/MF A01 CSCL 01E

This volume is one of a series of operations concepts for the FAA's Advanced Automation System (AAS). It describes how terminal and en route controllers in the Area Control Facilities may perform their operational jobs in the full Air Control Computer Complex (ACCC) environment. ACCC functionality is assumed to be as described in the AAS System Level Specification, 24 April 1987. Included are: composition graphs, showing the logical flow of operation tasks performed in response to or anticipation of external air traffic events; a series of analyses of these tasks, including task information requirements, cognitive/sensory attributes, performance criteria, and summary dialogue description; and a user interface language aggregating system. Data presented here are generated and maintained using the Computer-Human Operational Requirements Analysis System (CHORAS). CHORAS includes an automated task data base, specialized graphing capabilities, and display and hard copy output features tailored to the needs of operations concept analysis.
GRA

N88-14975# Computer Technology Associates, Inc., Colorado Springs, Colo.
FAA AIR TRAFFIC CONTROL OPERATIONS CONCEPTS. VOLUME 3: ISSS (INITIAL SECTOR SUITE SYSTEM) EN ROUTE CONTROLLERS Final Report
H. L. AMMERMAN, C. A. CLAUSSEN, E. E. INMAN, and W. K. TOBEY 6 Jul. 1987 622 p
(Contract DTF-A01-85-Y-010304)
(AD-A185981; DOT/FAA/AP-87-01-VOL-3) Avail: NTIS HC A99/MF A01 CSCL 01E

This volume is one of a series of operations concepts for the FAA's Advanced Automation System (AAS). It describes how en route controllers in Air Route Traffic Control facilities may perform their operational jobs in the Initial Sector Suite System (ISSS) environment. ISSS functionality is assumed to be as described in the AAS System Level Specification, 24 April 1987. Included here are: composition graphs, showing the logical flow of operational tasks performed in response to or anticipation of external air traffic events; a series of analyses of these tasks, including task information requirements, cognitive/sensory attributes, performance criteria, and summary dialogue description; a user interface language aggregating system input and output messages in a hierarchical organization; decomposition of tasks to their constituent procedural elements; traceability between tasks and supporting ISSS functionality; and sample operational scenarios for each position. Data presented here are generated and maintained using the Computer-Human Operational Requirements Analysis System (CHORAS). CHORAS includes an automated task data base, specialized graphing capabilities, and display and hard copy output features tailored to the needs of operations concept analysis.
GRA

N88-14976# Computer Technology Associates, Inc., Colorado Springs, Colo.
FAA AIR TRAFFIC CONTROL OPERATIONS CONCEPTS. VOLUME 4: TAAS (TERMINAL ADVANCED AUTOMATION SYSTEM) TERMINAL CONTROLLERS Final Report
H. L. AMMERMAN, C. A. CLAUSSEN, E. E. INMAN, G. W. JONES, and B. E. MELVILLE 6 Jul. 1987 504 p
(Contract DTF-A01-85-Y-010304)
(AD-A185982; DOT/FAA/AP-87-01-VOL-4) Avail: NTIS HC A22/MF A01 CSCL 01E

This volume is one of a series of operations concepts for the FAA's Advanced Automation System (AAS). It describes how terminal controllers in TRACON facilities may perform their operational jobs in the Terminal Advanced Automation System (TAAS) environment. TAAS functionality is assumed to be as described in the AAS System Level Specification, 24 April 1987. Included here are: composition graphs, showing the logical flow of operational tasks performed in response to or anticipation of external air traffic events; a series of analyses of these tasks, including task information requirements, cognitive/sensory attributes, performance criteria, and summary dialogue description; a user interface language aggregating system input and output messages in a hierarchical organization; decomposition of tasks to their constituent procedural elements; traceability between tasks and supporting TAAS functionality; and sample operational scenarios for each position. Data presented here are generated and maintained using the Computer-Human Operational Requirements Analysis System (CHORAS). CHORAS includes an automated task data base, specialized graphing capabilities, and display and hard copy output features tailored to the needs of operations concept analysis.
GRA

N88-14977# Computer Technology Associates, Inc., Colorado Springs, Colo.
FAA AIR TRAFFIC CONTROL OPERATIONS CONCEPTS. VOLUME 5: ATCT/TCCC (AIRPORT TRAFFIC CONTROL TOWER/TOWER CONTROL COMPUTER COMPLEX) TOWER CONTROLLERS Final Report
H. L. AMMERMAN, E. S. BECKER, L. J. BERGEN, C. A. CLAUSSEN, and D. K. DAVIES 31 Jul. 1987 699 p
(Contract DTF-A01-85-Y-010304)
(AD-A185983; DOT/FAA/AP-87-01-VOL-5) Avail: NTIS HC A99/MF A02 CSCL 01E

This volume is one of a series of operations concepts for the FAA's Advanced Automation System (AAS). It describes how Tower controllers in the Airport Traffic Control Towers (ATCT) may perform their operational jobs in the full tower control computer complex (TCCC) environment. TCCC functionally is assumed to be as described in the AAS System Level Specification, 24 April 1987. Separate analyses are presented for the three basic control positions: Local Control, Ground Control, and Clearance Delivery/Flight Data. Included here are: composition graphs showing the logical flow of operational tasks performed in response to or anticipation of external air traffic events; a series of analyses of these tasks, including task information requirements, cognitive/sensory attributes, performance criteria, and summary dialogue description; a user interface language aggregating system input and output messages in a hierarchical organization; decomposition of tasks to their constituent procedural element; and traceability between tasks and supporting TCCC functionality. Data presented here are generated and maintained using the Computer-Human Operational Requirements Analysis System (CHORAS). CHORAS includes an automated task data base, specialized graphing capabilities, and display and hard copy output features tailored to the needs of operations concept analysis.
GRA

N88-15783# Computer Resource Management, Inc., Vienna, Va.
CHICAGO'S O'HARE RUNWAY CONFIGURATION MANAGEMENT SYSTEM (RCMS). VOLUME 2: USERS GUIDE
ANTHONY BRADLEY, HELEN MONK, and EDWARD JAGGARD Jul. 1987 113 p
(Contract DTFA03-85-C-00046)
(AD-A186222; DOT/FAA/CT-86/15-2) Avail: NTIS HC A06/MF A01 CSCL 01E

Volume I of this report describes the proposed Runway Configuration Management System (RCMS) operational software for review by the facility personnel. It also serves as an input to RCMS functional specifications for the Traffic Management System (TMS) program. Using interactive computer logic, RCMS helps supervisors select runway configurations which reduce aircraft delays by optimizing throughput capacity in dynamic operational environments. Volume II of this report is the User's Guide to the RCMS. Author (GRA)

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A88-20705
USE OF NEW MATERIALS AND NEW TECHNOLOGIES IN THE RAFALE STRUCTURES
C. A. PICARD (Avions Marcel Dassault Breguet Aviation, Vaucresson, France) IN: Looking ahead for materials and processes; Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 18-21, 1987 . Amsterdam, Elsevier, 1987, p. 31-49.

An account is given of the design considerations that have figured in the incorporation of such novel primary structure advanced materials as Al-Li alloys, superplastically formable and diffusion-bonded Ti alloys, and aramid fiber/bismaleimide matrix composites. Attention is given to manufacturing cost reductions obtainable through the fabrication methods that these advanced materials can be formed by, as well as the weight and/or performance savings demonstrated. Detailed airframe material breakdown drawings are included. O.C.

A88-20824
THE WILL TO EUROPEAN UNITY AS EXEMPLIFIED BY A320. II [WILLE ZUR EUROPAEISCHEN EINHEIT AM BEISPIEL A320. II]
JEAN ROEDER Luft- und Raumfahrt (ISSN 0173-6264), vol. 8, 4th Quarter, 1987, p. 25-29. In German.

A general description of the A-320 passenger aircraft is presented. Consideration is given to the airframe design, the application of fiber-reinforced composite materials, the engines, the flight-control and avionics systems, the cockpit and cargo holds, the passenger cabin, and the operating envelope and overall performance. Diagrams, drawings, graphs, and photographs are provided. T.K.

A88-20937*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DRAGGING DOWN FUEL COSTS
JERRY N. HEFNER (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 26, Jan. 1988, p. 14-16.

It has been suggested that modest reductions in friction drag could save U.S. airlines $200-500 million a year. Potentially significant fuel savings are to be expected from laminar flow control (LFC) with suction surfaces on a CTOL subsonic transport; fuel savings from 25 to 40 percent are possible, depending on stage length. NASA has developed advanced computational design tools and methodology, subsonic and transonic NLF (natural laminar flow) and LFC airfoils, practical laminar wing construction techniques, and practical leading-edge treatments applicable to civil and military transports. It is concluded that skin-friction and induced drag approaches can combine to make a 50 percent reduction a reality for commercial and military aircraft of the future. B.J.

A88-21201
TWO X-29S PROBING NEW TACTICAL FRONTIERS
WILLIAM MEBES (Grumman Corp., Bethpage, NY) Horizons (ISSN 0095-7615), vol. 23, no. 2, 1987, p. 2-7.

The first X-29 forward-swept wing research aircraft has to date conducted aerodynamic, structural, and avionic technologies' development, and is now proceeding, in association with a second aircraft, to explore high angle-of-attack maneuvering. The 'high-alpha' research program specifically calls for the second X-29 to maneuver about all axes up to 40 deg, and as much as 70 deg about the pitch axis. The attempt to maintain a high degree of controllability at such angles-of-attack is of direct importance

to fighter combat tactics, where wing stall during high angle-of-attack maneuvering has been a persistent problem. O.C.

A88-21328
EUROPE'S EH 101 EMERGES
Air International (ISSN 0306-5634), vol. 33, Dec. 1987, p. 277-284.

An account is given of the design features and performance capabilities of the versions offered for the British/Italian EH 101 military/civilian transport helicopter. The scaling of the design was determined by naval version requirements, and in turn led to the adoption of a three-engined propulsion system configuration; this is especially advantageous for the civilian role envisioned, involving over-water flights to offshore oil rigs. The civilian version can carry 25/30 passengers, and the military utility version will accommodate 28 combat-equipped troops. Advanced main blade tip airfoils are employed. O.C.

A88-21978
RELIABILITY OF THE HYDRAULIC SYSTEMS OF AIRCRAFT [NADEZHNOST' GIDRAVLICHESKIKH SISTEM VOZDUSHNYKH SUDOV]
TRIFON MAKSIMOVICH BASHTA, VALENTINA DMITRIEVNA BABANSKAIIA, IURII STEFANOVICH GOLOVKO, G. I. ZAIONCHKOVSKII, V. M. RUZHAN et al. Moscow, Izdatel'stvo Transport, 1986, 280 p. In Russian. refs

The principal structural schemes of the hydraulic systems of aircraft are examined, and the main characteristics and criteria for evaluating their reliability are discussed. In particular, attention is given to methods for assessing the functional reliability of hydraulic systems and diagnostic techniques. Reliability analysis and ratings are presented for the hydraulic systems of some aircraft and helicopters currently produced in the USSR and abroad. V.L.

A88-22004*# Vigyan Research Associates, Inc., Hampton, Va.
COMPUTATION AND COMPARISON OF THE INSTALLATION EFFECTS OF COMPRESSION PYLONS FOR A HIGH WING TRANSPORT
B. CHANDRASEKARAN (Vigyan Research Associates, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(Contract NAS1-17919)
(AIAA PAPER 88-0004)

The three-dimensional transonic Euler method with boundary layer interaction is used to study the flow about a transport aircraft equipped with NASA-developed compression pylons. The results show that the present pylons perform well under the installed conditions, reducing the wing/pylon junction velocities and thus reducing the installed loft loss and drag. The predicted theoretical results are found to agree moderately well with experimental wind tunnel results. R.R.

A88-22015#
DESIGN OF AN ADVANCED PNEUMATIC DE-ICER FOR THE COMPOSITE ROTOR BLADE
NORBERT A. WEISEND, JR. (B. F. Goodrich Co., Aerospace and Defense Div., Uniontown, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0017)

Operating principles of the pneumatic de-icer and rubber's self-shedding characteristics are applied to the rotor blade. The de-icer system operation is discussed. Design criteria for the de-icer on a composite blade covers chordwise/spanwise coverage considerations, air connection location and airfoil profile retention. Also discussed is a method for determining the extent of de-icing tube coverage and the limit of self-shedding material at the outboard end of the blade. The use of smaller tubes to reduce de-icer inflation drag is also discussed. Author

A88-22016*# Wichita State Univ., Kans.
ELECTRO-IMPULSE DE-ICING ELECTRODYNAMIC SOLUTION BY DISCRETE ELEMENTS
W. D. BERNHART and R. L. SCHRAG (Wichita State University, KS) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(Contract NAG3-284)
(AIAA PAPER 88-0018)

This paper describes a technique for analyzing the electrodynamic phenomena associated with electro-impulse deicing. The analysis is done in the time domain and utilizes a discrete element formulation concept expressed in state variable form. Calculated results include coil current, eddy currents in the target (aircraft leading edge skin), pressure distribution on the target, and total force and impulse on the target. Typical results are presented and described. Some comparisons are made between calculated and experimental results, and also between calculated values from other theoretical approaches. Application to the problem of a nonrigid target is treated briefly. Author

A88-22017*# Wichita State Univ., Kans.
ELECTRO-IMPULSE DE-ICING - A STATUS REPORT
G. W. ZUMWALT (Wichita State University, KS) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p. refs
(Contract NAG3-284; DOT-FA03-86-C-00041)
(AIAA PAPER 88-0019)

The advantages and disadvantages of the Electro-Impulse De-Icing (EIDI) system are examined. The design and operation of the EIDI are described. The effect of repeated impulsive loads on the structure and skin of the aircraft surface is investigated. It is observed that the wing skin directly over the coil receives the greatest stresses. Data from the testing of metal leading edges reveal that after 11,500 impulses cracks appear in the sheet brackets attaching the ribs to the coil beams. The composite leading edge was evaluated for fatigue, and after 20,000 impulses no cracks were detected. The advantages of the band-aid coil mount are discussed. I.F.

A88-22018#
TEST AND ANALYSIS OF ELECTRO-IMPULSE DE-ICING SYSTEMS IN TURBINE ENGINE INLETS
DON O. NELEPOVITZ, HERMAN A. ROSENTHAL, and HEATHER M. ROCKHOLT (Rohr Industries, Inc., Chula Vista, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p. refs
(AIAA PAPER 88-0020)

The Electro-Impulse De-Icing (EIDI) system is evaluated using wind tunnel testing and computer analysis. A PW 142 engine with an inlet lip of molded fiberglass/epoxy was tested in a wind tunnel for various ice conditions and using different system energy levels. The tests revealed that EIDI performed well under all ice conditions. Turbofan engine tests were conducted using an A-310 high-bypass engine inlet to study the EIDI design parameters; it is observed that the EIDI is effective on ice accretion of 3 mm in thickness. Structural and electrical dynamic analyses were performed to collect data useful in the designing of inlet installed EIDI systems. The data reveal that the EIDI is a viable ice removal system for turbine engine inlets, and the modeling techniques developed are applicable to the future inlet ice protection system design program. I.F.

A88-22019#
LOW VOLTAGE ELECTRO-IMPULSE DE-ICER
PETER B. ZIEVE (Electroimpact, Inc., Seattle, WA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p. refs
(AIAA PAPER 88-0021)

A Low Voltage Electro-Impulse De-Icing (LVEIDI) module has been developed. The LVEIDI module has a capacitor bank and power supply mounted to the back of each coil. Modules are powered directly off of the ac aircraft power system similar to a row of light bulbs, each drawing an average current of 37 mA. Each module is inherently current limited. If any one should fail

other modules will be unaffected, lending considerable reliability. The low discharge voltage of 450 VDC is an attractive feature. LVEIDI modules are lightweight and inexpensive. Author

A88-22066#
DESIGN OF A ROTARY ENGINE-POWERED FOUR PLACE AIRCRAFT
JARED SMITH (Washington, University, Seattle) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(AIAA PAPER 88-0093)

This paper addresses the requirement for a new technology general aviation personal aircraft. A detailed development is presented of the Falconair 160TR, an affordable, high performance aircraft intended to compete with used aircraft sales. The performance advantages of utilizing a highly advanced rotary combustion engine include high power to weight and power to volume ratios, low specific fuel consumption, and multi-fuel capability. Cabin comfort is enhanced by the inherent low vibration of the rotary engine. Surface finish and dimensional control is improved due to construction methods incorporating advanced composite materials, allowing the use of new NASA low speed airfoils. Sound and vibration absorption along with lower manufacturing costs enhance the design. The aircraft was designed to be aesthetically pleasing to the customer. Author

A88-22075*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNSTEADY TRANSONIC ALGORITHM IMPROVEMENTS FOR REALISTIC AIRCRAFT APPLICATIONS
JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(AIAA PAPER 88-0105)

Improvements to a time-accurate approximate factorization (AF) algorithm have been implemented for steady and unsteady transonic analysis of realistic aircraft configurations. The algorithm improvements include: an Engquist-Osher (E-O) type-dependent switch to more accurately and efficiently treat regions of supersonic flow, extension of the E-O switch for second-order spatial accuracy in these regions, nonreflecting far field boundary conditions for more accurate unsteady applications, and several modifications which accelerate convergence to steady-state. Calculations are presented for several configurations to evaluate the algorithm modifications. The modifications have significantly improved the stability of the AF algorithm and hence the reliability of the CAP-TSD code in general. Author

A88-22195#
APPLICATION OF LOCALIZED ACTIVE NOISE CONTROL TO REDUCE PROPELLER NOISE TRANSMITTED THROUGH FUSELAGE SURFACE
M. SALIKUDDIN and K. K. AHUJA (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0266)

'Localized active noise control' for propeller aircraft cabin noise reduction acts only in the vicinity of an antiphase sound source mounted on the wall of the aircraft cabin. Several such sound sources on the cabin wall can reduce noise over larger areas. Attention is presently given to experimental verification of this effect that exhibits particular success at low frequencies. The method may also be applied to selected areas of the aircraft structure where sonic fatigue is a critical design consideration. O.C.

A88-22196#
PREDICTION OF AIRCRAFT PROPELLER INDUCED STRUCTURE-BORNE INTERIOR NOISE
JAMES F. UNRUH (Southwest Research Institute, San Antonio, TX) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. Research supported by the Southwest Research Institute. refs
(AIAA PAPER 88-0267)

Coupled analytical and empirical structural-acoustic models of an aircraft fuselage and wing structure driven by propeller wake/vortex induced loading are developed to predict structure-borne noise transmission into the aircraft cabin. Free-interface component coupling functions are used to couple the system components for structure-borne noise prediction. Predicted interior noise levels for the first two propeller tones are compared to laboratory-based test results to verify the predictive procedures. Author

A88-22208*# Toledo Univ., Ohio.
OVERVIEW OF NUMERICAL CODES DEVELOPED FOR PREDICTED ELECTROTHERMAL DEICING OF AIRCRAFT BLADES
THEO G. KEITH, KENNETH J. DE WITT, WILLIAM B. WRIGHT, and K. CYRIL MASIULANIEC (Toledo, University, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. NASA-supported research. refs
(AIAA PAPER 88-0288)

An overview of the deicing computer codes that have been developed at the University of Toledo under sponsorship of the NASA-Lewis Research Center is presented. These codes simulate the transient heat conduction and phase change occurring in an electrothermal deicier pad that has an arbitrary accreted ice shape on its surface. The codes are one-dimensional rectangular, two-dimensional rectangular, and two-dimensional with a coordinate transformation to model the true blade geometry. All modifications relating to the thermal physics of the deicing problem that have been incorporated into the codes will be discussed. Recent results of reformulating the codes using different numerical methods to increase program efficiency are described. In particular, this reformulation has enabled a more comprehensive two-dimensional code to run in much less CPU time than the original version. The code predictions are compared with experimental data obtained in the NASA-Lewis Icing Research Tunnel with a UH1H blade fitted with a B. F. Goodrich electrothermal deicer pad. Both continuous and cyclic heater firing cases are considered. The major objective in this comparison is to illustrate which codes give acceptable results in different regions of the airfoil for different heater firing sequences. Author

A88-22344#
FIREWALL DESIGN AND TESTING CONSIDERATIONS
W. A. WHITTEN (LTV Aerospace and Defense Co., Dallas, TX) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 5 p.
(AIAA PAPER 88-0468)

Firewalls in aircraft are constructed of material which will withstand a 2000 deg F fire for 15 minutes. A testing program may be required for a firewall which incorporates joints and penetrations for wires and tubes. The present paper deals with problems encountered in assuring correct heating rates for fire tests, and some results of testing a firewall electrical wire feed through are presented. Meeting Mil-Spec firewall test requirements involves special considerations in order for the test burner to yield the correct heating rate and temperature distribution at the test location. The use of a firewall sealant as a potting compound for a firewall electrical feed through fitting was not satisfactory. Author

A88-22496#
THE VELOCITY FIELD OF A LIFTING ROTOR IN LOW-SPEED FORWARD FLIGHT
S. G. LIOU, N. M. KOMERATH, and H. M. MCMAHON (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(Contract DAAG29-82-K-0084)
(AIAA PAPER 88-0666)

The velocity field of a simple rotor-airframe configuration in a wind tunnel has been measured. A pressure-instrumented circular cylinder with a hemispherical nose is used as the airframe model, with a two-bladed teetering rotor suspended above it. The data were shown to be free of tunnel wall effects. The periodic and time-averaged velocity fields were measured using a laser velocimeter in planes parallel to and both above and below the rotor tip path plane at advance ratios of 0.1 and 0.15 and a rotor-tip Mach number of 0.29. Variations along horizontal lines above the airframe surface also were measured. For the geometry studied, airframe influence on the rotor flow field was mostly confined to the front half of the rotor disk. Hub effects were noticeable, even with the minimal hub dimensions used. The wake geometry agreed well with predictions for an isolated rotor, except for distortions near the airframe. Strong vortex interaction effects were observed. Author

A88-22569#
TOWARD AN UNSTEADY-FLOW AIRPLANE
E. J. JUMPER (USAF, Weapons Laboratory, Kirtland AFB, NM), W. J. DARDIS, III (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH), and E. J. STEPHEN (USAF, Frank J. Seiler Research Laboratory, Colorado Springs, CO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 17 p. refs
(AIAA PAPER 88-0752)

It may be possible to sustain time-integrated lift coefficients of up to 1.5 times larger than the static maximum lift coefficient by use of specific, well-defined periodic airfoil pitch motions, without the associated drag penalties previously believed to be inherent in dynamic-stall-like lift augmentations. This paper takes a conservative look at methods of incorporating such lift improvements into aircraft design considerations for a relatively simple aircraft configuration. The type of aircraft considered is a cruise-missilelike vehicle. A generic base-line vehicle is developed and its performance is compared with two possible implementations of dynamic-motion-improved lift coefficient wings. Range improvements of as much as 20 percent can be realized after fuel and weight penalties are imposed to account for additional actuator/structure required for the dynamic motion of the wings. Specific yet-to-be-explored issues are also addressed. Author

A88-22575#
PRELIMINARY SIZING METHODOLOGY FOR HYPERSONIC VEHICLES
ARMAND J. CHAPUT (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 14 p.
(AIAA PAPER 87-2954)

Simplified design and analysis relationships are developed which are suitable for conceptual-level sizing and synthesis of hypersonic vehicles. The relationships are developed from point design studies and normalized for generalized vehicle design applications. First and second-order polynominal curve-fit expressions describe the normalized, aerodynamic and propulsion performance parameters. Geometry is represented by simple shapes and areas. Mass properties are approximated by unit weights and factors. A simplified atmosphere and equations of motion complete an equation set which can be iterated and solved using elementary programming techniques. Author

A88-22592#
AEROELASTIC PREDICTION OF ROTOR LOADS IN FORWARD FLIGHT
BERNADETTE PELEAU and DIDIER PETOT (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1987-138, 1987, 20 p. refs
(ONERA, TP NO. 1987-138)

A simple and fast method for calculation of the forced response of helicopter rotor blades in forward flight is presented. The code involves a step-by-step solution of the aeroelastic equations obtained by coupling the unsteady aerodynamics of the ONERA dynamic stall model with a modal representation of the structure. The periodic response of the blade is achieved after several revolutions. The method is validated by comparison of theoretical predictions with results obtained from the SA 349 GV helicopter flight tests. Significant prediction improvement is found using the METAR code, particularly at low speeds. Only a small number of elastic blade modes are required for a rotor performance analysis. R.R.

A88-22619
FATIGUE FAILURE ANALYSIS OF THE REAR PRESSURE BULKHEAD OF THE CRASHED BOEING 747 JUMBO JET PLANE
HIDEO KOBAYASHI, YOSHIO ARAI, and HARUO NAKAMURA (Tokyo Institute of Technology, Japan) Japan Society of Materials Science, Journal (ISSN 0514-5163), vol. 36, Oct. 1987, p. 1084-1089. In Japanese, with abstract in English. refs

Studies of the Boeing 747 crash suggest that the culprit was the fatigue crack growth emanating from the fastener holes which led to the failure of the rear pressure bulkhead. It was found that, when the flawed hole is adjacent to the sound holes, the fatigue holes from the flaws are arrested at the sound holes and crack reinitiation cycles are sufficiently long. However, when two or three adjacent holes are flawed, the specimen shows a drastic reduction in life. K.K.

A88-22666
CRASH SIMULATION CALCULATIONS AND COMPONENT IDEALIZATION FOR AN AIRCRAFT SUBFLOOR [CRASH-SIMULATIONSRECHNUNGEN UND BAUTEILIDEALISIERUNG FUER EINEN LUFTFAHRZEUGUNTERBODEN]
W. G. HIENSTORFER (DFVLR, Institut fuer Bauweisen- und Konstruktionsforschung, Stuttgart, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 11, July-Oct. 1987, p. 221-229. In German. refs

Several crash cases are simulated for an aircraft subfloor structure using the analytical crash code KRASH 79 (Gammon, 1978). The differences of the dynamic response behavior of the subfloor structure, related to typical load-deflection types (metal, composite design), are investigated. The results of the crash analysis are compared with the human tolerance limits. For future aircraft projects, a crashworthy design of the subfloor structure is discussed. Author

A88-22727
AERODYNAMICS OF THE HELICOPTER WORLD SPEED RECORD
F. J. PERRY (Westland Helicopters, Ltd., Yeovil, England) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 3-15.

The aerodynamic content of the Westland Lynx Helicopter World Speed Record is outlined and in particular the performance of the BERP main rotor and powerplant installation are discussed. Torque reaction and aircraft trim considerations are outlined along with airframe drag reduction efforts. Comparisons of rotor loads and overall aircraft performance with theory are shown. Author

A88-22736
DESIGN OF A HELICOPTER REMOTELY PILOTED VEHICLE
K. J. HEIGEL, JR. and B. J. SCALLAN (Saint Louis University, MO) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 125-130.

The design features and performance capabilities of the SH-250 helicopter RPV, which was designed for both civil and military operations, are presented. The advanced technology incorporated by this RPV encompasses the 'NOTAR' configuration, a bearingless main rotor, composite structural materials, and state-of-the-art avionics. A 420-hp engine is used which allows the SH-250 to reach 23,200 ft and yields a sea level range of 610 nautical miles; endurance is found to be over 8 hr at sea level. O.C.

A88-22743* McDonnell-Douglas Helicopter Co., Mesa, Ariz.
AH-64A SHAKE TEST AND CORRELATION WITH NASTRAN FINITE ELEMENT MODEL PREDICTIONS
MOSTAFA TOOSSI, FRIEDRICH STRAUB, RICHARD WEISENBURGER, and DOUGLAS FERG (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 197-204.
(Contract NAS1-17498)

A NASTRAN FEM code for the AH-64A helicopter airframe has been evaluated in light of suspended-fuselage shake tests that determined this aircraft's frequency-response characteristics at numerous measurement locations throughout the structure. Natural frequencies and mode shapes have been estimated from frequency-response data. On the basis of the correlation study results obtained, several modifications were made to the FEM model, yielding significant performance improvements. O.C.

A88-22744
STATISTICAL ANALYSIS OF STRUCTURAL FLIGHT TEST DATA
D. O. ADAMS (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 205-217.

This paper presents an improved method to extract dynamic component loads from a flight test data base for use in helicopter structural substantiations. Current Sikorsky methodology is to use the maximum recorded (high envelope) load for each flight regime from whatever flight test data is available. This load is then assumed to occur every time the particular regime is flown in service. This method is very conservative when a good sample of data is available, but can be unconservative when the data base is small. The improved method is based on a Weibull analysis of the available data and is illustrated with examples from several flight test programs. The method provides a rational means for choosing a 'high envelope' load not biased by the size of the test data sample and for 'gap filling' and trending a flight test data base. In addition, the Weibull loads distribution obtained can be used in probabilistic approaches to structural substantiation. Author

A88-22745
ACTIVE VIBRATION CONTROL OF THE RSRA/X-WING VEHICLE USING A TIME DOMAIN APPROACH
RONALD W. DU VAL and HOSSEIN-ALI SABERI (Advanced Rotorcraft Technology, Inc., Mountain View, CA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 221-230. refs

The strong vibration environment of the RSRA/X-wing vehicle necessitates effective vibration suppression in both steady state and dynamic flight conditions. The circulation control system to be utilized on this vehicle provides a unique mechanism for vibration suppression. This presentation describes an active controller based on time domain feedback that utilizes multicyclic blowing, although the concept is also readily applied to conventional swashplate control. The concept and design procedure are presented and the results of closed-loop computer runs using an aeroelastic simulation of the X-wing rotor are shown. Author

A88-22746
SIMULATION AND CORRELATION OF A HELICOPTER AIR-OIL STRUT DYNAMIC RESPONSE
WILLIAM A. WELSH (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 231-242. refs

A simple dynamic model of a typical air-oil landing gear (oleo) is described which encompasses several degrees of freedom representing the tire, floating piston, orifice piston, and simple fluid and adiabatic gas models. A series of simulation results provide correlation for overall oleo properties, such as ground resonance damping and impact response. The orifice-instability phenomenon observed during full-scale testing is also predicted; this response is characterized by large-amplitude limit cycle oscillations of the ground resonance metering orifice, causing an audible chattering noise during slow compression of the oleo. B.J.

A88-22747* McDonnell-Douglas Helicopter Co., Mesa, Ariz.
APPLICATION OF A COMPREHENSIVE ANALYTICAL MODEL OF ROTORCRAFT AERODYNAMICS AND DYNAMICS (CAMRAD) TO THE MCDONNELL DOUGLAS AH-64A HELICOPTER
C. CALLAHAN and D. BASSETT (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 243-256. NASA-supported research. refs

CAMRAD results on main rotor blade natural frequency and structural loads predictions are compared to flight test data and predictions of the Dynamic Analysis Research Tool (DART) and the Rotor/Airframe Comprehensive Aeroelastic Program (RACAP). Consideration is also given to the effects of various analytical options available in CAMRAD including dynamic stall, wake modeling, and the number of bending and torsion degrees of freedom included in the structural analysis. It is concluded that, while several modeling limitations are identified in the CAMRAD structural analyses, the structural loads predictions are as accurate as analysis codes which provide more representative models of the complex geometries and structures of the AH-64A rotor system. However, it is noted that the CAMRAD analysis cannot be considered fully reliable for dynamic predictions for more advanced bearingless rotor designs being proposed for future AH-64 configurations. B.J.

A88-22748* Maryland Univ., College Park.
AEROELASTIC MODELING OF SWEPT TIP ROTOR BLADES USING FINITE ELEMENTS
R. CELI (Maryland, University, College Park) and P. P. FRIEDMANN (California, University, Los Angeles) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 257-269. refs
(Contract NAG2-226)

A special finite element for the modeling of a swept tip rotor blade is derived. The swept tip blade undergoes moderate deflections in flap, lag and torsion. The nonlinear, partial differential equations of motion are discretized using a Galerkin finite element method. Tip sweep introduces flap-torsion and lag-axial couplings, and may lead to aeroelastic instabilities associated with frequency coalescence. When frequency coalescence does not occur, sweep is usually stabilizing. A comparison of the approximate model of a swept tip blade, using a blade with straight elastic axis and offsets of aerodynamic centers of gravity, with the exact swept tip model developed in this paper indicates that the approximate model can produce inaccurate results for the case of hingeless rotor blades. Author

A88-22749
V-22 DEVELOPMENT STATUS
STANLEY MARTIN, JR. (Bell Helicopter Textron, Inc., Fort Worth, TX), ALLEN H. SCHOEN (Boeing Vertol Co., Philadelphia, PA), and ROGER VEHORN (U.S. Navy, Naval Air Systems Command, Washington, DC) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 292-300.

The V-22 rotorcraft is being developed to meet the following JSOR requirements: hover on a hot day at high altitudes with 8300 lbs of payload; fly at 250 knots continuous cruise speed with a maximum speed of at least 275 knots; carry 24 troops plus a crew of 3 on a 200 nautical mile radius combat mission; self-deploy without in-flight refueling anywhere in the world; and have high maneuverability for evasive action during low-speed NOE flight and at high-speed cruise. This paper reviews the preliminary design phase, the current status (major bench and rig tests), and the V-22 benefit and emerging requirements. B.J.

A88-22750
ROTOR AERODYNAMIC OPTIMIZATION FOR HIGH SPEED TILTROTORS
DAVID J. PAISLEY (Boeing Vertol Co., Philadelphia, PA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 301-310.

This paper investigates the feasibility of aerodynamically designing a proprotor suitable for use on a high speed tiltrotor. A high speed tiltrotor requiremment is proposed from which baseline aircraft and rotor designs are derived. Variations of rotor geometry from the baseline are made to assess the effect of each geometric parameter. A rotor design is then derived from this data, which optimizes cruise performance without reducing hover performance. The aircraft is resized using this optimized design. The cruise performance improvement produces significant reductions in aircraft weight and cost. Author

A88-22752* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
REDUCTION OF HUB- AND PYLON-FAIRING DRAG
LARRY A. YOUNG, DAVID R. GRAHAM, ROBERT H. STROUB (NASA, Ames Research Center, Moffett Field, CA), and ALEXANDER W. LOUIE (Sterling Software, Inc., Palo Alto, CA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 323-344.

A wind tunnel test was conducted to obtain data on several drag reduction methods for rotorcraft hubs. The objective of the test was to use small-scale models to develop the technology to substantially reduce hub drag. A helicopter test model, which did not incorporate a rotor, was used to study single-rotor fairing configurations. The rotor shaft assembly was modeled with nonrotating hardware. Drag trend data was obtained for the following fairing configuration changes: hub-fairing camber, hub-fairing thickness ratio, hub-fairing surface curvature, hub-fairing height with respect to the fuselage, inclusion of blade shanks in the hub fairings, hub- and pylon-fairing gaps, pylon-fairing cross-sectional geometry, pylon-fairing thickness ratio and camber. Substantial drag reductions could potentially result from application of the test results to helicopter hub- and pylon-fairing design. Author

A88-22753
ROTOR PERFORMANCE OPTIMIZATION FOR FUTURE LIGHT HELICOPTERS
SHANTHA KUMAR and DUANE BASSETT (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 345-355. Research supported by McDonnell Douglas Internal Research and Development Funds. refs

A comprehensive rotor performance optimization analysis that is currently in use is presented. In this optimization analysis, the rotor blade chord, twist, and sweep distributions are varied to minimize rotor horsepower for a combination of hover and forward flight conditions. The optimal blade geometry obtained resulted in a net reduction of 8-12 percent in the main rotor horsepower for all the flight conditions considered. This saving in rotor horsepower can be translated into a similar percentage savings in fuel or increase in payload in hover. The optimized rotor blade geometry was achieved in a fraction of the time needed for conventional parametric studies which are labor-intensive. This can have a beneficial effect on the design scheduling of the project. Author

A88-22761* Sikorsky Aircraft, Stratford, Conn.
TREATED CABIN ACOUSTIC PREDICTION USING STATISTICAL ENERGY ANALYSIS
CHARLES A. YOERKIE, STEVEN T. INGRAHAM (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT), and JAMES A. MOORE (Cambridge Collaborative, Inc., MA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 461-468. refs
(Contract NAS1-16932)

The application of statistical energy analysis (SEA) to the modeling and design of helicopter cabin interior noise control treatment is demonstrated. The information presented here is obtained from work sponsored at NASA Langley for the development of analytic modeling techniques and the basic understanding of cabin noise. Utility and executive interior models are developed directly from existing S-76 aircraft designs. The relative importance of panel transmission loss (TL), acoustic leakage, and absorption to the control of cabin noise is shown using the SEA modeling parameters. It is shown that the major cabin noise improvement below 1000 Hz comes from increased panel TL, while above 1000 Hz it comes from reduced acoustic leakage and increased absorption in the cabin and overhead cavities. B.J.

A88-22762* Societe Nationale Industrielle Aerospatiale, Marignane (France).
PREDICTION OF SA 349/2 GV BLADE LOADS IN HIGH SPEED FLIGHT USING SEVERAL ROTOR ANALYSES
MICHEL GAUBERT (Aerospatiale, Division Helicopteres, Marignane, France) and GLORIA K. YAMAUCHI (NASA, Ames Research Center, Moffett Field, CA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 481-499. refs

The influence of blade dynamics, dynamic stall, and transonic aerodynamics on the predictions of rotor loads in high-speed flight are presented. Data were obtained from an Aerospatiale Gazelle SA 349/2 helicopter with three Grande Vitesse blades. Several analyses are used for this investigation. First, blade dynamics effects on the correlation are studied using three rotor analyses which differ mainly in the method of calculating the blade elastic response. Next, an ONERA dynamic stall model is used to predict retreating blade stall. Finally, advancing blade aerodynamic loads are calculated using a NASA-developed rotorcraft analysis coupled with two transonic finite-difference analyses. Author

A88-22764
COMPARISON OF BLACK HAWK SHAKE TEST RESULTS WITH NASTRAN FINITE ELEMENT ANALYSIS
JASON A. DURNO, GUY R. HOWLAND, and WILLIAM J. TWOMEY (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 511-526.

An extensive ground vibration test of the UH-60A helicopter has been conducted and the test data have been compared with analytical results from an improved finite element model. The shake test results have been used to verify the NASTRAN model using improved modal testing and comparison techniques. The finite element model is to be used for predicting rotorcraft vibrations and changes in vibratory characteristics caused by changes in

the structure. Two aircraft configurations were tested: an empty weight baseline configuration and a full fuel with cargo configuration. Over 130 response measurements were obtained for each of three independent excitations at the main rotor head. Advanced software allows for on-site data quality monitoring. Single-DOF and multi-DOF curve-fitting techniques have been used for accurate model parameter extraction. Frequency response functions and mode shapes have been compared with NASTRAN. The nonlinear behavior of the structure was investigated. Correlation of the modal parameters and frequency response has been significantly improved over previous efforts. Author

A88-22765
DYNAMIC TUNING OF THE SH-2F COMPOSITE MAIN ROTOR BLADE
FU-SHANG WEI and ROBERT JONES (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 527-537. refs

The composite main rotor blade (CMRB) vibration reduction flight tests for the SH-2F helicopter were successfully conducted at Kaman Aerospace Test Center using blade ballast tuning weight techniques. Prior to the flight tests, both CMRB and metal blades were shake tested and whirl tested to obtain blade nonrotating and rotating natural frequencies. During the whirl test, the CMRB aeroelastic stability boundaries were demonstrated to be comparable to those of the metal blade. Four different blade ballast configurations, combined with three root end index angle changes, were investigated during the development flight testing. Low vibration levels were achieved due to cancellation of blade intermodal forces via proper ballast configuration and root-end index angle. The total test period to accomplish the vibration reduction task was less than two months. Author

A88-22766* Military Academy, West Point, N. Y.
AEROELASTIC STABILITY OF BEARINGLESS ROTORS IN FORWARD FLIGHT
ANDREW L. DULL (U.S. Army, Military Academy, West Point, NY) and INDERJIT CHOPRA (Maryland, University, College Park) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 539-552A. refs
(Contract DAAG29-83-K-0002; NAG2-409)

The finite element method was used to determine the dynamic stability of bearingless rotor blades (BR) in forward flight. The analysis was applied to four different BR configurations and the results were correlated with experimental data. The analysis was correlated with hover lag mode stability data for a simple three-blade BR rotor tested in various pitch link configurations. In addition, a more advanced BR which includes precone, blade twist, blade sweep, and a lag shear restraint is analyzed and compared to experimental data in both hover and forward flight. B.J.

A88-22782
DEVELOPMENT OF AN ADVANCED PNEUMATIC DE-ICING SYSTEM
DAVE SWEET (BF Goodrich Co., Aerospace and Defense Div., Uniontown, OH) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 747-763.

The paper describes a deicing system whose main component is a 0.085-inch-thick externally mounted deicer. The deicer is pneumatic in operation, contains a metallic surface ply, and inflates very rapidly, within 10 millisec. The inflation process generates a rapid surface distortion which has proved effective in removing ice layers as thin as 0.030 inch. The system is specifically being developed for a fixed wing commercial aircraft aplication, but future application to rotorcraft including rotor blades is envisaged. B.J.

A88-22783* Texas A&M Univ., College Station.
MODEL HELICOPTER PERFORMANCE DEGRADATION WITH SIMULATED ICE SHAPES
ANA F. TINETTI and KENNETH D. KORKAN (Texas A & M University, College Station) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 765-780. refs
(Contract NAG3-626)

An experimental program using a commercially available model helicopter has been conducted in the Texas A&M University Subsonic Wind Tunnel to investigate main rotor performance degradation due to generic ice. The simulated ice, including both primary and secondary formations, was scaled by chord from previously documented artificial ice accretions. Base and iced performance data were gathered as functions of fuselage incidence, blade collective pitch, main rotor rotational velocity, and freestream velocity. It was observed that the presence of simulated ice tends to decrease the lift to equivalent drag ratio, as well as thrust coefficient for the range of velocity ratios tested. Also, increases in torque coefficient due to the generic ice formations were observed. Evaluation of the data has indicated that the addition of roughness due to secondary ice formations is crucial for proper evaluation of the degradation in main rotor performance. Author

A88-22796
ROTORCRAFT VIBRATION CRITERIA - A NEW PERSPECTIVE
SAM T. CREWS (U.S. Army, Aviation Systems Command, Saint Louis, MO) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 991-998. refs

Experience gained in recent rotorcraft development and production contracts has proven the need for improved rotorcraft development standards for vibration. A new Aeronautical Design Standard for vibration was subsequently developed by AVSCOM. The important criteria is described and justification for that criteria is included herein. Also recommended research for further improvement in that criteria is presented. Author

A88-22797
STRUCTURAL TECHNOLOGY ADVANCEMENTS FOR ROTORCRAFT
WOLF ELBER, FELTON D. BARTLETT, JR., and DANNY E. GOOD (U.S. Army, Aviation Research and Technology Activity, Hampton, VA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 999-1009.

Emerging technologies for the development of high strength composites (to minimize structural weight) and for the prediction and reduction of vibration are discussed, with application to the production of lighter, safer, and more cost-effective structures for rotorcraft. Issues involved in the manufacture, inspection, and durability of composites are considered, with special attention being given to the materials used in the Advanced Composite Airframe Program. Flight tests have demonstrated the achievement of low vibration levels through passive rotor design. The application of airframe finite-element analyses and total or 6-DOF main rotor isolation for vibration control is also considered. R.R.

A88-22803
RECENT INVESTIGATIONS IN TILT ROTOR FLIGHT TECHNOLOGY THROUGH XV-15 FLIGHT TESTING
ROSS P. MENGER and CHARLES B. HOGG (Bell Helicopter Textron, Inc., Fort Worth, TX) AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Paper. 17 p. refs

Series of flights were conducted on the XV-15 tilt rotor aircraft to investigate the lateral-directional stability, performance in sideward flight, level flight performance, and precision speed control. In each case, correlation of flight test results with the Generic Tilt Rotor (GTR) flight simulation model of Batra et al. (1986) is presented. The comparison between the simulation and flight tests was used to improve the model and to validate test results and modeling accuracies. I.S.

A88-23062
THE STATE OF THE ART - FLIGHT TEST - AIRBUS A320
HARRY HOPKINS Flight International (ISSN 0015-3710), vol. 132, Dec. 12, 1987, p. 23-27.

The A320 is the first fully fly-by-wire aircraft, and is accordingly engaged in pathbreaking development of appropriate airworthiness requirements. The A320 cockpit is dominated by side-by-side primary flight displays and navigation displays; sidestick flight control removes any obstruction to viewing the CRT flight instrument displays. The elimination of static stability in the airliner's advanced control logic has demanded speed and altitude protection. Full-authority digital engine control is also used. O.C.

A88-23189#
A STUDY ON EFFECTS OF AIRCRAFT NOISE ENVIRONMENT ON ITS STRUCTURE
SHIJIAN FU (Nanchang Aircraft Manufacturing Co., People's Republic fo China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Aug. 1987, p. B355-B361. In Chinese, with abstract in English.

This paper reports on some measurements of the noise environment at various aircraft service states. The obtained acoustic loading distribution and frequency spectra of the structure are presented, and a preliminary analysis is made of the factors affecting the magnitude of the relevant parameters and the acoustic vibration response characteristics of the structure. Acoustic loading spectra are summarized, and the method used to construct them is described in detail. The method used to detect acoustic fatigue is introduced along with the principles used to select parameters by testing on a full-scale fuselage inlet. Recommendations for analyzing and remedying acoustic fatigue troubles are made. A data base and a practical example for investigating the acoustic fatigue mechanism, the response characteristics of structures to acoustic loading, and a control method for preventing acoustic fatigue failure are presented. C.D.

A88-23200#
AN OPTIMUM METHOD FOR EXTRACTING THE AERODYNAMIC DERIVATIVES FROM FLIGHT TEST DATA FOR A HELICOPTER
SONGSHAN YANG (Flight Test Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Sept. 1987, p. A432-A438. In Chinese, with abstract in English.

This paper describes a method for extracting the aerodynamic derivatives of a helicopter from flight-test data by means of the frequency technique, Kalman filtering, and the Bayesian maximum-likelihood technique. In this method, the high-frequency effects from the rotor are eliminated using the frequency technique; the random noise can be reduced considerably using the Kalman filter; and the maximum likelihood technique minimizes the random noise and extracts the final derivatives. By using this method the bias error can be minimized. The results show that the multiple correlation coefficient would approach 1.0, and latent roots would approach true values. The results also show that the present method is more accurate than any other techniques (for example, the least-squares technique, the frequency technique, Kalman filtering, improved Kalman filtering, or the maximum-likelihood technique). Author

A88-23211#
DETERMINATION OF MAIN PARAMETERS OF A RETRACTABLE LANDING GEAR FOR MODERN HIGH PERFORMANCE AIRCRAFT
GUOZHU YANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Oct. 1987, p. A459-B466. In Chinese, with abstract in English. refs

A simple and convenient method is presented in this paper to determine the pivoting direction, the angle of rotation of the landing gear from its down to up position, and the angle of rotation of the wheel axis. In addition, vector analysis is applied to elucidate the relationship between the individual rigid body components of spatial configurations, and the rotation matrix is obtained mainly by the use of coordinate transformation. The method described is suitable for computer computation. Author

A88-23215#
APPLICATION OF THE OPTIMAL METHOD ON AIR-CONDITIONING SYSTEM DESIGN
HUISHAN HE (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Oct. 1987, p. B488-B495. In Chinese, with abstract in English. refs

An application of optimal design to an air-conditioning system for a fighter cabin is studied. As an example, a turbine-fan cooling system is considered. In the analysis, aircraft penalty expressed by additional fuel weight resulting from the system is taken as an object function, provided that the comfort requirements of the pilot are satisfied. Empirical formulas obtained from a test study of the heat load and air distribution for a cabin are adopted. The selection of the air conditioning system parameters is optimized. The computational results show that the mathematical model and the Sequential Unconstrained Minimization Technique and the Simplex Method adopted here are suitable for the optimal design of the air-conditioning system. C.D.

A88-23261
A COMPUTER AIDED DESIGN SYSTEM FOR AIRPLANE CONFIGURATION
C. L. BRITTON (Boeing Computer Services Co., Seattle, WA) and W. W. JENKINSON (Boeing Commercial Airplane Co., Seattle, WA) IN: Computer applications in aircraft design and operation; Proceedings of the First International Conference on Computer Aided Design, Manufacture and Operation in the Aeronautics and Space Industries, Paris, France, June 16-18, 1987 . Billerica, MA, Computational Mechanics Publications, 1987, p. 15-27.

The Configuration Design Computing System (CDCS), a CAD system developed specifically for aircraft design, is described. Instead of 'drawing' the design, the user enters parametric information about the design, and CDCS produces a dimensioned, annotated drawing from this information. CDCS 'remembers' how the user created this design, so that when modifications need to be made, the user need only change a few parametric values and the system then automatically modifies all other dependent parts of the design. In this paper, the key features of the CDCS and the system's use are described. Its differences from other CAD systems are pointed out, and the design and implementation of the system are discussed. The current status of system development and plans for future enhancements are addressed. C.D.

A88-23267
COMPUTER-AIDED FLIGHT ENVELOPE EXPANSION FOR AN ADVANCED TECHNOLOGY FIGHTER
J. F. ELLIOTT (British Aerospace, PLC, Warton Div., Preston, England) IN: Computer applications in aircraft design and operation; Proceedings of the First International Conference on Computer Aided Design, Manufacture and Operation in the Aeronautics and Space Industries, Paris, France, June 16-18, 1987 . Billerica, MA, Computational Mechanics Publications, 1987, p. 107-120.

A ground-based, near-real time computation system is described which allows rapid and safe expansion of an aircraft's maneuvering flight envelope. In the system, existing computational tools are linked to the aircraft in flight with the design engineers in the loop. The system has allowed low-altitude aerobatic maneuvers to be demonstrated on a completely new airframe within two weeks of the first flight. C.D.

A88-23271
COMPUTER AIDED DESIGN AND MANUFACTURE OF AIRCRAFT ENGINE STRUT STRUCTURE
W. A. CREEL (Boeing Commercial Airplane Co., Seattle, WA) IN: Computer applications in aircraft design and operation; Proceedings of the First International Conference on Computer Aided Design, Manufacture and Operation in the Aeronautics and Space Industries, Paris, France, June 16-18, 1987 . Billerica, MA, Computational Mechanics Publications, 1987, p. 177-193.

The use of CAD/CAM to design and build engine strut structures is discussed. CAD/CAM applications in the 757 and 767 aircraft are reviewed, and the application of CAD/CAM to the CF6-80C strut is addressed, discussing the dataset flow and the method of fabrication. The benefits of a 100 percent CAD/CAM program are considered, and the lessons learned and applied to other programs are discussed. C.D.

A88-23274
PROGRESS TOWARDS AN AIRCRAFT DESIGN EXPERT SYSTEM
J. ALSINA, J. P. FIELDING, and A. J. MORRIS (Cranfield Institute of Technology, England) IN: Computer applications in aircraft design and operation; Proceedings of the First International Conference on Computer Aided Design, Manufacture and Operation in the Aeronautics and Space Industries, Paris, France, June 16-18, 1987 . Billerica, MA, Computational Mechanics Publications, 1987, p. 229-247. refs

A two-pass approach to the development of an expert system for aircraft design is described. The first pass, involving the creation of a wing design program, is described together with its implementation. The second pass, involving an aircraft configuration program, is discussed, identifying the sources and types of information used. Extensions of the system developed in the first pass are enumerated. C.D.

A88-23758
PROPELLER AIRCRAFT INTERIOR NOISE MODEL. I - ANALYTICAL MODEL
L. D. POPE, E. G. WILBY, and J. F. WILBY (BBN Laboratories, Canoga Park, CA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 118, Nov. 8, 1987, p. 449-467. refs

A basic propeller aircraft interior noise model is presented which allows prediction of tonal levels in the cabin of a propeller-driven airplane at the blade passage frequency and its harmonics. The present model requires a precise description of the propeller noise signature on the fuselage skin, and it includes the fuselage sidewall dynamic restraint offered by a structurally integral stiffened floor in a ring-stringer stiffened cabin shell. The acoustic modes of the complex cabin configuration may be used when practical. The sidewall trim properties are used to determine the cabin acoustic and perceived fuselage structural modal losses. R.R.

A88-23759* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PROPELLER AIRCRAFT INTERIOR NOISE MODEL. II - SCALE-MODEL AND FLIGHT-TEST COMPARISONS
C. M. WILLIS and W. H. MAYES (NASA, Langley Research Center, Hampton, VA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 118, Nov. 8, 1987, p. 469-493. refs

A program for predicting the sound levels inside propeller driven aircraft arising from sidewall transmission of airborne exterior noise is validated through comparisons of predictions with both scale-model test results and measurements obtained in flight tests on a turboprop aircraft. The program produced unbiased predictions for the case of the scale-model tests, with a standard deviation of errors of about 4 dB. For the case of the flight tests, the predictions revealed a bias of 2.62-4.28 dB (depending upon whether or not the data for the fourth harmonic were included) and the standard deviation of the errors ranged between 2.43 and 4.12 dB. The analytical model is shown to be capable of taking changes in the flight environment into account. R.R.

A88-23994
THE SUPERSONIC FLYING WING
ROBERT T. JONES Aerospace (UK) (ISSN 0305-0831), vol. 15, Jan. 1988, p. 8-11. refs

Due to automatic stability and aerodynamic advances, the oblique flying wing SST is reconsidered. With stability provided by a narrow trailing edge flap under computer control, a rearward limit for the center of gravity turns out to be 35 to 40 percent of the chord. Such a flap used in conjunction with a laser velocimeter can act to keep the lift force constant, smoothing out the effect of the gusts. It is shown that, according to the tests, the lift/drag ratio with the wing at 45 degrees was better than 20 at all Mach numbers below 1. The estimation of fuel consumption per passenger vs range for flying wing SST is discussed. A maximum gross weight of 775,000 lb and a payload of 300 passengers was assumed. During Mach 2 cruise at 60,000 ft, the conversion efficiency of the turbojets was calculated as 40 percent. It is concluded that a variable bypass engine can have an efficiency of perhaps 30 percent, during overland cruise at Mach 1. A.S.

A88-24122*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
EXPERIMENTAL INVESTIGATION OF ROTORCRAFT HUB AND SHAFT FAIRING DRAG REDUCTION
LARRY A. YOUNG, DAVID R. GRAHAM, and ROBERT H. STROUB (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 24, Dec. 1987, p. 861-867. Previously cited in issue 17, p. 2474, Accession no. A86-37814. refs

A88-24755
CONSTRUCTION OF INCOMPLETE MODELS OF AIRCRAFT STRUCTURES [POSTROENIE NEPOLNYKH MODELEI AVIATSIONNYKH KONSTRUKTSII]
V. P. BOL'SHAKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1987, p. 18-22. In Russian.

A method is proposed for constructing dynamic models with two and three degrees of freedom with respect to frequencies and modes of an oscillatory system with a large number of degrees of freedom. The method is based on the solution of the inverse oscillation problem. The approach proposed here is illustrated by examples. V.L.

A88-24761
SYNTHESIS OF LOCAL OPTIMUM CONTROL FOR ELASTIC AIRCRAFT [SINTEZ LOKAL'NO-OPTIMAL'NOGO UPRAVLENIIA UPRUGIMI LETATEL'NYMI APPARATAMI]
G. L. DEGTIAREV, V. V. KONDRAT'EV, and V. A. RAEVSKII Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1987, p. 43-46. In Russian.

A computationally simple method is proposed for calculating the matrix coefficients of the gain of local optimal control and the Luenberger observer that would provide for the required stability margin of a closed-loop system. Control algorithms, that have been synthesized by the approach proposed here, are demonstrated for an aircraft carrying a large elastic antenna. V.L.

A88-24763
THE POSSIBILITY OF ASSURING A SPECIFIED FLIGHT SAFETY LEVEL THROUGH REDUNDANCY IN AIRCRAFT SYSTEMS [O VOZMOZHNOSTI OBESPECHENIIA ZADANNOGO UROVNIA BEZOPASNOSTI POLETOV REZERVIROVANIEM SAMOLETNYKH SISTEM]
G. N. KOTEL'NIKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1987, p. 50-55. In Russian. refs

A solution is presented for the problem of assuring a specified flight safety level through redundancy in individual aircraft systems designed for counteracting the effects of failures. The problem is solved using the method of discrete dynamic programming. An analytical criterion for estimating the flight safety level is derived. V.L.

A88-24767
EVALUATION OF THE RELIABILITY OF AIRCRAFT SYSTEMS FROM RESULTS OF TESTS OF PROGRESSIVELY INCREASING SEVERITY [OTSENKA BEZOTKAZNOSTI AGREGATOV LETATEL'NYKH APPARATOV PO REZUL'TATAM POSLEDOVATEL'NO FORSIRUEMYKH ISPTANII]
V. P. SAVCHUK and V. B. CHERNIAVSKII Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1987, p. 68-71. In Russian. refs

A method for assessing reliability indices is proposed which is based on using tests of progressively increasing severity and on the availability of a priori information. The method uses the Bayes approach to statistical conclusions. The advantages of the reliability evaluation procedure proposed here are demonstrated using a numerical example. V.L.

N88-14930*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATION OF A FULL POTENTIAL METHOD FOR ANALYSIS OF COMPLEX AIRCRAFT GEOMETRIES
KENNETH M. JONES and NOEL A. TALCOTT, JR. *In its* Langley Symposium on Aerodynamics, Volume 1 p 73-87 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 01C

A supersonic potential flow solver was developed to analyze the flow over complex realistic aircraft geometries. Enhancements to the method were made to accommodate regions of subsonic flow, the effect of trailing wakes on other aircraft components, and the modeling/gridding of complete configurations. Validation of the method was demonstrated by comparisons with experimental aerodynamic force and surface pressure measurements. The predicted results are in very good agreement with the experimental data. The bibliography contains additional information on the use of the potential flow code to predict the aerodynamics of high-speed wing/body configurations, waverider concepts, TAV, and the Space Shuttle orbiter package. Author

N88-14949*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NATURAL LAMINAR FLOW NACELLE FOR TRANSPORT AIRCRAFT
MILTON LAMB, WILLIAM K. ABEYOUNIS, JAMES C. PATTERSON, JR., and RICHARD J. RE *In its* Langley Symposium on Aerodynamics, Volume 1 p 445-460 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 01C

The potential of laminar flow nacelles for reducing installed engine/nacelle drag was studied. The purpose was twofold: to experimentally verify a method for designing laminar flow nacelles and to determine the effect of installation on the extent of laminar flow on the nacelle and on the nacelle pressure distributions. The results of the isolated nacelle tests illustrated that laminar flow could be maintained over the desired length. Installing the nacelles on wing/pylon did not alter the extent of laminar flow occurring on the nacelles. The results illustrated that a significant drag reduction was achieved with this laminar flow design. Further drag reduction could be obtained with proper nacelle location and pylon contouring. B.G.

N88-14951*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN AND EXPERIMENTAL EVALUATION OF A SWEPT SUPERCRITICAL LAMINAR FLOW CONTROL (LFC) AIRFOIL
W. D. HARVEY, C. D. HARRIS, C. W. BROOKS, P. G. CLUKEY, and J. P. STACK *In its* Langley Symposium on Aerodynamics, Volume 1 p 475-484 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 01C

A large chord swept supercritical laminar flow control (LFC) airfoil was designed, constructed, and tested in the NASA Langley 8-ft Transonic Pressure Tunnel (TPT). The LFC airfoil experiment was established to provide basic information concerning the design and compatibility of high-performance supercritical airfoils with suction boundary layer control achieved through discrete fine slots or porous surface concepts. It was aimed at validating prediction techniques and establishing a technology base for future transport designs and drag reduction. Good agreement was obtained between measured and theoretically designed shockless pressure distributions. Suction laminarization was maintained over an extensive supercritical zone up to high Reynolds numbers before transition gradually moved forward. Full-chord laminar flow was maintained on the upper and lower surfaces at M sub infinity = 0.82 up to R sub c is less than or equal to 12 x 10 to the 6th power. When accounting for both the suction and wake drag, the total drag could be reducted by at least one-half of that for an equivalent turbulent airfoil. Specific objectives for the LFC experiment are given. Author

N88-14954*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INSECT CONTAMINATION PROTECTION FOR LAMINAR FLOW SURFACES
CYNTHIA C. CROOM and BRUCE J. HOLMES *In its* Langley Symposium on Aerodynamics, Volume 1 p 539-556 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 01C

The ability of modern aircraft surfaces to achieve laminar flow was well-accepted in recent years. Obtaining the maximum benefit of laminar flow for aircraft drag reduction requires maintaining minimum leading-edge contamination. Previously proposed insect contamination prevention methods have proved impractical due to cost, weight, or inconvenience. Past work has shown that insects will not adhere to water-wetted surfaces, but the large volumes of water required for protection rendered such a system impractical. The results of a flight experiment conducted by NASA to evaluate the performance of a porous leading-edge fluid discharge ice protection system operated as an insect contamination protections system are presented. In addition, these flights explored the environmental and atmospheric conditions most suitable for insect accumulation. Author

N88-14955*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RIBLETS FOR AIRCRAFT SKIN-FRICTION REDUCTION
MICHAEL J. WALSH *In its* Langley Symposium on Aerodynamics, Volume 1 p 557-571 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 01C

Energy conservation and aerodynamic efficiency are the driving forces behind research into methods to reduce turbulent skin friction drag on aircraft fuselages. Fuselage skin friction reductions as small as 10 percent provide the potential for a 250 million dollar per year fuel savings for the commercial airline fleet. One passive drag reduction concept which is relatively simple to implement and retrofit is that of longitudinally grooved surfaces aligned with the stream velocity. These grooves (riblets) have heights and spacings on the order of the turbulent wall streak and burst dimensions. The riblet performance (8 percent net drag reduction thus far), sensitivity to operational/application considerations such as yaw and Reynolds number variation, an alternative fabrication technique, results of extensive parametric experiments for geometrical optimization, and flight test applications are summarized. Author

N88-14956*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AIRFOIL LARGE EDDY BREAKUP DEVICES FOR TURBULENT DRAG REDUCTION
J. B. ANDERS *In its* Langley Symposium on Aerodynamics, Volume 1 p 573-585 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 01C

It was determined from the present LaRC experiments that tandem, airfoil-shaped large eddy breakup (LEBU) devices can reduce local skin friction as much as 30 percent with a recovery region extending more than 100 boundary layer thicknesses downstream. These airfoils experience near laminar skin friction device drag and produce net drag reductions of up to 7 percent. In contrast to the thin plates used in previous experiments, these airfoils are more than 1000 time stiffer and hence have the potential to withstand the real flight environment (dynamic pressure 36 times larger than in low-speed wing tunnels). In addition, the higher Reynolds numbers of the present tests indicate drag reduction

performance is at least as good (or better) as at lower Reynolds numbers. Author

N88-14979# Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
FLAPS-UP TAKOFF PERFORMANCE OF THE OV-1D AIRCRAFT WITH YT53-L-704 ENGINE INSTALLED Final Report, 9 Feb. 1986 - 3 Feb. 1987
JOSEPH C. MIESS, GEORGE M. YAMAKAWA, JEFFREY L. LINEHAN, and ROBERT D. ROBBINS May 1987 69 p
(AD-A185960; AD-F000114) Avail: NTIS HC A04/MF A01
CSCL 01B

The flaps-up procedure eliminates the portion of the takeoff profile where the aircraft cannot accelerate because the flaps are down and the flaps cannot be retracted because the airspeed is below flaps-up minimum control speed. Flaps-up procedures avoided the temporary altitude loss which occurred with the flaps-15 takeoff procedure when the flaps were retracted at high gross weight/density altitude conditions. Flaps-up takeoffs should be incorporated into operational unit procedures. Accelerate-stop distance using wheel brakes only was excessive. The brakes became overheated and ineffective. Ineffectiveness of the OV/RV-1D wheel brake system is a deficiency. A procedure using aerodynamic braking with speed brakes and a flaps-45 setting was developed and used effectively to slow the aircraft until elevator effectiveness was lost, then wheel brakes were used to bring the aircraft to a stop. The aerodynamic braking procedure should be incorporated into the Aircrew Training Manual program. An anti-skid wheel brake system should be incorporated on the OV/RV-1D aircraft. Single-engine ground minimum control speed (v sub meg) was 55 knots indicated airspeed (KIAS) for flaps-up and 50 KIAS for flaps-15. OV-1D V (sub meg) characteristics are satisfactory. GRA

N88-14980# Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
PRELIMINARY AIRWORTHINESS EVALUATION OF A UH-1 EQUIPPED WITH A TERRAIN MAPPING RECEIVER ANTENNA Final Report
FREDERICK W. STELLAR, JAMES D. BROWN, and CHRISTOPHER P. BUTLER Feb. 1987 38 p
(AD-A186274; USAAEFA-86-20) Avail: NTIS HC A03/MF A01
CSCL 17I

The preliminary airworthiness evaluation of the UH-1H helicopter equipped with the receiver antenna of the Terrain Mapping Radar System was conducted in Lakehurst, New Jersey, between 21 November and 8 December 1986. The evaluation required 12 flights for a total of 14.8 hours, or which 12.0 hours were productive. Performance, handling qualities, and structural dynamic response tests were conducted. The modified UH-1H equipped with the receiver antenna demonstrated adequate handling qualities for the terrain mapping mission. However, the proposed mission profile requires extensive operation of the helicopter in an out-of-ground effect (OGE) hover. Although the handling qualities are acceptable, the degraded autorotational characteristics may preclude a safe autorotational landing in the event of a sudden engine failure at an OGE hover below 1000 feet above ground level. The minimum directional control margin and high pilot workload to maintain heading during low speed flight were a shortcoming. Three additional shortcomings were found during the evaluation. GRA

N88-15784# Naval Postgraduate School, Monterey, Calif.
A DYNAMIC SIMULATION AND FEEDBACK CONTROL SCHEME FOR THE U.S. MARINE CORPS' AIRBORNE REMOTELY OPERATED DEVICE (AROD) M.S. Thesis
WILLIAM G. BASSETT Sep. 1987 166 p
(AD-A186597) Avail: NTIS HC A08/MF A01 CSCL 01C

The equations of motion for a ducted fan hovering device are developed and programmed in a computer simulation. Experimental aerodynamic data is integrated with the computer model. A feedback control scheme for the multiple-input, multiple-output system is determined using optimal control techniques. Time response results are obtained and analyzed. As a separate issue, the body of the device is modelled for electro-magnetic analysis and a basic radio antenna design is determined for UHF transmission. GRA

N88-15811*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH-SPEED INLET RESEARCH PROGRAM AND SUPPORTING ANALYSES
ROBERT E. COLTRIN *In its* Aeropropulsion '87. Session 6: High-Speed Propulsion Technology 20 p Nov. 1987
Avail: NTIS HC A06/MF A01 CSCL 01C

A Mach 5 cruise aircraft was studied in a joint program effort. The propulsion system chosen for this aircraft was an over-under turbojet/ramjet system. The ramjet portion of the inlet is to be tested in NASA Lewis' 10 x 10 SWT. Goals of the test program are to obtain performance data and bleed requirements, and also to obtain analysis code validation data. Supporting analysis of the inlet using a three-dimensional Navier-Stokes code (PEPSIS) indicates that sidewall shock/boundary layer interactions cause large separated regions in the corners underneath the cowl. Such separations generally lead to inlet unstart, and are thus a major concern. As a result of the analysis, additional bleed regions were added to the inlet model sidewalls and cowl to control separations in the corners. A two-dimensional analysis incorporating bleed on the ramp is also presented. Supporting experiments for the Mach 5 programs were conducted in the Lewis' 1 x 1 SWT. A small-scale model representing the inlet geometry up to the ramp shoulder and cowl lip was tested to verify the accelerator plate test technique and to obtain data on flow migration in the ramp and sidewall boundary layers. Another study explored several ramp bleed configurations to control boundary layer separations in that region. Design of a two-dimensional Mach 5 cruise inlet represents several major challenges including multimode operation and dual flow, high temperatures, and three-dimensional airflow effects. Author

N88-16051# Sandia National Labs., Albuquerque, N. Mex.
ANALYSIS OF SHOCK AND VIBRATION ENVIRONMENTS FOR CARGO ON C9B TRANSPORT AIRCRAFT
THOMAS J. BACA, JAMES W. DOGGETT, and CLARENCE A. DAVIDSON *In* Shock and Vibration Information Center The Shock and Vibration Bulletin. Part 3: Isolation and Damping, Vibration Test Criteria and Vibration Analysis and Test p 133-146 Jan. 1987
(Contract DE-AC04-76DP-00789)
Avail: NTIS HC A10/MF A01 CSCL 01C

The definition of shock and vibration environments on the floor of cargo aircraft is of prime importance to designers of hardware which must be transported. The DOE/DOD Environmental Data Bank maintains an extensive collection of environmental definitions for aircraft. The process involved in acquiring and analyzing shock and vibration data on the cargo floor of a C9B turbojet for incorporation into the Environmental Data Bank is described. The dual objectives are to show the procedure by which the environmental definition is created and to compare the results with existing definitions of shock and vibration environments on fixed-wing aircraft. Special emphasis is placed on instrumentation considerations which help ensure data integrity. Computerized data analysis techniques are described which greatly expedite the analysis of voluminous amounts of shock and vibration data stored on a computer data base system. Included in these analyses are auto-spectral density estimates, shock response spectra, and a relatively new shock characteristic called the shock intensity spectra. The resulting environment definition for cargo transport on the C9B aircraft was significant because it revealed frequency ranges in which the C9B shock and vibration environments exceeded levels seen on other military transport aircraft. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A88-22570#
AN INTEGRATED NAVIER-STOKES AND WAVE OPTICS NUMERICAL SIMULATION TECHNIQUE FOR PREDICTING THE AERO-OPTICAL PERFORMANCE ABOUT SUBSONIC SURVEILLANCE AIRCRAFT
R. C. FARRIS and R. L. CLARK (Teledyne Brown Engineering, Huntsville, AL) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(Contract DASG60-84-C-0101)
(AIAA PAPER 88-0753)

A two-dimensional, fully compressible, Navier-Stokes Computational Fluid Dynamics (CFD) code is coupled with a Wave Optics (WO) propagation code to numerically predict the aerooptical performance of optical sensors located in open cavities onboard subsonic aircraft. The CFD code is used to define the aerodynamic flowfield surrounding the sensor installation. The WO code uses the time-averaged, spatially varying density fields computed by the CFD code to calculate the optical bias, blur, and Strehl ratio at the sensor focal plane caused by the presence of the turbulent aerodynamic flowfield in the sensor's field of view (FOV). Both codes are validated using aerooptical measurements made in a recent wind-tunnel test. The numerical results agree extremely well with experimental data. The validated codes are used to study the scaling effects associated with subscale ground testing and to analyze a full-scale flight test configuration for a variety of external flow conditions, sensor positions, sensor lines of sight (LOS), and cavity-blowing rates. The results of the parametric study indicate that the aerodynamic performance of the cavity and the aerooptical performance of the sensor in the cavity are both strong functions of the cavity-blowing rates and sensor LOS and weak functions of the external flow and the sensor position. Author

A88-22737
THE EFFECT OF SIMULATED HELICOPTER VIBRATION ON VOICE RECOGNITION SYSTEM PERFORMANCE
THOMAS W. DENNISON (Honeywell, Inc., Sperry Defense Systems Div., Albuquerque, NM) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 133-136. refs

The performance of a helicopter cockpit voice-recognition system may be substantially degraded when digital voice templates programmed in controlled ground conditions must recognize pilot vocal commands that are distorted by vehicle vibrations. A Cobra helicopter seat mounted on a vibrating platform has been used to vibrate 12 crewmen at three intensity levels for each of two frequencies simulating the 1/rev and 4/rev harmonics of a four-blade rotor system; a total of 50 words were tested by the crewmen against preprogrammed digital templates. No degradation of system performance was noted under any of the intensity/frequency conditions tested. O.C.

A88-22739
THE EH101 ELECTRONIC INSTRUMENT SYSTEM
KEITH ATKIN (Smiths Industries, PLC, Cheltenham, England) and JOHN REVELL (Westland Helicopters, Ltd., Yeovil, England) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 143-155.

This paper describes the background to the introduction of an Electronic Instrument System (EIS) on the Anglo/Italian EH101 helicopter. The demanded flexibility to accommodate the display needs of several roles leading logically to the adoption of full color multipurpose display surfaces and the drive to achieve maximum commonality between military and civil variants is discussed. The configurations arrived at for both variants are described together with the operating philosophy and display formats developed during an ongoing simulator program. The paper continues with a detailed description of the hardware implementation of the EIS including the fully integrated systems architecture and details of the symbol generators, display units and display mode selectors. Emphasis is placed on the robust integrity characteristics and reversionary switching philosophy of the system. Author

A88-22740
AUTOMATIC FLIGHT CONTROL SYSTEM FOR THE ANGLO-ITALIAN EH101 HELICOPTER
J. MEADOWS and G. R. PARR (Smiths Industries Aerospace and Defence Systems, Ltd., Cheltenham, England) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 157-169.

The Automatic Flight Control System incorporated by the EH101 military helicopter furnishes failure-survival autostabilization about the cyclic and yaw axes, together with a wide range of autopilot functions, on the basis of four microprocessors that are configured as two computer units with distributed processing functions in order to minimize the likelihood and consequences of common mode failures. Attention is given to such unique features of this system as memory protection and monitoring, and to the methodology being used by independent teams to furnish software. O.C.

A88-22779
DIAGNOSTIC MONITORING'S POTENTIAL IMPACT ON RELIABILITY AND PERFORMANCE
JAMES L. PETTIGREW (Howell Instruments, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 719-732. refs

Applications involving both military and civilian helicopters are examined in the light of the concept that the demonstrated ability to improve operational reliability is potentially essential to maximize flight safety and control operating costs. Based on the documented impact of engine monitoring and analysis of engine performance using EPAMS and PEATS, it is concluded that data from advanced technology digital acquisition and analysis methods provide a basis for the improved management of installed turbine engines. This enhanced ability to make better management decisions produces a more reliable power system with resulting lower operating costs and safer operation. B.J.

A88-23063
AVIONICS FOR GENERAL AVIATION
DON PARRY Flight International (ISSN 0015-3710), vol. 132, Dec. 12, 1987, p. 38-45.

A distinct trend is emerging in general aviation avionics applications towards improved flight safety. Turbulence-detection radar and lightning detection, which can give useful indications of turbulence, are noted to be increasingly available; it is now also possible for aircraft without radar to avoid severe weather, with NWS radar images covering about 200 miles from each transmitter being directly received by aircraft over a subcarrier of commercial radio stations. An additional trend is noted in the integration of displays and electronics for business aircraft, to form multifunction displays. O.C.

A88-23872
AVIONICS SYSTEMS IN CIVIL HELICOPTERS - CORPORATE OPERATOR'S VIEWPOINT
DAVID WARREN (Trafalgar House Helicopters, England) IN: Avionic systems for civil helicopters; Proceedings of the Symposium, London, England, Feb. 18, 1987 . London, Royal Aeronautical Society, 1987, p. 24-31.

Based on the corporate operator's point of view, various additions to avionic options have been suggested. These include an onboard component health monitoring system, a flight management computer, and datalink transmission of airfield information and weather data to be displayed on either radar or

EFIS screens. The need for an accurate and reliable icing indicator is discussed. K.K.

A88-23873
ADVANCED RADAR FOR CIVIL HELICOPTERS
GIOVANNI ABRATE (Allied-Signal, Inc., Bendix Avionics Div., Fort Lauderdale, FL) IN: Avionic systems for civil helicopters; Proceedings of the Symposium, London, England, Feb. 18, 1987 . London, Royal Aeronautical Society, 1987, p. 32-38.

Recent developments and the possible future evolution of civil helicopter radars are discussed with attention given to areas of product improvement in which considerable research and development funds are currently being invested. It is noted that current developments in displays move toward the integration of navigational and visual information with radar data, and the development of solid-state flat-panel raster-type displays. Recent developments in the areas of radar transmitter/receiver units, antennas, and monopulse and active arrays are described as well. K.K.

A88-23874
LIGHTWEIGHT AND COST EFFECTIVE DISPLAYS
J. A. HILL (GEC Avionics, Ltd., Rochester, England) IN: Avionic systems for civil helicopters; Proceedings of the Symposium, London, England, Feb. 18, 1987 . London, Royal Aeronautical Society, 1987, p. 39-50.

Liquid crystal display technology offers a wide range of controllable parameters such that low-cost low-power displays can be designed for placement within practical cockpit layouts. Other advantages include good visibility in direct sunlight, integral backlighting for night viewing, high reliability and integrity, a customer defined format, multifunction displays, and -50 to +85 C operation. Pilot evaluation, flight trials, and current developments are discussed. K.K.

A88-24170
THE ROLE OF NOISE CANCELLATION TECHNIQUES IN AIRCREW VOICE COMMUNICATIONS SYSTEMS
P. D. WHEELER (Racal Acoustics, Ltd., Wembley, England) IN: Aircrew helmets and helmet mounted devices; Proceedings of the Symposium, London, England, Feb. 10, 1987 . London, Royal Aeronautical Society, 1987, p. 9.1-9.6. refs

The small physical dimensions of an aircrew helmet's earshell furnishes an ideal setting for antiphase noise cancellation-employing active noise reduction (ANR) systems. An ANR system of this type employs an analog closed-loop electroacoustic feedback circuit that incorporates a miniature microphone within the earshell cavity, as well as a phase-compensating filter, a feedback amplifier, and an earphone that also transmits incoming speech signals. By obviating the passive attenuation requirements of a conventional earshell design, ANR allows a very low-profile, lightweight headset to be obtained. O.C.

A88-24171
FERRANTI NITE-OP - NIGHT VISION GOGGLES FOR AIRCREW
L. BLACKIE (Ferranti Defence Systems, Ltd., Edinburgh, Scotland) IN: Aircrew helmets and helmet mounted devices; Proceedings of the Symposium, London, England, Feb. 10, 1987 . London, Royal Aeronautical Society, 1987, p. 10.0-10.9.

The helmet-mounted Nite-Op night vision goggle system for helicopter flight crews employs two viewing channels in separate monocular housings, each of which consists of an objective lens assembly, an image intensifier tube, and an eyepiece lens assembly. When the helicopter crew in question undertakes night operations, the outside world will be visible through the Nite-Op goggles while the illuminated cockpit instruments, displays, and navigation aids remain visible downwards and to the sides of the eyepieces. UK military helicopters of all three flight services are to be equipped with the Nite-Op system. O.C.

A88-24175
HELMET MOUNTED DEVICES - SOME SAFETY CONSIDERATIONS
K. COPP (Royal Aircraft Establishment, Farnborough, England) IN: Aircrew helmets and helmet mounted devices; Proceedings of the Symposium, London, England, Feb. 10, 1987 . London, Royal Aeronautical Society, 1987, p. 14.0-14.5.

Aircrew helmets must protect men from hard during ejection-seat escapes, bird strikes, and canopy debris impacts, as well as attenuate heavy blows and reduce shock load transmissions to head and face. Attention is presently given to design criteria that emerge from the generation of high velocity cockpit debris by preejection seat canopy detonations, the crewmember's encounter of postejection airblast, and the need to incorporate such helmet-mounted electrooptical equipment as night-vision goggles, which can become debris-generation hazards in cases of ejection or birdstrike. O.C.

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.

A88-20780#
LIQUID-FUELED SUPERSONIC COMBUSTION RAMJETS - A RESEARCH PERSPECTIVE
PAUL J. WALTRUP (Johns Hopkins University, Laurel, MD) Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, Nov.-Dec. 1987, p. 515-524. Previously cited in issue 08, p. 994, Accession no. A86-22679. refs
(Contract N00024-85-C-5301)

A88-20781#
NUMERICAL SIMULATIONS OF ACOUSTIC-VORTEX INTERACTIONS IN A CENTRAL-DUMP RAMJET COMBUSTOR
K. KAILASANATH, J. H. GARDNER, J. P. BORIS, and E. S. ORAN (U.S. Navy, Naval Research Laboratory, Washington, DC) Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, Nov.-Dec. 1987, p. 525-533. Navy-sponsored research. Previously cited in issue 20, p. 2962, Accession no. A86-42749. refs

A88-20785*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RESULTS OF NASA'S ENERGY EFFICIENT ENGINE PROGRAM
CARL C. CIEPLUCH (NASA, Lewis Research Center, Cleveland, OH), DONALD Y. DAVIS (General Electric Co., Evendale, OH), and DAVID E. GRAY (United Technologies Corp., Pratt and Whitney Div., East Hartford, CT) Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, Nov.-Dec. 1987, p. 560-568. refs

The major activity undertaken in the NASA Energy Efficient Engine Program has been completed. This paper reports on the progress made toward achieving the program goal of developing advanced technology to significantly reduce fuel consumption and operating costs of future subsonic transport-type propulsion systems. An additional goal was that the advanced concepts be compatible with future environmental regulations. Along with the results obtained, a brief overview of the design details of both the General Electric and Pratt and Whitney energy efficient engines and the overall program scope are presented. Overall, this program has been highly successful; the technology developed during its course is, and will continue to be, effectively employed in both current and future advance transport aircraft engine designs. Author

A88-20881
A COMPACT DIFFUSER SYSTEM FOR ANNULAR COMBUSTORS
R. C. ADKINS (Cranfield Institute of Technology, England) and J. O. YOST (Rolls-Royce, PLC, Filton, England) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 3, no. 4, 1986, p. 257-267. refs

Airflow tests have been conducted on an aerodynamic simulation of a combustor with prediffuser of compact configuration. The inlet Mach number throughout the tests was 0.35. The configuration was successful because of the attainment of a high pressure recovery, coupled with an exceptionally low total pressure loss. A useful analytical relationship is derived between the aerodynamic performance of combustor, compressor exit Mach number, and diffuser performance. Author

A88-22043*# Analatom, Inc., San Jose, Calif.
NUMERICAL SIMULATIONS OF AN OBLIQUE DETONATION WAVE ENGINE
JEAN-LUC CAMBIER (Analatom, Inc., San-Jose, CA), HENRY ADELMAN, and GENE P. MENEES (NASA, Ames Research Center, Moffet Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 18 p. refs
(AIAA PAPER 88-0063)

An account is given of the numerical methods employed in a code for the simulation of supersonic combustion, which is then applied to the simulation of attached detonations and flames associated with the oblique-detonation wave supersonic combustor concept. The addition of heat by a detonation wave results in a shorter combustor than can be obtained in more conventional scramjet designs. Pure oblique detonations have been produced in a stoichiometric, uniformly mixed hydrogen/air stream; the wave rotates upstream with energy release, according to simple analytical arguments. Flow visualization maps for Mach number and temperature are presented. O.C.

A88-22069*# Eloret Corp., Palo Alto, Calif.
ANALYTICAL AND EXPERIMENTAL VALIDATION OF THE OBLIQUE DETONATION WAVE ENGINE CONCEPT
HENRY G. ADELMAN (Eloret Institute, Palo Alto, CA), JEAN-LUC CAMBIER (Analatom, Inc., San Jose, CA), GENE P. MENEES, and JOHN A. BALBONI (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(AIAA PAPER 88-0097)

The Oblique Detonation Wave Engine (ODWE) for hypersonic flight has been analytically studied by NASA using the CFD codes which fully couple finite rate chemistry with fluid dynamics. Fuel injector designs investigated included wall and strut injectors, and the in-stream strut injectors were chosen to provide good mixing with minimal stagnation pressure losses. Plans for experimentally validating the ODWE concept in an arc-jet hypersonic wind tunnel are discussed. Measurements of the flow field properties behind the oblique wave will be compared to analytical predictions. R.R.

A88-22108#
LINEAR STABILITY OF THE INLET JET IN A RAMJET DUMP COMBUSTOR
A. TROUVE (CNRS; Ecole Centrale des Arts et Manufactures, Chatenay-Malabry, France; California, University, Berkeley), S. M. CANDEL (CNRS; Ecole Centrale des Arts et Manufactures, Chatenay-Malabry, France), and J. W. DAILY (California, University, Berkeley) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(Contract N00014-84-K-0372)
(AIAA PAPER 88-0149)

The linear spatial instability of a plane shear layer and a plane jet is studied in a ramjet situation with temperature inhomogeneity. The complex dispersion relation is determined numerically. It is found that the density gradient has a significant effect on the instability characteristics and that, in the case of combustion, the most amplified frequency is nearly doubled with respect to the homogeneous flow. A simple criterion is established to identify thin and thick jets. In most practical situations, the jet at the dump may be considered as thick and the single shear layer results are shown to be directly applicable. Author

A88-22109#
COMBUSTION INSTABILITY MECHANISMS IN RAMJETS
U. G. HEGDE, D. M. REUTER, and B. T. ZINN (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(Contract N00014-84-K-0470)
(AIAA PAPER 88-0150)

The control of longitudinal combustion instabilities in dump type ramjet engines is a problem of considerable practical importance. It is shown in this paper that the geometry of the flame in the combustion chamber can strongly influence both the level as well as the frequency of the observed instabilities and thus serve as a means for their control. Results obtained for different flame shapes, realized by relatively displacing two flame holders in the combustion chamber, are described. The important mechanism governing the instabilities is found to be a periodic merging of the flame fronts from the two flame holders. This results in periodic changes in the flame surface area and leads to unsteady heat release rates at the merging frequency which, in turn, drive the acoustic oscillations. By adjusting the relative displacements of the flame holders, the merging of the flame fronts can be manipulated and the instability controlled. Author

A88-22111#
A GAS TURBINE ENGINE EMISSIONS MODEL AS A FUNCTION OF ENGINE OPERATING CONDITIONS, FUEL PROPERTIES AND COMBUSTOR GEOMETRY
M. M. MARX (U.S. Navy, Naval Air Propulsion Test Center, Trenton, NJ) and I. NAMER (Drexel University, Philadelphia, PA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0153)

Emissions of carbon monoxide, unburned hydrocarbons, oxides of nitrogen and smoke from gas turbine engines must comply with environmental regulations. As fuel quality, combustor design and operating conditions change, the emissions of carbon dioxide, carbon monoxide, unburned hydrocarbons, oxides of nitrogen and smoke will be impacted. Therefore, to assess the impact of fuel quality on emissions, an emission model of a state of the art combustor was made using data obtained by varying combustor operating conditions and fuel type using a second order, second level factorial design approach. This model shows that the aromatic content of the fuel is the dominant controlling factor in the emissions measured. This J85 combustor model was applied to a Garrett Turbine Engine Company T76 engine and was able to predict the engine emissions with the use of an engine scaling parameter. Author

A88-22120#
TURBULENT AIR FLOW NEAR REPEATED RIBS WITH STAGGERED-TYPE APPLICABLE TO GAS TURBINE BLADE INTERNAL COOLING AND DESIGN
SHOU-SHING HSIEH (National Sun Yat-Sen University, Kaohsiung, Republic of China) and YING-JONG HONG AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0167)

Flow visualization, manometry, and hot wire anemometry have been applied to approximately three-dimensional air flow around separated ribs with rib spacing-to-height ratio equal to 5.31, rib height-to-hydraulic diameter ratio 0.19, and Reynolds number ranging from 13,000 to 130,000 in order to simulate important aspects relating to turbine blade internal cooling design. Moreover, smoke flow pattern was observed and discussed in the range of Re(H) between 100 and 9000. The main features of the flow which is eventually periodic in the streamwise direction, developing lengths, pressure loss coefficient and mean and rms velocity distribution are presented. Author

A88-22132#
NEAR FIELD EXHAUST ENVIRONMENT MEASUREMENTS OF A FULL SCALE AFTERBURNING JET ENGINE WITH TWO-DIMENSIONAL NOZZLE
L. O. BRASE (McDonnell Aircraft Co., Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0182)

A test to measure the acoustic noise and static pressure environment on structure exposed to engine exhaust flow was conducted at the NASA-Lewis Research Center (LeRC) engine test facilities, using the XD-11-12 (F-100 derivative) engine with a two-dimensional convergent-divergent (2D/CD) nonflight-weight demonstrator nozzle. Testing was conducted in a six-axis, high-altitude engine test cell, a pressurized facility which allows for static testing at simulated altitude for both intermediate and augmented engine power settings. A highly instrumented, water cooled flat panel was placed behind the 2D nozzle and tests were conducted at simulated Mach/altitude flight conditions with the engine at military (MIL) or maximum afterburner (MAX A/B) power setting. The panel instrumentation consisted of acoustic pressure microphones, thermocouples, and static pressure pickups. Author

A88-22149#
ICING SCALING CONSIDERATIONS FOR AIRCRAFT ENGINE TESTING
C. SCOTT BARTLETT (Sverdrup Technology, Inc., Arnold AFB, TN) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0202)

A look at the current state of icing condition scaling or icing similitude for application to aircraft inlet/engine systems is presented. The influences of aircraft flight Mach number and the engine power setting are considered in determining the icing test conditions that must be considered for application of icing similitude. Some of the recent studies into this area of icing similitude are discussed. Some typical examples of the influences that flight Mach number, engine power setting, and free-stream icing conditions have on the icing conditions that exist throughout an inlet/engine system are presented. Data are presented that indicate the critical influence of temperature changes upon ice accretions and of the insignificant influence of pressure changes upon ice accretions. Summary conclusions and recommendations for further study are given. Author

A88-22248#
NUMERICAL SIMULATIONS OF HIGH-SPEED FLOWS IN AN AXISYMMETRIC RAMJET
K. KAILASANATH, J. H. GARDNER, E. S. ORAN, and J. P. BORIS (U.S. Navy, Laboratory for Computational Physics and Fluid Dynamics, Washington, DC) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. Navy-sponsored research. refs
(AIAA PAPER 88-0339)

A numerical study of the effects of changing the inflow Mach number on the acoustic-vortex interactions in an axisymmetric ramjet combustor is presented. Three different inflow Mach numbers are considered, 0.15, 0.31 and 0.61. The Mach numbers are varied by changing the flow velocity while holding the pressure and density, and hence the sound speed, the same. When the flow velocity is increased, the natural instability frequencies of the shear layer increase but the acoustic frequencies remain essentially the same. Hence, this changes the coupling between the acoustics and the flow instabilities. From this series of calculations, it is concluded that the shear layer in a confined geometry such as a combustor rolls up at either its natural instability frequency or at a dominant acoustic frequency of the system, if that acoustic frequency is nearly equal to or greater than the natural instability frequency. In all the simulations, the acoustic frequencies affect the vortex mergings which occur within the combustor. Author

A88-22497*# Lockheed-Georgia Co., Marietta.
MEASUREMENT AND PREDICTION OF PROPELLER FLOW FIELD ON THE PTA AIRCRAFT AT SPEEDS OF UP TO MACH 0.85
ABDULLAH S. ALJABRI (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p.
(Contract NAS3-24339)
(AIAA PAPER 88-0667)

High speed subsonic transports powered by advanced propellers provide significant fuel savings compared to turbofan powered transports. Unfortunately, however, propfans must operate in aircraft-induced nonuniform flow fields which can lead to high blade cyclic stresses, vibration and noise. To optimize the design and installation of these advanced propellers, therefore, detailed knowledge of the complex flow field is required. As part of the NASA Propfan Test Assessment (PTA) program, a 1/9 scale semispan model of the Gulfstream II propfan test-bed aircraft was tested in the NASA-Lewis 8 x 6 supersonic wind tunnel to obtain propeller flow field data. Detailed radial and azimuthal surveys were made to obtain the total pressure in the flow and the three components of velocity. Data was acquired for Mach numbers ranging from 0.6 to 0.85. Analytical predictions were also made using a subsonic panel method, QUADPAN. Comparison of wind-tunnel measurements and analytical predictions show good agreement throughout the Mach range. Author

A88-22584#
AEROELASTIC PRESSURE MEASUREMENTS ON A COMPRESSOR BLADE COMPARISON WITH STRAIGHT CASCADE RESULTS
E. SZECHENYI and I. CAFARELLI (ONERA, Chatillon-sous-Bagneux, France) (Symposium on Unsteady Aerodynamics and Aeroelasticity of Turbomachines and Propellers, 4th, Aachen, West Germany, Sept. 6-10, 1987) ONERA, TP, no. 1987-130, 1987, 11 p. refs
(ONERA, TP NO. 1987-130)

A study performed to validate the flutter predictions that can be made using aeroelasticity tests in a straight cascade wind tunnel is described. Aeroelastic pressure coefficients were measured on a blade in a compressor which had previously been simulated in the straight cascade. Good agreement is generally found between the compressor and cascade results. This validates the two-dimensional straight cascade experimentation for at least the inlet speed range of the tests. It is concluded that the three-dimensional effects are of a second order as far as aeroelasticity is concerned. The results show that aeroelastic blade-to-blade coupling plays only a very secondary role, at least in the subsonic and transonic flow regimes. C.D.

A88-22781
DESIGN, DEVELOPMENT AND COST IMPACTS RESULTING FROM METRICATION OF T800-LHT-800 TURBOSHAFT ENGINE
NORMAN F. EGBERT (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 739-746.

The impact of metrication is analyzed with reference to the T800-LHT-800 engine, the first major U.S. aircraft propulsion system that is fully metric. T800 FSED experience indicates that a majority of metrication issues occur early in a program. Based on work to date, metrication impacts have been readily accommodated. It is concluded that metrication costs represent less than 1 percent of the total development program expenditures at completion. B.J.

A88-23177#
SIMULATION OF FLIGHT SPECTRUM FOR AERO-COMPRESSOR BLADING
QIXIN LU and ZONGLIAN ZHUANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, July 1987, p. A335-A341. In Chinese, with abstract in English. refs

Inflight recordings of the loads incident on aircraft engine compressor blading have been obtained according to a random sequence of mission profiles for several engine types, in order to improve service life prediction accuracies where vibrational loading is a major factor. These flight data are then simulated in the laboratory. Attention is given to the blade random vibration spectrum-simulation technique used; a step-load spectrum well suited to microcomputer programming load control in fatigue testing is obtained. O.C.

A88-23188#
A REVIEW OF THE DEVELOPMENT OF COMPOSITE FAN BLADES
RUI LI and HUANCHENG SONG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Aug. 1987, p. B348-B354. In Chinese, with abstract in English. refs

This paper shows a potential advantage of composite fan blades over the traditional metal fan blades. The history of the development of composite fan blades is reviewed. The design fabrication, molding inspection, finishing operation, and nondestructive evaluation methods are introduced. Emphasis is given to the analysis of resistance to foreign object damage to composite fan blades. The fan blade design concepts of leading edge shield composite, internal metal spar composite, solid hybrid composite, spar shell composite, and superhybrid composite as an internal spar configuration, designated Ti Core, and a leading-edge spar configuration, designated TiCom are evaluated briefly. It is considered that the superhybrid composite fan blade is most likely to be introduced into the fan rotor assembly of commercial turbofan engine. Author

A88-23222#
STEADY-STATE PERFORMANCE ANALYSIS OF WP-8 JET ENGINE
YONGRUI MIAO (Xian Aeroengine Co., People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Oct. 1987, p. B544-B548. In Chinese, with abstract in English. refs

In this article, a statistical analysis of the performance of 373 acceptable engines is made, and an acceptable performance curve for the engine on its test bed is obtained. The engine flight performance in steady state is calculated. Using this method can simplify engine test procedures, save fuel, and facilitate the use of microprocessors for data processing on the test bed. The method is characterized by simplicity and usability in the absence of high altitude test beds and flying test beds. C.D.

A88-23319#
DEVELOPMENT OF DIGITAL ELECTRONIC CONTROL FOR AEROENGINE
TATSUKI SATOH, MINEO KISHIMOTO, MASAHIRO KUROSAKI, and MINORU ARAHATA Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 27, Sept. 1987, p. 281-287. In Japanese, with abstract in English.

Digital electronic control for aeroengines has been advancing from the development phase into practical applications. Integrated flight and propulsion control may improve the control performance of total aircraft systems. In this paper, the performance improvement of engines and propulsion systems due to the introduction of digital electronic control is explained. An outline of the system configuration is presented, and results of tests on FADEC (Full Authority Digital Electronic Control) systems in the XF3-30 turbofan engine and the TF40 reheat turbofan engine are reviewed. C.D.

A88-24042#
GAS TURBINE FUEL CONTROL SYSTEMS FOR UNMANNED APPLICATIONS
R. A. HARRISON and M. S. YATES (Dowty and Smiths Industries Controls, Ltd., Cheltenham, England) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 110, Jan. 1988, p. 33-40.
(ASME PAPER 87-GT-76)

An account is given of the design features and performance characteristics of an unmanned aircraft gas turbine fuel control and electrical power generation system that employs simple hydromechanical components and a minimal number of electronics inputs. Attention is given to the design considerations of engine dynamics, fuel-valve profiling, engine surge phenomena, and engine lightup/starting operations. The control laws used are based on closed-loop spool acceleration. O.C.

A88-24370#
AERODYNAMIC DESIGN PROBLEMS OF PROPFAN
DAOZHI LIU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power, vol. 2, Oct. 1987, p. 295-298, 367. In Chinese, with abstract in English. refs

The development of aerodynamic analytical methods for propfans is reviewed. The aerodynamic design procedures of propfan and the design philosophy of its supercritical airfoil sections are discussed. Some key points for profan development are indicated. Author

A88-24371#
ON AEROELASTICITY AND AEROACOUSTICS OF PROPFAN
XIAOFENG SUN and ZONGAN HU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power, vol. 2, Oct. 1987, p. 299-302, 368. In Chinese, with abstract in English. refs

Aeroelasticity and aeroacoustics of the propfan are two keys to development of the propfan. The achievements in research on these subjects are reviewed with the emphasis on the theoretical models and the related numerical techniques. Some comments and proposals for further research on them are presented. Author

A88-24372#
PERFORMANCE PREDICTION OF A PROPFAN
DIYI TANG (Northwestern Polytechnical University, Xian, People's Republic of China) and YUMIN LIU (Yanliang Aircraft Institute, People's Republic of China) Journal of Aerospace Power, vol. 2, Oct. 1987, p. 303-306, 368. In Chinese, with abstract in English.

The airplane/engine performance matching of a propfan requires that the engine performances are evaluated over the entire range of Mach numbers and altitudes. The problem of the critical engine sizing requirements is considered first; an aerodynamic model is then provided to estimate the propfan efficiency trend and to determine the pressure drop in each expansion unit under the off-design conditions. Based on this model, two curves, are recommended to reduce the propfan efficiency map, and a redistribution curve of the generalized pressure ratio over each expansion unit is obtained. According to these curves, the off-design performances of a propfan, inclusive of the flight, take-off and throttle characteristics, are predicted. Author

A88-24373#
AERODYNAMIC AND ACOUSTIC OPTIMIZATION IN PROPFAN DESIGN
NIANGUO ZHU and MAOZHANG CHEN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power, vol. 2, Oct. 1987, p. 307-311, 368, 369. In Chinese, with abstract in English. refs

Integrated design is the main feature of advanced propfan design. From this point of view, methods adopted for aerodynamic and acoustic design of a propfan are reviewed, comments on their application in propfan optimization are made, principles of selecting design parameters, such as power loading, number of

blades, blade tip speed, airfoil section, and shape of nacelle, are considered. The main objects of aerodynamic and acoustic optimization and the possible performance improvements obtained from the optimization are pointed out. The optimization of the blade tip sweep should be determined from both aerodynamic and acoustic considerations, and the factors which should be taken into account in integrated or single optimization are indicated accordingly. Author

A88-24374#
ELASTICITY MODEL FOR SCALING GAS TURBINE PERFORMANCE PREDICTION
XINGJIAN ZHU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) and W. F. O'BRIEN (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Aerospace Power, vol. 2, Oct. 1987, p. 312-316, 369. In Chinese, with abstract in English.

Before a gas turbine is designed, many candidate designs with different values of design parameters must be studied. Calculation of design and off-design performances of proposed engines is needed, but actual component maps do not exist. In this paper, new scaling laws are developed and shown to produce component maps and estimates of new engine performances which are predicted to be close to the actual values. This 'elasticity' model is based on the fundamental operating principles of the components. Author

A88-24753
METHODS FOR OPTIMIZING THE HYDRAULIC PATH OF AIRCRAFT ENGINES [METODY OPTIMIZATSII GIDRAVLICHESKOGO TRAKTA DVIGATELIA LETATEL'NOGO APPARATA]
B. A. ASTAKHOV and N. S. SOKOLOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1987, p. 12-15. In Russian.

Formulas are obtained for calculating the optimal diameter and cross-sectional area of the flow passage of a section of the hydraulic system of an aircraft engine. The formulas allow for the effects of other sections of the hydraulic system, the feed system, and final flight speed and altitude. The optimization procedure proposed here is applicable to various sections of the hydraulic system, including noncircular sections and sections with local resistance. V.L.

A88-24757
THE PROBLEM OF OPTIMIZING THE USE OF REVERSE-THRUST DEVICES [K VOPROSU OB OPTIMIZATSII PRIMENENIIA REVERSIVNYKH USTROISTV]
A. G. GILERSON Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1987, p. 25-29. In Russian. refs

A study is made of the efficiency of using reverse-thrust devices during the postlanding run. It is found that the dependence of reverse-thrust efficiency on the ratio of the total reverse thrust to the aircraft gravity is the same for a wide variety of modern aircraft. A calculation procedure is proposed for optimizing the number of reverse-thrust devices on aircraft. V.L.

A88-24759
COMBUSTION PROCESSES IN A MODEL BYPASS ENGINE AFTERBURNER WITH INLET FLOW SWIRLING [PROTSESSY GORENIIA V MODEL'NOI FORSAZHNOI KAMERE TRDDF V USLOVIIAKH ZAKRUTKI POTOKOV NA VKHODE]
V. N. GRUZDEV, V. M. ZAIZHENNYI, and A. V. TALANTOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1987, p. 34-38. In Russian. refs

The effect of flow swirling at the inlet of a model afterburner with a stabilizer in the form of a grooved ring on flow dynamics and combustion is investigated experimentally. It is shown that swirling in opposite directions generates higher turbulence and contributes to the formation of a narrower recirculation zone. As a result, the flame front angle increases and the required time decreases, which explains the advantage of bidirectional swirling over unidirectional swirling. V.L.

A88-24765
OPTIMIZATION OF THE CHARACTERISTICS OF A POWERPLANT WITH ADJUSTABLE FLOW PATH ELEMENTS [OPTIMIZATSIIA KHARAKTERISTIK SILOVOI USTANOVKI S REGULIRUEMYMI ELEMENTAMI PROTOCHNOI CHASTI]
IU. N. NECHAEV, V. N. KOBEL'KOV, and E. V. TOFANOVSKII Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1987, p. 60-63. In Russian. refs

The problem of optimizing the characteristics of an aircraft powerplant is analyzed for the case of powerplants containing a large number of adjustable elements in the flow path. A method for calculating the optimum effective performance characteristics of such powerplants is presented which uses a modified scanning technique. The method has been implemented in computer software. V.L.

A88-24789
FUNDAMENTALS OF AVIATION ENGINE ASSEMBLY [OSNOVY SBORKI AVIATSIONNYKH DVIGATELEI]
ALEKSANDR IOSIFOVICH IL'IANKOV and MIKHAIL EFIMOVICH LEVIT Moscow, Izdatel'stvo Mashinostroenie, 1987, 288 p. In Russian. refs

The principles, technology, and typical processes of the assembly of aircraft and rocket engines are covered in this textbook. Topics discussed include general information on aircraft and rockets; the general design of jet, turbojet, turbofan, and rocket engines; quality control at aviation engine-building plants; and general data on the reliability of aviation engines. Attention is also given to the automation and control of engine assembly processes, the use of industrial robots in engine assembly, testing of aviation engines, and safety engineering at engine assembly plants. V.L.

N88-14985*# United Technologies Corp., East Hartford, Conn.
FUEL-INJECTOR/AIR-SWIRL CHARACTERIZATION Final Report
J. B. MCVEY, J. B. KENNEDY, and S. RUSSELL Jan. 1988
58 p
(Contract NAS3-24352)
(NASA-CR-180864; NAS 1.26:180864) Avail: NTIS HC A04/MF A01 CSCL 21E

Experimental data on the characteristics of the spray produced by a gas-turbine engine airblast fuel injector are reported. The data acquired include the mass-flux distribution measured by use of a high-resolution spray patternator; the gas-phase velocity field measured by use of a two-component laser Doppler velocimeter, and the liquid droplet size and velocity distributions measured by use of a single-component phase-Doppler anemometer. The data are intended for use in assessments of two-phase flow computational methods as applied to combustor design procedures. Author

N88-15787*# National Aeronautics and Space Administration. *Lewis Research Center, Cleveland, Ohio.*
DETERMINING STRUCTURAL PERFORMANCE
MICHAEL A. ERNST and LOUIS J. KIRALY *In its* Aeropropulsion '87. Session 2: Aeropropulsion Structures Research 14 p Nov. 1987
Avail: NTIS HC A04/MF A01 CSCL 21E

An overview is given of the methods and concepts developed to enhance and predict structural dynamic characteristics of advanced aeropropulsion systems. Aeroelasticity, Vibration Control, Dynamic Systems, and Computational Structural Methods are four disciplines that make up the research program at NASA/Lewis Research Center. The Aeroelasticity program develops analytical and experimental methods to minimize flutter and forced vibration of aerospace propulsion systems. Both frequency domain and time domain methods have been developed for applications on the turbofan, turbopump, and advanced turboprop. To improve life and performance, the Vibration Control program conceives, analyzes, develops, and demonstrates new methods to control vibrations in aerospace systems. Active and passive vibration control is accomplished with electromagnetic dampers, magnetic bearings,

and piezoelectric crystals to control rotor vibrations. The Dynamic Systems program analyzes and verifies the dynamics of interacting systems, as well as develops concepts and methods for high-temperature dynamic seals. The Computational Structural Methods program uses computer science to improve solutions of structural problems. Author

N88-15788*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIFE PREDICTION TECHNOLOGIES FOR AERONAUTICAL PROPULSION SYSTEMS
MICHAEL A. MCGAW *In its* Aeropropulsion '87. Session 2: Aeropropulsion Structures Research 12 p Nov. 1987
Avail: NTIS HC A04/MF A01 CSCL 21E

Fatigue and fracture problems continue to occur in aeronautical gas turbine engines. Components whose useful life is limited by these failure modes include turbine hot-section blades, vanes and disks. Safety considerations dictate that catastrophic failures be avoided, while economic considerations dictate that noncatastrophic failures occur as infrequently as possible. The design decision is therefore in making the tradeoff between engine performance and durability. The NASA Lewis Research Center has contributed to the aeropropulsion industry in the areas of life prediction technology for 30 years, developing creep and fatigue life prediction methodologies for hot-section materials. Emphasis is placed on the development of methods capable of handling both thermal and mechanical fatigue under severe environments. Recent accomplishments include the development of more accurate creep-fatigue life prediction methods such as the total strain version of Lewis' Strainrange Partitioning (SRP) and the HOST-developed Cyclic Damage Accumulation (CDA) model. Other examples include the Double Damage Curve Approach (DDCA), which provides greatly improved accuracy for cumulative fatigue design rules. Author

N88-15799*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DIRECTIONS IN PROPULSION CONTROL
CARL F. LORENZO *In its* Aeropropulsion '87. Session 4: Instrumentation and Controls Research 15 p Nov. 1987
Avail: NTIS HC A05/MF A01 CSCL 21E

The research needs in the area of propulsion control as driven by trends in advanced aircraft are considered. Ongoing propulsion control research at NASA Lewis is discussed. Special emphasis is made on research to improve control system reliability through the use of analytical redundancy to accommodate failed control sensors. In conclusion, a discussion of new research thrusts in the area of supersonic STOVL integrated control and intelligent system control is presented. Author

N88-15800*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AEROPROPULSION '87. SESSION 5: SUBSONIC PROPULSION TECHNOLOGY
Nov. 1987 153 p Conference held in Cleveland, Ohio, 17-19 Nov. 1987 Submitted for publication
(NASA-CP-10003-SESS-5; E-3798-SESS-5; NAS 1.55:10003-SESS-5) Avail: NTIS HC A08/MF A01 CSCL 21E

NASA is conducting aeropropulsion research over a broad range of Mach numbers. In addition to the high-speed propulsion research described, major progress was recorded in research aimed at the subsonic flight regimes of interest to many commercial and military users. Recent progress and future directions in such areas as small engine technology, rotorcraft transmissions, icing, Hot Section Technology (HOST) and the Advanced Turboprop Program (ATP) are covered.

N88-15801*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SMALL ENGINE TECHNOLOGY PROGRAMS
RICHARD W. NIEDZWIECKI *In its* Aeropropulsion '87. Session 5: Subsonic Propulsion Technology 35 p Nov. 1987
Avail: NTIS HC A08/MF A01 CSCL 21E

Small engine technology programs being conducted at the NASA Lewis Research Center are described. Small gas turbine research is aimed at general aviation, commutercraft, rotorcraft, and cruise missile applications. The Rotary Engine Program is aimed at supplying fuel flexible, fuel efficient technology to the general aviation industry, but also has applications to other missions. There is a strong element of synergism between the various programs in several respects. All of the programs are aimed towards highly efficient engine cycles, very efficient components, and the use of high temperature structural ceramics. This research tends to be generic in nature and has broad applications. The Heavy Duty Diesel Transport (HDTT), rotary technology, and the compound cycle programs are all examining approached to minimum heat rejection, or adiabatic systems employing advanced materials. The Automotive Gas Turbine (AGT) program is also directed towards ceramics application to gas turbine hot section components. Turbomachinery advances in the gas turbines will benefit advanced turbochargers and turbocompounders for the intermittent combustion systems, and the fundamental understandings and analytical codes developed in the research and technology programs will be directly applicable to the system projects. Author

N88-15804*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AIRCRAFT ENGINE HOT SECTION TECHNOLOGY: AN OVERVIEW OF THE HOST PROJECT
DANIEL E. SOKOLOWSKI and MARVIN H. HIRSCHBERG *In its* Aeropropulsion '87. Session 5: Subsonic Propulsion Technology 10 p Nov. 1987
Avail: NTIS HC A08/MF A01 CSCL 21E

NASA sponsored the Turbine Engine Hot Section Technology (HOST) Project to address the need for improved durability in advanced aircraft engine combustors and turbines. Analytical and experimental activities aimed at more accurate prediction of the aerothermal environment, the thermomechanical loads, the material behavior and structural responses to loads, and life predictions for cyclic high-temperature operation were underway for the last 7 years. The project has involved representatives from six engineering disciplines who are spread across three work sectors (industry, academia, and NASA). The HOST Project not only initiated and sponsored 70 major activities, but was also the keystone in joining the multiple disciplines and work sectors to focus on critical research needs. A broad overview of the project is given along with initial indications of the project's impact. Author

N88-15805*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OVERVIEW OF NASA PTA PROPFAN FLIGHT TEST PROGRAM
EDWIN J. GRABER *In its* Aeropropulsion '87. Session 5: Subsonic Propulsion Technology 26 p Nov. 1987
Avail: NTIS HC A08/MF A01 CSCL 21E

During the last several years high-speed propellers have made the transition from a wind tunnel curiosity to a very likely near-term, fuel-efficient propulsion system that could revolutionize the subsonic commercial air transport industry. A key ingredient in this remarkable progress is the advanced turboprop industry. Working together, NASA and industry have developed and flight tested two propeller propulsion systems to provide answers to key technical questions and concerns. An industry team is currently developing a third propeller propulsion system for flight testing late this year. The progress of one of the NASA-industry flight test programs, called the Propfan Test Assessment (PTA) Program is reported. In PTA, a 9 foot diameter propfan was installed on the left wing of a Gulfstream GII executive jet and is undergoing extensive flight testing at Dobbins Air Force Base to evaluate

propfan structural integrity, near and far field noise, and cabin interior noise characteristics. This research testing includes variations in propeller tip speed and power loading, nacelle tilt angle, and aircraft Mach number and altitude. As a result, extensive parametric data will be obtained to verify and improve computer codes for predicting propeller structural aeroelastic, aerodynamic, and acoustic characteristics. Over 600 measurements are being recorded for each of approximately 600 flight test conditions.
Author

N88-15806*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ADVANCED PROPELLER RESEARCH
JOHN F. GROENEWEG and LAWRENCE J. BOBER *In its* Aeropropulsion '87. Session 5: Subsonic Propulsion Technology 30 p Nov. 1987
Avail: NTIS HC A08/MF A01 CSCL 21E

Resent results of aerodynamic and acoustic research on both single and counter-rotation propellers are reviewed. Data and analytical results are presented for three propellers: SR-7A, the single rotation design used in the NASA Propfan Test Assessment (PTA); and F7-A7, the 8+8 counterrotating design used in the proof-of-concept Unducted Fan (UDF) engine. In addition to propeller efficiencies, cruise and takeoff noise, and blade pressure data, off-design phenomena involving formation of leading edge vortices are described. Aerodynamic and acoustic computational results derived from three-dimensional Euler and acoustic radiation codes are presented. Research on unsteady flows, which are particularly important for understanding counterrotation interaction noise, unsteady loading effects on acoustics, and flutter or forced response is described. The first results of three-dimensional unsteady Euler solutions are illustrated for a single rotation propeller at an angle of attack and for a counterrotation propeller. Basic experimental and theoretical results from studies of the unsteady aerodynamics of oscillating cascades are outlined. Finally, advanced concepts involving swirl recovery vanes and ultra bypass ducted propellers are discussed. Author

N88-15807*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AEROPROPULSION '87. SESSION 6: HIGH-SPEED PROPULSION TECHNOLOGY
Nov. 1987 119 p Conference held in Cleveland, Ohio, 17-19 Nov. 1987 Submitted for publication
(NASA-CP-10003-SESS-6; E-3798-SESS-6; NAS 1.55:10003-SESS-6) Avail: NTIS HC A06/MF A01 CSCL 21E

NASA is conducting aeronautical research over a broad range of Mach numbers. In addition to the advanced CTOL propulsion research described in a separate session, the Lewis Research Center has intensified its efforts towards propulsion technology for selected high-speed flight applications. In a companion program, the Langley Research Center has also accomplished excellent research in Supersonic Combustion Ramjet (SCRAM) propulsion. What is presented in this session is an unclassified review of some of the propulsion research results that are applicable for supersonic to hypersonic vehicles. Not only is a review provided for several key work areas, it also presents a viewpoint on future research directions by calling attention to cycles, components, and facilities involved in this rapidly expanding field of work.

N88-15808*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUPERSONIC STOVL PROPULSION TECHNOLOGY PROGRAM: AN OVERVIEW
BERNARD J. BLAHA and PETER G. BATTERTON *In its* Aeropropulsion '87. Session 6: High-Speed Propulsion Technology 23 p Nov. 1987
Avail: NTIS HC A06/MF A01 CSCL 21E

Planning activities are continuing between NASA, DOD, and two foreign governments to develop the technology and to demonstrate the design capability for advanced, supersonic, short-takeoff and vertical-landing (STOVL) aircraft by the mid-1990s. As a result, a Memorandum of Understanding (MOU) was established by the United Kingdom to jointly pursue the required technology; and an MOU with Canada is expected to be signed shortly. The NASA Lewis Research Center will play a lead role in the development of the required propulsion technologies which were identified as being critical to achieve viable STOVL aircraft. These planning activities have already resulted in initial research programs focused on technologies common to two or more of the proposed propulsion system concepts. An overview of the Lewis Research Center's role in the overall program plan and recent results in the development of the required propulsion technologies is presented. Author

N88-15809*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PROPULSION CHALLENGES AND OPPORTUNITIES FOR HIGH-SPEED TRANSPORT AIRCRAFT
WILLIAM C. STRACK *In its* Aeropropulsion '87. Session 6: High-Speed Propulsion Technology 19 p Nov. 1987
Avail: NTIS HC A06/MF A01 CSCL 21E

For several years there was a growing interest in the subject of efficient sustained supersonic cruise technology applied to a high-speed transport aircraft. The major challenges confronting the propulsion community for supersonic transport (SST) applications are identified. Both past progress and future opportunities are discussed in relation to perceived technology shortfalls for an economically successful SST that satisfies environmental constraints. A very large improvement in propulsion system efficiency is needed both at supersonic and subsonic cruise conditions. Toward that end, several advanced engine concepts are being considered that, together with advanced discipline and component technologies, promise at least 40 percent better efficiency that the Concorde engine. The quest for higher productivity through higher speed is also thwarted by the lack of a conventional, low-priced fuel that is thermally stable at the higher temperatures associated with faster flight. Airport noise remains a tough challenge because previously researched concepts fall short of achieving FAR 36 Stage 3 noise levels. Innovative solutions may be necessary to reach acceptably low noise. While the technical challenges are indeed formidable, it is reasonable to assume that the current shortfalls in fuel economy and noise can be overcome through an aggressive propulsion research program.
Author

N88-15812*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HYPERSONIC PROPULSION RESEARCH
G. BURTON NORTHAM *In* NASA. Lewis Research Center, Aeropropulsion '87. Session 6: High-Speed Propulsion Technology 20 p Nov. 1987
Avail: NTIS HC A06/MF A01 CSCL 21E

The NASA Langley Research Center has conducted hypersonic propulsion research since the 1960s. A variety of inlet concepts were explored and characterized. The emphasis of the inlet program was the development of the short (light weight), fixed geometry, side-wall-compression inlets that operate efficiently over a wide Mach number range. As hypersonic combustion tunnels were developed, programs to study the parameters controlling fuel mixing and combustion with single and multiple strut models were conducted using direct connect test techniques. These various tests supported the design of subscale engine test hardware that integrated inlet and combustor technology and allowed the study of the effect of heat release on thrust and combustor/inlet interaction. A number of subscale engine tests have demonstrated predicted performance levels at Mach 4 and 7 simulated flight conditions. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A88-20926
SELECTION OF SERVOMOTORS FOR FLIGHT CONTROLS AND AUTOPILOT [CHOIX DES SERVOMOTEURS POUR COMMANDES DE VOL ET PILOTE AUTOMATIQUE]
M. BOSSARD (Aerospatiale, Division Avions, Toulouse, France) (Societe Francaise des Mecaniciens, Reunion sur les Asservissements, Paris, France, Oct. 1, 2, 1986) Revue Francaise de Mecanique (ISSN 0373-6601), no. 3, 1987, p. 119-125. In French.

Criteria for the selection of flight control and autopilot servomotors are discussed, and the replacement of electrohydraulic flight control servocontrols by electrical or hydroelectrical actuators in future subsonic aircraft is considered. It is noted that such a change would not have any effect on the general aircraft design. The impact of these actuators on aircraft weight and costs is evaluated. Problems related to the installation of the flight controls and the hydraulic and power generation systems are also discussed. The hydroelectric actuators are shown to demonstate superior performance to mechanical servocontrols. For applications including the actuation of flaps, it is noted that actuators are more easily powered electrically than hydraulically. R.R.

A88-22127#
ON ESTIMATING AIRCRAFT NONLINEAR ROTARY DERIVATIVES FROM STATIC WIND TUNNEL DATA
JAMES R. RITTER (Wichita State University, KS) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0177)

One problem in mathematical modeling of aircraft poststall behavior lies in the difficulty in describing aerodynamic moments due to airplane rates of rotation. In particular, the rolling and yawing rate derivatives are crucial to accurate motion modeling. These derivatives are not constant values when the linear assumptions of unstalled flight are abandoned. One method for calculating these derivatives was applied to a low-wing, single-engine general aviation airplane for which sufficient, high angle-of-attack wind tunnel data is available. This method involves approximations that limit the validity of the model and produce unsatisfactory results when used in an established spin modeling program and compared with extensive, full-scale flight test results. By using a new method and an extended computational technique, a better match with flight test data was obtained. The response to controls during stall departure is characteristic of the subject airplane when the new derivatives are used. Unlike the old derivatives, the new ones are sensitive to variations of the state space parameters, and in a predictable manner. Sensitivity to aerodynamic spanwise loading is also evaluated. Comparisons are made between the old and new derivatives, and between outputs of otherwise identical executions of the spin program. Author

A88-22296*# PRC Kentron, Inc., Hampton, Va.
OBLIQUE-WING RESEARCH AIRPLANE MOTION SIMULATION WITH DECOUPLING CONTROL LAWS
ROBERT W. KEMPEL (PRC Kentron, Inc., McLean, VA), WALTER E. MC NEILL (NASA, Ames Research Center, Moffett Field, CA), and TRINDEL A. MAINE (NASA, Flight Research Center, Edwards, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 21 p. refs
(AIAA PAPER 88-0402)

A large piloted vertical motion simulator was used to assess the performance of a preliminary decoupling control law for an early version of the F-8 oblique wing research demonstrator airplane. Evaluations were performed for five discrete flight conditions, ranging from low-altitude subsonic Mach numbers to moderate-altitude supersonic Mach numbers. Asymmetric sideforce as a function of angle of attack was found to be the primary cause of both the lateral acceleration noted in pitch and the tendency to roll into left turns and out of right turns. The flight control system was shown to be effective in generally decoupling the airplane and reducing the lateral acceleration in pitch maneuvers. R.R.

A88-22518#
DYNAMIC RESPONSE OF AIRCRAFT-AUTOPILOT SYSTEMS TO ATMOSPHERIC DISTURBANCES
R. JOHN HANSMAN, JR. and JAMES L. STURDY (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p.
(Contract DOT-FA03--86-C-00016)
(AIAA PAPER 88-0692)

Linearized models of aircraft dynamics and of altitude-hold autopilots are presently analyzed in order to characterize the dynamic response of aircraft autopilots to atmospheric disturbances. Attention is given to the extent to which pressure surface fluctuations, vertical gusts, and horizontal gusts cause dynamic altitude errors by coupling with the aircraft autopilot dynamics; three different airliners are studied at flight levels of 29,000, 33,000, and 37,000 ft. Atmospheric conditions are found which can indeed cause aircraft to exhibit dynamic pressure errors in excess of 1000 ft, with pressure surface fluctuations being the dominant source of altitude errors in flights through extreme mountain wave activity. O.C.

A88-22568*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLYING QUALITIES FROM EARLY AIRPLANES TO THE SPACE SHUTTLE
WILLIAM H. PHILLIPS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 14 p. refs
(AIAA PAPER 88-0751)

This paper discusses the historical development of the study of flying qualities and the evolution of flying qualities requirements. Subjects considered include the scope of flying qualities, early historical development of flying qualities, research on flying qualities requirements, human response characteristics, command control systems, gust response and its relation to flying qualities, prediction of flying qualities, discussion of the Space Shuttle and of some recent airplanes, and format of the flying qualities requirements. Author

A88-22573#
INTEGRATION OF ADVANCED SAFETY ENHANCEMENTS FOR F-16 TERRAIN FOLLOWING
DONALD SWIHART, WILLIAM URSCHEL (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH), and JAMES BLAYLOCK (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Saint Louis, MO, Sept. 14-16, 1987. 6 p.
(AIAA PAPER 87-2906)

Application of System-Wide Integrity Management (SWIM) to the maximization of flight safety for the F-16 terrain following (TF) system is considered. The architecture of the F-16 TF system is discussed, identifying areas where conventional self-test is not sufficient to ensure flight safely. Detection of flight-critical malfunctions by SWIM is followed by an automatic recovery maneuver consisting of a roll to wings-level fly-up for the F-16 system. The addition of SWIM to the single-thread configuration of the F-16 TF system results in 14 percent predicted mishap rate reduction at far less cost and installation impact that the redundant configuration (which offers a 17-percent reduction). R.R.

A88-22606#
LIMITED EVALUATION OF THE LONGITUDINAL FLYING QUALITIES OF A CENTERSTICK AIRCRAFT WITH VARIATIONS IN STICK FEEL PARAMETERS
WILLIAM M. QUINN, JR. (USAF, Washington, DC) and MALCOLM A. CUTCHINS (Auburn University, AL) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Nov.-Dec. 1987, p. 528-534. Previously cited in issue 20, p. 2855, Accession no. A84-42347. refs

A88-22607*# University of Western Michigan, Kalamazoo.
EIGENSYSTEM SYNTHESIS FOR ACTIVE FLUTTER SUPPRESSION ON AN OBLIQUE-WING AIRCRAFT
GURBUX S. ALAG (Western Michigan University, Kalamazoo) and JOHN J. BURKEN (NASA, Flight Research Center, Edwards, CA) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 812-817) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Nov.-Dec. 1987, p. 535-539. Previously cited in issue 23, p. 3410, Accession no. A86-47491. refs

A88-22612*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
ENERGY MANAGEMENT OF THREE-DIMENSIONAL MINIMUM-TIME INTERCEPT
HENRY J. KELLEY, EUGENE M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg), and HENDRIKUS G. VISSER Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Nov.-Dec. 1987, p. 574-580. NASA-supported research. Previously cited in issue 21, p. 3051, Accession no. A85-43841. refs

A88-22741
TESTING OF THE ADVANCED DIGITAL OPTICAL FLIGHT CONTROL SYSTEM (ADOCS)
LAWRENCE J. HARTMAN, PAUL V. LA SALA, and JOHN S. TULLOCH (Boeing Vertol Co., Philadelphia, PA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 173-188.

A Black Hawk flight test helicopter has been equipped with an all-digital/optical control system (DOCS) in order to evaluate its performance. Attention is presently given to test program objectives and methodology, which proceeded according to a unique concept that combined the modified aircraft, the flight test data system, and a flight simulator laboratory. Both augmented and unaugmented versions of the DOCS have undergone development histories over the course of the flight test program, whose results to date are presented. O.C.

A88-22742
DESIGN DEVELOPMENT AND FLIGHT EVALUATION OF AN ADVANCED DIGITAL FLIGHT CONTROL SYSTEM
B. P. GUPTA, BENNY B. BARNES, GREG DOCKTER, RON HODGE, and CHAN MORSE (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 189-196.

Flight test results have been obtained for an Apache helicopter-mounted Advanced Digital Flight Control System incorporating a redundant set of microprocessor-based computers and sensors; this system controls a set of secondary actuators driving the mechanical input valves of the aircraft primary actuators. The system is commanded by means of side-arm controllers having four-axis control capability. An advanced set of control laws that reduce pilot workload are incorporated by the system software. Velocity vector management, automoding, self-trimming, and envelope control, have all been demonstrated. O.C.

A88-22763
MODEL HOVER STABILITY TEST OF SIKORSKY'S INTEGRATED TECHNOLOGY ROTOR
ROBERT K. GOODMAN and DAVID G. MATUSKA (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 501-509.

Reduced tip speed hover stability testing of the ITR model has established the aeromechanical stability characteristics of the rotor. It was found that the model is stable and handles well with isolated rotor and air resonance fixed system simulators. Ground resonance instability induced during testing was eliminated by the use of larger dampers. B.J.

A88-22773
A TREATMENT OF THE IMPACT OF ROTOR-FUSELAGE COUPLING ON HELICOPTER HANDLING QUALITIES
DAVID G. MILLER and FRED WHITE (Boeing Vertol Co., Philadelphia, PA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 631-644. refs

An algorithm which allows the computer generation of a comprehensive linear rotor/fuselage model is presented. Analyses can be easily conducted for many levels of model sophistication and many rotorcraft configurations by eliminating the tedious task of manual derivation of the equations of motion without the problems associated with numerical differentiation. The proposed algorithm is used to evaluate the impact of such modeling phenomena as flap, lead lag, drive system, and dynamic inflow DOFs on the handling quality modes of motion of the aircraft. A comparison with flight test data shows the effect of model sophistication on the accuracy of predicting the usable bandwidth for an aggressive flight control system. B.J.

A88-22774* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A SIMULATOR INVESTIGATION OF PARAMETERS AFFECTING HELICOPTER HANDLING QUALITIES IN AIR COMBAT (HAC II)
MICHAEL S. LEWIS, M. HOSSEIN MANSUR (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and ROBERT T. N. CHEN (NASA, Ames Research Center, Moffett Field, CA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 645-662. refs

The Helicopter Air Combat system was used to conduct a pilot simulation study investigating the handling qualities and flight characteristics required for helicopter air-to-air combat. Results indicate that a well-damped directional response, low sideforce caused by sideslip, and some effective dihedral are all desirable for weapon system performance, good handling qualities, and low pilot workload. An angular rate command system was favored over the attitude-type pitch and roll response for most applications, and an enhanced maneuver envelope size over that of current generation aircraft was found to be of advantage. B.J.

A88-22776
DESIGN OF A MULTIVARIABLE HELICOPTER FLIGHT CONTROL SYSTEM FOR HANDLING QUALITIES ENHANCEMENT
WILLIAM L. GARRARD and BRADLEY S. LIEBST (Minnesota, University, Minneapolis) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 677-696. refs
(Contract DAAL03-86-K-0056)

Eigenspace assignment methods are used to design a feedback system for use in precise hovering control for a modern attack helicopter. Eigenvalue placement is used for stability enhancement and eigenvector shaping is used for modal decoupling. Good closed loop transient response and transfer functions are obtained. Author

A88-22777
AN ADVANCED DIGITAL FLIGHT CONTROL CONCEPT FOR SINGLE PILOT, ATTACK HELICOPTER OPERATIONS
CHARLES A. PARLIER (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 697-704. refs

This paper examines the fundamental requirements (and the rationale behind the requirements) for the Advanced Digital Flight Control System for the prototype Apache, YAH-64 AV05 (77-23258). Consideration is given to issues touching on the pilot, the crewstation, the cockpit control configuration, the flight control system requirements concept, the basic control modes, the special control modes, and envelope control. Preliminary results indicate that the concept is viable and superior to previous control systems in some flight regimes. B.J.

A88-22778
EVALUATION OF ADOCS DEMONSTRATOR HANDLING QUALITIES
STEVEN I. GLUSMAN, CHARLES DABUNDO, and KENNETH H. LANDIS (Boeing Vertol Co., Philadelphia, PA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 705-716. refs
(Contract DAAK51-82-C-0002)

A flight test program was conducted on a modified JUH-60A Black Hawk helicopter to demonstrate flight control system technologies for next generation scout/attack rotorcraft. Distinct system features included multiaxis side-stick controllers and a digital flight control system employing a model following control law architecture. The Advanced Digital Optical Control System Demonstrator provided Level 1 handling qualities for most mission tasks evaluated. Excellent gust rejection and stabilization characteristics were demonstrated. Author

A88-22795* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NEW HANDLING-QUALITIES REQUIREMENTS AND HOW THEY CAN BE MET
DAVID L. KEY (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) and ROGER H. HOH (Systems Technology, Inc., Hawthorne, CA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 975-990. refs

The structure and coverage of the proposed MIL-H-8501B specification for helicopter handling qualities are reviewed. The specification prescibes the desired vehicle command response as a function of the mission task and the usable visual cues. It takes into account failures and flight envelopes, and it prescribes a set of flight demonstration maneuvers. Helicopter performance requirements with degraded visual cues are proposed, in addition to specific longitudinal and lateral dynamics requirements. R.R.

A88-22799
MANEUVER PERFORMANCE OF TILTROTOR AIRCRAFT
JOHN J. SCHILLINGS, BRADFORD J. ROBERTS, TOMMIE L. WOOD, and KENNETH G. WERNICKE (Bell Helicopter Textron, Fort Worth, TX) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, 16 p. refs

The maneuver performance, rotor and airframe aerodynamic capabilities, and rotor maneuvering loads of the XV-15 tiltrotor research aircraft are discussed. Test data have been correlated with simulation results, indicating that the XV-15 demonstrates aerodynamic capability approaching the structural V-n diagram, and total lift up to 90 percent of the maximum predicted aerodynamic capability. Advanced aerodynamic and structural technology employed on the V-22 Osprey are applied to the AV-15, showing the agility and maneuverability of the tiltrotor for air-to-air combat and gunship-type maneuvers. R.R.

A88-22801#
ADVANCED FLIGHT CONTROL TECHNOLOGY
JOHN A. MACRINO and JOEL L. TERRY, JR. (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Paper. 7 p.

The emergence of digital flight control technology for helicopter applications has been the major contributor in providing flight control engineers the tools to improve mission performance and reduce pilot workload through control law tailoring while simplifying hardware mechanization. As more complex vehicles appear on the horizon, the ability to control these sophisticated systems is greatly enhanced by a better understanding of integrated control concepts. The challenge for tommorrow will be the ability of the flight control community to adapt new control techniques integrated with mission equipment for an efficient and effective weapons system. Author

A88-23184#
THE INFLUENCES OF THE INDUCED VELOCITY DISTRIBUTION AND THE FLAPPING-LAGGING COUPLING ON THE DERIVATION OF THE ROTOR AND STABILITY OF THE HELICOPTER
XINYU XU and RENLIANG CHEN (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, July 1987, p. A398-A403. In Chinese, with abstract in English. refs

The first-harmonic variation of induced velocity distribution derived by a generalized vortex theory is taken into account, and the first flapping-lagging bending mode of blade elasticity is considered, in the present helicopter rotor blade treatment. Sample calculations are made for a typical helicopter with attention to the influence exerted by induced velocity distribution and coupling-flapping lagging on the derivatives of the rotor and the stability of the helicopter. O.C.

A88-23192#
STUDY ON THE PILOT-INDUCED OSCILLATION OF LONGITUDINAL PILOT-AIRPLANE SYNTHESIS SYSTEM
YACHANG FENG, SONGFEN MUO, TIEMEI YAO, and XINFU XU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Aug. 1987, p. B391-B398. In Chinese, with abstract in English. refs

This paper presents a practical mathematic model of a pilot. The PIO (pilot-induced oscillation) problem of a synthetic system of 'men-mechanical control system (containing the dynamic characteristics of the mechanical stick system and the nonlinear effect)-aircraft' and 'men-control augmentation system-aircraft' is discussed. The influence upon PIO of the parameter variations in the pilot model and the nonlinear effects of the mechanical control system is analyzed. Some good results have been obtained. These results are also useful in the study of the PIO problem of 'men-fly by control system-aircraft' synthetic system. Author

A88-23198#
HIERARCHICAL SELF-TUNING FLIGHT CONTROL
LI FU (Harbin Institute of Technology, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Aug. 1987, p. B441-B446. In Chinese, with abstract in English.

This paper introduces a hierarchical self-tuning flight control system scheme. The first level is the control of three angular motions. The second level is the control of three linear motions. The third level is the set-point generation. The decentralized and hierarchical algorithm can reduce the computing time and enhance the adaptive ability. So it is an effective and feasible scheme for such a control system. An example is given for illustration.
Author

A88-23206#
SYNTHESIS AND CONVERSION OF AIRCRAFT DIRECT FORCE CONTROL MODES
YIDONG YANG and LIXIN GAO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Sept. 1987, p. A503-A512. In Chinese, with abstract in English. refs

The direct force control (DFC) for CCV aircraft consists of the following modes: direct lift, fuselage aiming, vertical translation, and maneuver enhancement. These modes can be selected by the pilot according to the various fighting tasks and some flight functions. Based on the implementation of digital control of each DFC mode with a microprocessor, this paper presents a scheme for multimode synthesis and conversion between modes. The results of a system hybrid simulation experiment have shown that the technique of mode conversion is successful and the aircraft transient response during the operation of conversion is satisfactory. Author

A88-23221#
DYNAMIC STIFFNESS CALCULATION OF Z-6 HELICOPTER LONGITUDINAL FLIGHT CONTROL SYSTEM
YOUYI LEI (Chinese Helicopter Research and Design Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Oct. 1987, p. B535-B539. In Chinese, with abstract in English.

This paper gives the calculation of dynamic stiffness characteristics of Z-6 helicopter longitudinal control system. In the paper, the method of establishing complex matrix equation of a multifreedom mechanical model and the procedure of calculating dynamic stiffness and eigenvalues for a real mechanical hydraulic flight controls system are presented. Author

A88-23314
CORRELATION OF PREDICTED AND FREE-FLIGHT RESPONSES NEAR DEPARTURE CONDITIONS OF A HIGH INCIDENCE RESEARCH MODEL
A. JEAN ROSS and GERALDINE F. EDWARDS (Royal Aircraft Establishment, Farnborough, England) Aeronautical Journal (ISSN 0001-9240), vol. 91, Nov. 1987, p. 397-405. refs

The mathematical model of aerodynamic forces and moments is described, based on results from various wind-tunnel experiments with the RAE High Incidence Research Model (HIRM). Simulations of the responses due to longitudinal and lateral control inputs at high angles of attack are compared with the responses measured on free-flight models of the configuration. It is shown that the main features of the flight behavior are reproduced, in particular such phenomena as roll-off, wing rock and nose slice. Author

A88-23857
AIRSHIP FLIGHT CONTROL - AN APPLICATION OF FLY-BY-LIGHT
T. I. HALL (GEC Avionics, Ltd., Flight Automation Research Laboratory, Rochester, England) IN: Applications of light in guided flight; Proceedings of the Symposium, London, England, Jan. 22, 1987 . London, Royal Aeronautical Society, 1987, p. 5-24. refs

This paper describes how fiber optical data transmission is being used in fly-by-wire systems to produce what is referred to as fly-by-light (FBL). An FBL demonstration rig is described, and the use of FBL to solve important problems in the SKS600 airship is addressed. The system architecture and fiber optics on the SKS600 are described, and the installation of fiber optics in the system is recounted. A study undertaken to ascertain the feasibility of installing an experimental FBL system on the test bed BAC 1-11 aircraft is addressed, including the use of a fiber optic rotation position transducer. C.D.

A88-23860
FIBRE OPTICS SENSORS (FOS) FOR AIRCRAFT FLIGHT CONTROLS
P. T. GARDINER and R. A. EDWARDS (Smiths Industries Aerospace and Defence Systems Co., London, England) IN: Applications of light in guided flight; Proceedings of the Symposium, London, England, Jan. 22, 1987 . London, Royal Aeronautical Society, 1987, p. 42-63. refs

Fiber optic sensor (FOS) technology is reviewed, and the suitability of particular FOS techniques for certain flight control applications is discussed. Digital, unmultiplexed, time-division multiplexed, wavelength division multiplexed (WDM), and analog methods for FOS are addressed, and FOS techniques to produce intensity modulation, spectral modulation, phase modulation, and polarization modulation are considered. The selection of the most suitable FOS techniques is examined, including the choice between intrinsic and extrinsic sensors, digital and analog sensors, and various digital FOS design approaches. A digital, WDM, fiber optic displacement transducer design is described. C.D.

A88-24439#
SENSITIVITY OF AIRCRAFT STABILITY TO CROSS-COUPLING DERIVATIVES AND ANGULAR ACCELERATION DERIVATIVES AT HIGH ANGLES OF ATTACK
ZHIDAI HE (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 5, Dec. 1987, p. 334-344. In Chinese, with abstract in English. refs

The stability of advanced fighter aircraft at high angles of attack is investigated analytically, with a focus on the effects of including aerodynamic cross-coupling derivatives in the governing equations. The derivation is explained in detail, and the results of numerical computations on 6-DOF equations are presented in graphs. At least some of the cross-coupling effects are shown to be of significance for aircraft design. T.K.

A88-24505#
LARGE MOTION FLIGHT CONTROL SYSTEM DESIGN FOR AIRCRAFT BY THE THEORY OF PERFECT SERVO
SHOKICHI KANNO (Ichinoseki National College of Technology, Japan), AKIRA HASHIMOTO, and TATSUO CHUBACHI (Iwate University, Ueda, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 30, Nov. 1987, p. 133-149. refs

A decoupled and linearized tracking flight control system design for the large motion of aircraft is analyzed as an application of the theory of a nonlinear perfect tracking servo. The nonlinear rigid body dynamics are considered, but the nonlinear aerodynamics are neglected. The nonlinear terms of state equations are estimated and transformed to be added to the input signals of aircraft, and the nonlinearities are canceled. These nonlinear compensations permit the aircraft system to become linear. The precompensators with signal limiters and subcompensators are added, and the nonlinear perfect servo systems are achieved. The transfer matrix of this servo equals I3, even if the signals are saturated. Simulations on a high-speed aircraft show good results. C.D.

A88-24752
SYNTHESIS OF SELF-OSCILLATORY PROCESSES FOR THE CONTROL OF FLIGHT VEHICLE MANEUVERS [SINTEZ AVTOKOLEBATEL'NYKH REZHIMOV PRI UPRAVLENII MANEVROM LETATEL'NOGO APPARATA]
S. K. ARUTIUNOV and A. I. DIVEEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1987, p. 7-11. In Russian.

A method is presented for the synthesis of a nonlinear regulator in the control system of a flight vehicle. The nonlinear adaptive regulator proposed here provides for self-oscillatory processes in the control circuit of a flight vehicle during maneuvers between balance states. To demonstrate the approach, control synthesis for a heavy aircraft is considered as an example. V.L.

A88-24769
DAMPING MOMENT OF AIRCRAFT PITCHING IN UNSTEADY FLOW [DEMPFIRUIUSHCHII MOMENT TANGAZHA LETATEL'NOGO APPARATA PRI NESTATSIONARNOM OBTEKANII]
F. I. GANIEV and V. I. MOROZOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1987, p. 77, 78. In Russian.

The damping characteristics of various types of aircraft due to nonstationary aerodynamic effects are investigated using current numerical methods. The contributions of individual aircraft components and their interference to the damping moment of pitching are determined. Results are presented for both subsonic and supersonic flight velocities. V.L.

A88-24798
AIRCRAFT DYNAMICS AND CONTROLLABILITY (2ND REVISED AND ENLARGED EDITION) [DINAMIKA I UPRAVLIAEMOST' SAMOLETA /2ND REVISED AND ENLARGED EDITION/]
IGOR' MIKHAILOVICH PASHKOVSKII Moscow, Izdatel'stvo Mashinostroenie, 1987, 248 p. In Russian. refs

The physical principles underlying the theory of aircraft stability and controllability are examined. In particular, attention is given to quantitative stability and controllability characteristics, the dynamic characteristics of modern aircraft, critical phenomena in the controllability dynamics of aircraft, and classification of the critical flight regimes of high-speed aircraft. The discussion also covers methods of flight evaluation of the dynamic properties and controllability of high-speed aircraft and methods for the analysis of critical flight conditions. V.L.

N88-14987*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HANDLING QUALITIES OF A WIDE-BODY TRANSPORT AIRPLANE UTILIZING PITCH ACTIVE CONTROL SYSTEMS (PACS) FOR RELAXED STATIC STABILITY APPLICATION
WILIAM D. GRANTHAM, LEE H. PERSON, JR., PHILIP W. BROWN, LAWRENCE E. BECKER, GEORGE E. HUNT, J. J. RISING, W. J. DAVIS, C. S. WILLEY, W. A. WEAVER, and R. COKELEY Dec. 1985 109 p
(NASA-TP-2482; L-15928; NAS 1.60:2482) Avail: NTIS HC A06/MF A01 CSCL 01C

Piloted simulation studies have been conducted to evaluate the effectiveness of two pitch active control systems (PACS) on the flying qualities of a wide-body transport airplane when operating at negative static margins. These two pitch active control systems consisted of a simple 'near-term' PACS and a more complex 'advanced' PACS. Eight different flight conditions, representing the entire flight envelope, were evaluated with emphasis on the cruise flight conditions. These studies were made utilizing the Langley Visual/Motion Simulator (VMS) which has six degrees of freedom. The simulation tests indicated that (1) the flying qualities of the baseline aircraft (PACS off) for the cruise and other high-speed flight conditions were unacceptable at center-of-gravity positions aft of the neutral static stability point; (2) within the linear static stability flight envelope, the near-term PACS provided acceptable flying qualities for static stabilty margins to -3 percent; and (3) with the advanced PACS operative, the flying qualities were demonstrated to be good (satisfactory to very acceptable) for static stabilty margins to -20 percent. Author

N88-15813*# Purdue Univ., West Lafayette, Ind.
A SIMULATION STUDY OF THE FLIGHT DYNAMICS OF ELASTIC AIRCRAFT. VOLUME 2: DATA
MARTIN R. WASZAK, JOHN B. DAVIDSON, and DAVID K. SCHMIDT Washington NASA Dec. 1987 223 p
(Contract NAG1-254)
(NASA-CR-4102-VOL-2; NAS 1.26:4102-VOL-2) Avail: NTIS HC A10/MF A01 CSCL 01C

The simulation experiment described addresses the effects of structural flexibility on the dynamic characteristics of a generic family of aircraft. The simulation was performed using the NASA Langley VMS simulation facility. The vehicle models were obtained as part of this research project. The simulation results include complete response data and subjective pilot ratings and comments and so allow a variety of analyses. The subjective ratings and analysis of the time histories indicate that increased flexibility can lead to increased tracking errors, degraded handling qualities, and changes in the frequency content of the pilot inputs. These results, furthermore, are significantly affected by the visual cues available to the pilot. 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.

A88-21206
UNIQUE TEST CAPABILITIES OF THE EGLIN AFB MCKINLEY CLIMATIC LABORATORY
LORIN D. KLEIN (USAF, McKinley Climatic Laboratory, Eglin AFB, FL) (Institute of Environmental Sciences, Annual Technical Meeting, 33rd, San Jose, CA, May 1987) Journal of Environmental Sciences (ISSN 0022-0906), vol. 30, Nov.-Dec. 1987, p. 27-29.

The 92,900 cu m main chamber of the Climatic Laboratory is the largest and most complex climatic environmental test chamber in the world. It employs an air makeup system to cool or heat air to the test tempertures and ingest this air into the chamber to allow the operation of jet engines during climatic tests. Other test chambers discussed are the 2750 cu m Engine and Equipment Test Facility and the 2125 cu m Sun, Wind, Rain, and Dust Facility. Author

A88-22035#
COMBUSTOR TEST FACILITY AND OPTICAL INSTRUMENTATION FOR COMPLEX TURBULENT REACTING FLOW
R. E. WALTERICK, W. A. DE GROOT, J. I. JAGODA, and W. C. STRAHLE (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(Contract AF-AFOSR-83-0356)
(AIAA PAPER 88-0052)

The flowfield in the flame stabilization region of a backward-facing step configuration, with mass injection from the bottom wall behind the step, is presently simulated by a two-dimensional subsonic wind tunnel configuration. State-of-the-art LDV, Rayleigh light scattering and Raman spectroscopy instruments are incorporated in order to measure reacting and nonreacting flows; acoustic/flowfield interaction studies can also be conducted with a system for the input of acoustic pressure waves. Auxiliary systems are used to deliver combustible and inert gases to the facility and to accomplish data acquisition/analysis and flowfield-visualization functions. O.C.

A88-22036#
THE ASU UNSTEADY WIND TUNNEL AND FUNDAMENTAL REQUIREMENTS FOR FREESTREAM TURBULENCE MEASUREMENTS
WILLIAM S. SARIC, SHOHEI TAKAGI, and MARC C. MOUSSEUX (Arizona State University, Tempe) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(Contract -N00014-85-K-0527)
(AIAA PAPER 88-0053)

In order to assess the flow quality in wind tunnels used for sensitive experiments, requirements for the measurement of freestream turbulence levels are stated. These requirements are applied to the steady-flow calibration of a new wind-tunnel facility at Arizona State University. Examples of freestream turbulence and boundary-layer transition measurements are given. Author

A88-22037*# Kansas Univ. Center for Research, Inc., Lawrence.
EXPERIMENTAL INVESTIGATION OF INLET FLOW-CONTROL CASCADES FOR THE NFAC 80- BY 120-FOOT INDRAFT WIND TUNNEL
JOHANNES M. VAN AKEN (University of Kansas Center for Research, Inc., Lawrence) and NINA M. SCHELLER (U.S. Army, Aviation Research and Technology Activity, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 22 p. refs
(Contract NCC2-320; NCC2-417)
(AIAA PAPER 88-0054)

The present investigation of aerodynamic performance for various inlet cascade configurations of an indraft wind tunnel with a short inlet and a low contraction ratio has given attention to the effects of inlet wall shape, antiturbulence screens, and horizontal flow straighteners on test-section flow quality. It is found that an inlet cascade with a tailored vane-splay distribution, antiturbulence screen, and horizontal splitters, will both yield good test section flow quality and furnish isolation from atmospheric winds and turbulence. O.C.

A88-22038*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE DEVELOPMENT OF A FACILITY FOR FULL-SCALE TESTING OF AIRFOIL PERFORMANCE IN SIMULATED RAIN
JOHN T. TAYLOR, CADD T. MOORE, III, BRYAN A. CAMPBELL (NASA, Langley Research Center, Hampton, VA), and W. EDWARD. MELSON, JR. (NASA, Wallops Flight Center, Wallops Island, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0055)

NASA Langley's Aircraft Landing Dynamics Facility has been adapted in order to test the performance of airfoils in a simulated rain environment, at rainfall rates of 2, 10, 30, and 40 inches/hour, and thereby derive the scaling laws associated with simulated rain in wind tunnel testing. A full-scale prototype of the rain-generation system has been constructed and tested for suitable rain intensity, uniformity, effects of crosswinds on uniformity, and drop size range. The results of a wind tunnel test aimed at ascertaining the minimum length of the simulated rain field required to yield an airfoil performance change due to the rain environment are presented. O.C.

A88-22101*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EVALUATION OF A FLEXIBLE WALL TESTING TECHNIQUE TO MINIMIZE WALL INTERFERENCES IN THE NASA LANGLEY 0.3-M TRANSONIC CRYOGENIC TUNNEL
STEPHEN W. D. WOLF (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0140)

Free air simulations in conventional transonic wind tunnels require improvement which adaptive wall testing techniques can provide primarily by minimizing wall interferences. In addition, these techniques offer other substantial advantages such as increased Reynolds number capability and a reduction in tunnel drive power. The combination of an adaptive wall test section with a continuous flow cryogenic wind tunnel is unique. The test section has four solid walls with two flexible walls mounted between rigid sidewalls. This modification of an existing major facility stresses the practicalities of the testing technique. These practicalities were evaluated in terms of flexible wall test section design and operation. Increased hardware and operating complexity of the new test section is offset by a significant improvement in real-time data accuracy in two-dimensional testing. Validation testing has expanded the experience with flexible walled test sections into the realms of flight Reynolds numbers and high lift. Data accuracy has been assessed with regard to test section geometry and operating tolerances. The successful evaluation of the testing technique in two-dimensional testing has proved that a production type operation is possible, with suitable control system and test section design. The 0.3-m Transonic Cryogenic Tunnel with an adaptive wall test section currently represents the most advanced two-dimensional facility anywhere. Author

A88-22103*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
OPERATING CHARACTERISTICS OF A 60 CM AND A 10 CM ELECTRIC ARC-DRIVEN SHOCK-TUBE
SURENDRA P. SHARMA, CHUL PARK (NASA, Ames Research Center, Moffett Field, CA), and ROBERT E. DANNENBERG (Kendan Associates, Mountain View, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 20 p. refs
(AIAA PAPER 88-0142)

This paper describes the current status of the operating characteristics of the electric arc-driven shock-tube facility at Ames Research Center, focusing on its potential usefulness in the current and anticipated future applications. The paper specifically addresses the questions as to: (1) how well the behavior of the arc driver is understood and controlled, (2) how well the facility is equipped to test low-density, very-high-velocity nonequilibrium flow regimes, and (3) how closely the facility is expected to produce an equilibrium hypersonic flow when operated in shock-tunnel modes. For these issues, it is shown that: (1) a plasma kinetics model of the exploding wire closely describes the arc behavior in the driver, (2) the facility can produce a spectroscopically-clean flow in a low density regime with a shock velocity of 13 km/sec in air when used with an aluminum driven tube, and (3) when operated as a shock-tunnel, the high enthalpy flow in the test section is expected to deviate only slightly from the perfect equilibrium flow conditions at enthalpies corresponding to flight speeds of 5 km/sec or less. Author

A88-22104*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN AND FABRICATION REQUIREMENTS FOR LOW-NOISE SUPERSONIC/HYPERSONIC WIND TUNNELS
I. E. BECKWITH, F.-J. CHEN, and M. R. MALIK (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0143)

Analyses of NASA Langley experimental results obtained from efforts to develop a low disturbance wind tunnel by means of linear stability theory have shown that the amplification of Gortler vortices on the concave walls of nozzles at Mach numbers from 3 to 5 are the cause of transition. The theory is used to design advanced nozzles for Mach numbers of 3.5 and 6 which can generate substantially longer quiet test regions. Transition on the nozzle walls is noted to be extremely sensitive to nozzle wall roughness and contamination. O.C.

A88-22124#
REAL-TIME COMPUTER GENERATED IMAGERY FOR A LOW COST HELICOPTER FLIGHT SIMULATOR
T. A. KAYE AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. Army-supported research. refs
(AIAA PAPER 88-0174)

The design and development of a low cost Computer Generated Image system conducted by the author was specifically tailored around the needs of helicopter simulator flight training. Pilot visual requirements, scene management techniques, image display algorithms, data storage organization, and new low cost graphics processing hardware were considered during the study. Author

A88-22140#
RESULTS FROM LASER SHEET VISUALIZATION OF A PERIODIC ROTOR WAKE
A. G. BRAND, N. M. KOMERATH, and H. M. MCMAHON (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p.
(Contract DAAG29-82-K-0084)
(AIAA PAPER 88-0192)

The laser sheet flow visualization technique was applied to a periodic rotor wake from a rotorcraft in forward flight. For the

experiments, a model consisting of a stiff two-bladed teetering rotor mounted independently of an idealized airframe was installed in a wind tunnel. Tests were carried out at three different advance ratios at one value of rotor collective pitch angle. The laser sheet technique made it possible to visualize flow in great detail and to obtain accurate quantitative data regarding the location of the rotor tip vortex. Results of the visualization experiment indicate that the rotor wake is a complex flow field not amenable to a simple analysis. I.S.

A88-22579#
AN AP-FORTRAN APPLICATION - A FLIGHT SIMULATOR
CLAIRE MICHELON (ONERA, Chatillon-sous-Bagneux, France)
ONERA, TP, no. 1987-117, 1987, 26 p.
(ONERA, TP NO. 1987-117)

A fixed-base simulator has been developed for preliminary studies on control concepts, including task-oriented control systems and real-time flight-path guidance. The simulator hardware is described, including the host computer equipped with its peripheral devices, the array processor, the cockpit with controls and visual hardware system, the management terminal, and the analysis equipment. The software for time sharing, real-time computation and visualization, and results analysis is described. Finally, a transport aircraft application is shown. C.D.

A88-22580#
PROGRESS AND PROBLEMS IN LARGE AERODYNAMIC TESTING FACILITIES [PROGRES ET PROBLEMES DES GRANDS MOYENS D'ESSAIS AERODYNAMIQUES]
JEAN CHRISTOPHE (ONERA, Chatillon-sous-Bagneux, France)
ONERA, TP, no. 1987-125, 1987, 33 p. In French. refs
(ONERA, TP NO. 1987-125)

Following a review of the development of aerodynamic test methods, the characteristics and problems of various large ONERA wind tunnels, including the cryogenic transonic T2 facility, are discussed. Wind tunnel determinations of the effects of Mach and Reynolds number on scale models, in addition to the effects of disturbances on aerodynamic surfaces and on the upstream flow, are considered. Test flight data/wind tunnel data comparisons are discussed for the case of the 310 Airbus. The use of wind tunnel data in validating and improving numerical methods for the prediction of aerodynamic flows is also considered. R.R.

A88-22597#
PRECISION IMPROVEMENT OF TRANSPORT AIRCRAFT DRAG MEASUREMENTS [AMELIORATION DE LA PRECISION DE LA MESURE DE LA TRAINEE D'UN AVION DE TRANSPORT]
C. ARMAND (ONERA, Modane, France) and C. PUJOL (Aerospatiale, Paris, France) (NATO, AGARD, Symposium sur la Precision et Qualite des Resultats des Mesures Aerodynamiques - Besoins et Realisations, Naples, Italy, Sept. 28-Oct. 1, 1987) ONERA, TP, no. 1987-144, 1987, 24 p. In French. refs
(ONERA, TP NO. 1987-144)

Methods employed in the ONERA S1MA and S2MA wind tunnels for attaining the desired absolute precision of 0.0001 in drag measurements of Airbus-type transport aircraft are discussed. Factors considered include the quality of the balances, the precision of the incidence measurements, and the effects of friction and extreme temperatures. It is also noted that in order to obtain accurate drag measurements the airfoil geometry and the pressure distribution on the airfoil must be known to a high degree of precision. The results are corrected for the pressure fields in the test section and for the effects of the walls and the sting. R.R.

A88-22599#
INSTANTANEOUS FORCE MEASUREMENTS ON A MODEL SUBJECTED TO RAPID CONTROL VARIATIONS [MESURE DES EFFORTS INSTANTANES SUR UNE MAQUETTE SOUMISE A DES VARIATIONS RAPIDES DE COMMANDE]
J. P. DREVET (ONERA, Modane, France) and M. ROBERT (Aerospatiale, Paris, France) (NATO, AGARD, Symposium sur la Precision et Qualite des Resultats des Mesures Aerodynamiques - Besoins et Realisations, Naples, Italy, Sept. 28-Oct. 1, 1987) ONERA, TP, no. 1987-146, 1987, 21 p. In French.
(ONERA, TP NO. 1987-146)

The development of a wind-tunnel model using a lateral-jet system to enact rapid control variations is discussed, and the results of instantaneous force measurements obtained with the model without wind in the supersonic test section of the ONERA S2MA facility are reported. The range of frequencies to be avoided in controlling the generator are identified, and a mathematical model for calculating the model motion is developed. Torsion applied to the model is measured with a precision of + or - 5 percent in roll and + or - 10 percent in pitch and yaw over a range of frequencies from 0 to 60 Hz. Good correlation is found between the applied and measured forces. R.R.

A88-22802*# Boeing Vertol Co., Philadelphia, Pa.
MODEL 360 ROTOR TEST AT DNW - REVIEW OF PERFORMANCE AND BLADE AIRLOAD DATA
LEO DADONE, DON EKQUIST (Boeing Vertol Co., Philadelphia, PA), SETH DAWSON, and DONALD BOXWELL (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Paper. 13 p. refs

The results of tests on a pressure gage instrumented model rotor, performed at the Duits Nederlandse Windtunnel (DNW) are discussed. The rotor, which was a 1/5 scale model of the Boeing Vertol model 360 rotor, was tested both in the anechoic open jet test section, and in the 8 x 6 m closed test section of the DNW. The wind tunnel, the blade instrumentation, and the test conditions are described, and data on rotor performance, blade and control loads, and blade-pressure and acoustic measurements are presented. I.S.

A88-22873
A NEW APPROACH FOR FLIGHT SIMULATOR VISUAL SYSTEMS
KEITH BLANTON (IVEX Corp., Atlanta, GA) IN: Simulators IV; Proceedings of the SCS Conference, Orlando, FL, Apr. 6-9, 1987 . San Diego, CA, Society for Computer Simulation, 1987, p. 229-233.

Unlike conventional simulator visual systems which are high-speed polygon drawing engines, the described system is based on image extrapolation techniques. True six-degree-of-freedom motion is permitted over a flat terrain having extremely high quality texturing and detail. The system uses a video disk for mass storage and is capable of spanning a 50 mile x 50 mile database, from 0 to 100,000 feet in altitude. The approach is relatively low cost, yet guarantees new images at a 30 Hertz rate. Author

A88-22874
A NEW GENERATION OF FLIGHT SIMULATORS - DESIGN CONFIGURATION WITH DISCRETE-EVENT SIMULATION
J. K. COCHRAN, N. F. HUBELE (Arizona State University, Tempe), and D. J. SYKES (Honeywell, Inc., Training and Control Systems Div., West Covina, CA) IN: Simulators IV; Proceedings of the SCS Conference, Orlando, FL, Apr. 6-9, 1987 . San Diego, CA, Society for Computer Simulation, 1987, p. 234-238. refs

Preliminary studies into a new generation of flight simulators are presented. The system employs digitized photographs of scene components which are superimposed in real time on the screen. The timing difficulties in this new type of system are based on the retrieval and hardware processing speed of photographic information stored in various rotating memory devices. Several distinct alternative system configurations were proposed, and two significant discrete-event simulation models were constructed to

evaluate the anticipated performance of the competing configurations. The preliminary results from prototype simulation studies suggest that there is great potential for this new generation of flight simulators. K.K.

A88-22875
SIMULATED AIRCRAFT MAINTENANCE TRAINERS - THEN AND NOW
DON S. BOYER and KATHY V. HILLBURG (Honeywell, Inc., Training and Controls Systems Div., West Covina, CA) IN: Simulators IV; Proceedings of the SCS Conference, Orlando, FL, Apr. 6-9, 1987 . San Diego, CA, Society for Computer Simulation, 1987, p. 260-265.

The development of software-based simulators for training USAF flight line technicians to diagnose, troubleshoot, and repair aircraft systems is traced. In connection with simulated aircraft maintenance trainers, emphasis is placed on instructor/student interfaces, simulation fidelity, software/courseware development, and processors. It is noted that new technologies such as videodisks are greatly enhancing training by providing more flexibility and ease of use, with an order of magnitude increase in support visuals and training aids. K.K.

A88-23522
A NEW LARGE-SCALE TEST RIG FOR COMPRESSOR RESEARCH [NEUER GROSSPRUEFSTAND FUER DIE VERDICHTERFORSCHUNG]
HANS HUNGENBERG (DFVLR, Institut fuer Antriebstechnik, Cologne, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1987, p. 30, 31. In German.

The test rig for one-shaft or two-shaft multistage compressors installed at the propulsion technology institute at DFVLR Koeln-Porz in 1987 is described. The 10-MW (2 x 5 MW) rig is driven by two electric motors (maximum speed 2000 rpm in either direction) coupled to the compressor shaft or shafts by a gear system permitting compressor speeds up to 15,000 rpm; both open-loop and closed-loop operation (at inlet pressures as low as 0.3 bar) are provided for. Diagrams of the facility and the computer control structure are provided, and the applicability of the rig to turbocompressors for aircraft engines or the air-breathing hybrid engines of proposed SSTO spacecraft is indicated. T.K.

A88-23523
INTERNATIONAL COOPERATION AT THE EUROPEAN TRANSONIC WIND TUNNEL (ETW) IN KOELN-PORZ [INTERNATIONALE ZUSAMMENARBEIT BEIM EUROPAEISCHEN TRANSSONISCHEN WINDKANAL (ETW) IN KOELN-PORZ]
DIETER SCHIMANSKI and DIETRICH VENNEMANN (DFVLR, Cologne, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1987, p. 32-34. In German.

The overall design and current status of the ETW, a 50-MW cryogenic wind tunnel being constructed for use by the European aircraft industry, are discussed. The ETW will have a 2.4 x 2.0-m working section and use N2 cooled to as low as 90 K to test transport-aircraft models at M = 0.15-1.3, pressure 1.25-4.5 bar, and realistic Reynolds numbers; a novel arrangement with exchangeable model carriers is intended to minimize warming up and recooling of the ETW during model reconfigurations. The efficient design of the ETW should permit 5000 polar measurements per year. Plans call for completion of detailed plans by May 1988, completion of major construction by 1992, and first project measurements in June 1994. The estimated construction costs of 560 million DM are divided as follows (in percent): FRG 38, France 28, UK 28, and Netherlands 6. T.K.

A88-24501
INTO THE WIND
VICTOR D. CHASE Air and Space (ISSN 0886-2257), vol. 2, Feb.-Mar. 1988, p. 58-67.

A development status evaluation is presented for the variety of wind tunnel sizes, operating regimes, and types that are routinely employed at NASA's Langley and Ames aerodynamics research facilities. The wind tunnels are of continuous or intermittent flow, subsonic, transonic, supersonic or hypersonic, high-temperature or cryogenic, and employ a variety of instrumentation and flow visualization devices in conjunction with digital test data gathering and analysis resources. The creativity and the discoveries that have distinguished the career of aerodynamicist R. T. Whitcomb in conjunction with NASA wind tunnel work are noted. O.C.

A88-24785
HARD RUNWAY AND HIGHWAY PAVEMENTS [ZHESTKIE POKRYTIIA AERODROMOV I AVTOMOBIL'NYKH DOROG]
GEORGII IVANOVICH GLUSHKOV, VALERII FEDOROVICH BABKOV, IOSIF ARKAD'EVICH MEDNIKOV, L. I. GORETSKII, V. E. TRIGONI et al. Moscow, Izdatel'stvo Transport, 1987, 255 p. In Russian. refs

Hard runway and highway pavements are examined with reference to various climatic and hydrogeological regions of the USSR. The discussion covers requirements for pavement materials, structures of state-of-the-art runway and highway pavements, and environmental and service-related factors affecting the runway and highway pavements. A unified approach is presented to the design of hard pavements with allowance for the static and dynamic loads and temperatures typical of their operation. The use of a systems approach in the analysis and design of pavements is discussed. V.L.

N88-14937*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LOW-DISTURBANCE WIND TUNNELS
I. E. BECKWITH, Z. T. APPLIN, P. C. STAINBACK, and L. MAESTRELLO *In its* Langley Symposium on Aerodynamics, Volume 1 p 209-223 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 14B

During the past years, there was an extensive program under way at the Langley Research Center to upgrade the flow quality in several of the large wind tunnels. This effort has resulted in significant improvements in flow quality in these tunnels and has also increased the understanding of how and where changes in existing and new wind tunnels are most likely to yield the desired improvements. As part of this ongoing program, flow disturbance levels and spectra were measured in several Langley tunnels before and after modifications were made to reduce acoustic and vorticity fluctuations. A brief description of these disturbance control features is given for the Low-Turbulence Pressure Tunnel, the 4 x 7 Meter Tunnel, and the 8 Foot Transonic Pressure Tunnel. To illustrate typical reductions in disturbance levels obtained in these tunnels, data from hot-wire or acoustic sensors are presented. A concept for a subsonic quiet tunnel designed to study boundary layer stability and transition is also presented. Techniques developed at Langley in recent years to eliminate the high intensity and high-frequency acoustic disturbances present in all previous supersonic wind tunnels are described. In conclusion, the low-disturbance levels present in atmospheric flight can now be simulated in wind tunnels over the speed range from low subsonic through high supersonic. Author

N88-14939*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STATUS OF MAGNETIC SUSPENSION TECHNOLOGY
RICHMOND P. BOYDEN and PING TCHENG *In its* Langley Symposium on Aerodynamics, Volume 1 p 261-277 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 14B

The reasons for the continuing interest in the Magnetic Suspension and Balance System (MSBS) are highlighted. Typical problems that can arise because of model-support interference in a transonic wind tunnel are shown to illustrate the need for MSBS. The two magnetic suspension systems in operation at Langley are the only ones active in the U.S. One of these systems is the 13 inch MSBS which was borrowed from the Air Force Arnold Engineering Development Center. The other system is the 6 inch MSBS which was developed by MIT Aerophysics Laboratory with NASA and DOD funding. Each of these systems is combined with a subsonic wind tunnel. Ongoing research in both of these systems

is covered. Last year, Madison Magnetics, Inc., completed a contractual design and cost study utilizing some advance concepts for a large MSBS which would be compatible with an 8 foot transonic wind tunnel and the highlights of the study are presented. Sverdrup Technology, Inc., recently performed a study under contract for Langley on the potential usefulness to the aerospace industry of a proposed large MSBS combined with a suitable transonic wind tunnel. The results of that study are discussed. Langley has partially funded the MSBS work at the University of Southampton for about 6 years under a grant arrangement and the major results are summarized. Author

N88-14941*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRELIMINARY CALIBRATION AND TEST RESULTS FROM THE NATIONAL TRANSONIC FACILITY
LINWOOD W. MCKINNEY and DENNIS E. FULLER *In its* Langley Symposium on Aerodynamics, Volume 1 p 311-331 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 14B

The National Transonic Facility (NTF) was operated to design condition of 120 million Reynolds number at a Mach number of 1.0. All systems were checked out except plenum isolation valves; modifications are being made to heaters on the actuators. Initial steady-state calibration indicates excellent steady flow characteristics. The first test of the Pathfinder 1 model indicated significant Reynolds number effects. Some effect of temperature on instrumentation were obtained. The cause of these effects is being evaluated. Author

N88-14990# Computer Resource Management, Inc., Vienna, Va.
CHICAGO'S O'HARE RUNWAY CONFIGURATION MANAGEMENT SYSTEM (RCMS). VOLUME 1: DESCRIPTION OF THE OPERATIONAL SOFTWARE
ANTHONY BRADLEY, HELEN MONK, and EDWARD JAGGARD Jul. 1987 94 p
(Contract DTFA03-85-C-00046)
(AD-A185886; DOT/FAA/CT-86/15-1) Avail: NTIS HC A05/MF A01 CSCL 01E

Volume I of this report describes the proposed Runway Configuration Management System (RCMS) operational software for review by the facility personnel. It also serves as an input to RCMS functional specifications for the Traffic Management System (TMS) program. Using interactive computer logic, RCMS helps supervisors select runway configurations which reduce aircraft delays by optimizing throughput capacity in dynamic operational environments. Author (GRA)

N88-14991# Navy Personnel Research and Development Center, San Diego, Calif.
FIELD EVALUATION OF INTERACTIVE SIMULATION FOR MAINTENANCE TRAINING: SH3 HELICOPTER ELECTRO-MECHANICAL BLADEFOLD SYSTEM Technical Report, Nov. 1985 - Dec. 1986
VERNON M. MALEC and MICHAEL LUSZCZAK Oct. 1987 35 p
(AD-A185923; AD-F000114; NPRDC-TR-88-2) Avail: NTIS HC A03/MF A01 CSCL 05I

This report describes an evaluation of the training effectiveness and suitability of an interactive simulation device and its instructional and simulation software used in connection with SH-3 helicopter electro-mechanical bladefold system training in the Naval Air Maintenance Training Group Detachment training environment. Although the study did not have sufficient subjects in all measurement categories for the application of statistical analysis methods, the results indicate that the training device is an effective supplement to both hydraulic and electrical systems training currently being performed on the SH-3 helicopter composite trainer. Trainees using the interactive training system required less time to complete troubleshooting exercises on the composite trainer, made fewer replacement errors, and obtained higher grades on written tests relating to the bladefold systems. GRA

N88-14992# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
THE ROLE OF ADAPTIVE SUPPLEMENTAL VISUAL CUING IN FLIGHT SIMULATION M.S. Thesis
EDDY R. BILLMAN 1987 51 p
(AD-A185932; AD-F000114; AFIT/CI/NR-87-106T) Avail: NTIS HC A04/MF A01 CSCL 05I

The utility of adaptive visual cues for instructing an approach-to-landing task in a personal computer-based flight simulator was tested. Flight naive subjects in a control group trained with reference to a visual display that consisted of horizon, runway outline, runway centerline and touchdown aimpoint. Two experimental groups trained with glidepath and heading cues augmenting the display either constantly or adaptively. A simulator-to-simulator transfer-of-training design found no significant differences between instructional methods. Because other research had found adaptive cueing to be beneficial in transfer, implications of the differences in design considerations such as visual display field of view and the amount or content of subject pre-training is discussed and related to this study. GRA

N88-14993# Army Engineer Waterways Experiment Station, Vicksburg, Miss. Geotechnical Lab.
COMPARATIVE STUDY OF NONDESTRUCTIVE PAVEMENT TESTING, MACDILL AIR FORCE BASE, FLORIDA Final Report, Aug. 1982 - Sep. 1983
JIM W. HALL, JR Jul. 1987 270 p
(AD-A186082; WES/TR/GL-87-15) Avail: NTIS HC A12/MF A01 CSCL 13B

This project is the most comprehensive single undertaking to date which is directed toward an evaluation of the validity of concepts of nondestructive evaluation of the load-carrying capacity of airfield pavements. Seven nondestructive test devices tested five sections of airfield pavements at MacDill Air Force Base (AFB) which consisted of two rigid, two flexible, and one composite pavements, ranging from 20-in. portland cement concrete (PCC) to 5.5-in. asphaltic concrete. Analytical treatments of the test data included empirical correlation analyses, and layered-elastic and finite element computer analyses. Six private firms each with a different nondestructive testing (NDT) evaluation method provided evaluation results in terms of allowable aircraft loads and overlay thicknesses. The Air Force produced one set of results using its new nondestructive pavement testing method, and Waterways Experiment Station provided three sets of results. This study has shown that NDT technology exists for evaluation of airfield pavements. For the pavements at MacDill AFB, some NDT evaluation methods agreed better with the standard test-pit method than others. However, the pavements at MacDill AFB are rather nontypical, and those NDT evaluation methods that did not give good results at MacDIII may give more agreeable results on different pavements. The lack of agreement between results of the NDT evaluation methods does justify concern and may point to the need for a standard evaluation method. GRA

N88-15814*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL INVESTIGATION OF THE SUBSONIC HIGH-ALTITUDE OPERATION OF THE NASA LEWIS 10- BY 10-FOOT SUPERSONIC WIND TUNNEL
CHRISTOPHER E. HUGHES and ROBERT J. JERACKI Jan. 1988 26 p
(NASA-TM-100214; E-3823; NAS 1.15:100214) Avail: NTIS HC A03/MF A01 CSCL 14B

An experimental investigation was conducted in the NASA Lewis 10- by 10-Foot Supersonic Wind Tunnel during subsonic tunnel operation in the aerodynamic cycle to determine the test section flow characteristics near the Advanced Turboprop Project propeller model plane of rotation. The investigation used an eight-probe pitot static flow survey rake to measure total and static pressures at two locations in the wind tunnel: the test section and the bellmouth section (upstream of the two-dimensional flexible-wall nozzle). A cone angularity probe was used to measure any flow angularity in the test section. The evaluation was

conducted at tunnel Mach numbers from 0.10 to 0.35 and at three operating altitudes from 2,000 to 50,000 ft. which correspond to tunnel reference total pressures from 1960 to 245 psfa, respectively. The results of this experimental investigation indicate a total-pressure loss area in the center of the test section and a static-pressure gradient from the test section centerline to the wall. These total and static pressure differences were observed at all tunnel operating altitudes and diminished at lower tunnel velocities. The total-pressure loss area was also found in the bellmouth section, which indicates that the loss mechanism is not the tunnel flexible-wall nozzle. The flow in the test section is essentially axial since very small flow angles were measured. The results also indicate that a correction to the tunnel total and static pressures must be applied in order to determine accurate freestream conditions at the test section centerline. Author

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ASTRONAUTICS

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

A88-21522#
THE CONCEPT OF A WORLDWIDE SATELLITE-BASED COMMUNICATIONS, NAVIGATION AND SURVEILLANCE SYSTEM
C. ROSETTI (ESA, Directorate of Telecommunications, Paris, France) ESA Bulletin (ISSN 0376-4265), no. 52, Nov. 1987, p. 30-37.

Rapid developments in satellite technology mean that the latest satellite navigation systems have significant potential for replacing today's expensive and inefficient terrestrial radio-navigation networks. The new systems can offer high precision, global coverage and permit a significant reduction in the equipment that has to be carried on board mobiles, in particular aircraft. They can also serve several categories of user, thereby reducing costs, and can be integrated with such other functions as communications, surveillance, and search and rescue. Author

A88-23324
US PREPARES FOR A HYPERSONIC FUTURE
DAVID BAKER New Scientist (ISSN 0028-6664), vol. 116, Dec. 3, 1987, p. 42-46.

A configurational concept and component technology development status report is presented for the NASA National Aerospace Plane 'NASP', the X30 experimental aircraft that will demonstrate its most essential technologies' readiness, and the Hotol SSTAV that is Britain's competitor to the NASP. Attention is given to high temperature airframe and propulsion system materials' availability, as well as to the prospects for active cooling and the optimization of turboject/scramjet dual propulsion systems. Both the military and civilian applications of these transatmospheric vehicles are evaluated. O.C.

A88-24800
NONLINEAR DYNAMICS OF FLIGHT VEHICLES WITH DEFORMABLE ELEMENTS [NELINEINAIA DINAMIKA LETATEL'NYKH APPARATOV S DEFORMIRUEMYMI ELEMENTAMI]
LEV VIKTOROVICH DOKUCHAEV Moscow, Izdatel'stvo Mashinostroenie, 1987, 232 p. In Russian. refs

The paper is concerned with the motion of flight vehicles involving large angles of rotation, with deformable elements, such as rods, plates, compartments, and fluid masses, undergoing vibrational displacement under the effect of mass forces. Attention is given to the most important aspects of constructing a dynamic scheme of three-dimensional flight vehicle motion, which is represented by a system of nonlinear differential equations. The necessary and sufficient conditions are obtained for the stability of the stationary motions of flight vehicles. Some theoretically and practically important cases of dynamic instability associated with the passive orientation dynamics of flight vehicles with deformable elements are discussed. V.L.

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A88-20719
A HYBRID FIBERGLASS-CFRP CLOTH FOR NEW FURNISHINGS
M. J. FRUSTIE (Aerospatiale, Toulouse, France) IN: Looking ahead for materials and processes; Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 18-21, 1987 . Amsterdam, Elsevier, 1987, p. 249-256. refs

A phenolic resin-matrix/hybrid fiberglass and carbon fiber cloth-reinforced prepreg has been developed with a view to compliance with FAR 25 Amendment 61 and FAR Amendment 189 fire-resistance regulations for cabin interior furnishings. Attention is presently given to the weight-performance and production cost consequences of the use of this material in airliner cabin furnishings. The reinforcing cloth is 33-percent carbon fiber, to achieve the requisite mechanical characteristics, and 66-percent fiberglass, to achieve relative sealing. O.C.

A88-20941#
DECIPHERING CLUES TO SOVIET COMPOSITES
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 26, Jan. 1988, p. 30-32.

Based on the exhibition of the An-124 at the 1985 Paris Air Show, it is reported that the Soviet Union is predisposed to nongraphite composites in lightly loaded skins and fairings. Interior use features graphite, whereas mostly aramids and glass fiber appeared externally. A Soviet engineer has reported that graphite skins on the An-124's doors and panels are bonded to honeycomb cores, which are either aluminum or a phenolic. It was reported in 1987 in Paris that the next Antonov transport will be larger than the An-124 and that 25-30 percent of the structural weight will be composites; this may point to major structural beams made of composites, but no pressure bulkheads which have too many attachments with point loads. Finally, the work of J. Schoutens in reviewing the Soviet literature on metal matrix composites is described. B.J.

A88-21877
QUALITY OPTIMIZATION AND UNIFICATION OF AVIATION GASOLINES [OPTIMIZATSIIA KACHESTVA I UNIFIKATSIIA AVIATSIONNYKH BENZINOV]
E. A. NIKITINA, V. E. EMEL'IANOV, P. V. CHULKOV, N. I. CHERKASOVA, and S. R. LEBEDEV (Vsesoiuznyi Nauchno-Issledovatel'skii Institut Neftianoi Promyshlennosti, Moscow, USSR) Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 11, 1987, p. 39, 40. In Russian. refs

The need for developing a unified aviation gasoline to replace the two kinds of aviation gasolines, B-91/115 and B-95/130, currently in production, is discussed, and the principal requirements for the unified aviation gasoline are briefly examined. In particular, arguments are presented in support of eliminating the rich-mixture knock rating from the aviation gasoline specifications. The main quality characteristics of the proposed new gasoline are listed. V.L.

A88-22554#
REDUCED H2-O2 MECHANISMS FOR USE IN REACTING FLOW SIMULATION
B. D. HITCH and D. W. SENSER (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. refs
(AIAA PAPER 88-0732)

A reduced hydrogen oxidation mechanism suitable for use in propulsion design computations is presented. This mechanism consists of fourteen elementary reactions between eight species and contains the minimum amount of detail necessary to accurately predict H2-air ignition and heat release over wide ranges in temperature, pressure, and equivalence ratio. The influence of common wind tunnel contaminants such as H2O, CO, and CO2 as well as naturally occurring O3 can be accounted for by the addition of six reactions and four species. Mechanism reduction was facilitated by assembling a verified full mechanism and systematically eliminating unnecessary reactions and species. Candidates for removal were identified by examination of species fluxes and rate sensitivities. Ignition and reaction times predicted with the reduced mechanism are within 10 percent of those predicted with the verified full mechanism. Author

A88-22768
LOW-VELOCITY IMPACT DAMAGE IN COMPOSITES
MICHAEL L. BASEHORE (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 577-585.

An effort was made to quantify the effects of low-velocity impact damage on the mechanical behavior of current graphite/epoxy material systems (C3K/5225, HT42/5245C, and C12K/5225). The tests were conducted to assess the relative damage tolerance merit of the material systems and to provide indications of the bounds on the effect impact damage may have on structural performance. Both static and fatigue tests after impact were performed and an effort was made to correlate impact damage with open holes. B.J.

A88-22769* Textron Bell Helicopter, Fort Worth, Tex.
ANALYSIS, PREDICTION, AND PREVENTION OF EDGE DELAMINATION IN ROTOR SYSTEM STRUCTURES
WEN S. CHAN (Bell Helicopter Textron, Inc., Fort Worth, TX), LARRY W. REHFIELD (Georgia Institute of Technology, Atlanta), and T. KEVIN O'BRIEN (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 587-596. refs

Analytical methods such as simple sublaminate analysis, as well as quasi three-dimensional finite element analysis, provide insight into delamination characteristics and reliable trend data with which to make rapid evaluations of competitive concepts in the design environment. It is concluded that free edge delamination can be managed by analysis and prevented by design. However, in order to ensure durable composite structures, more work is needed to characterize delamination that occurs from other sources, such as matrix cracking and ply drops. Author

A88-22771
KAMAN BRAIDED STRUCTURES
N. E. KREBS and E. W. RAHNENFUEHRER (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 605-611. refs

An overview of five recent braided composite structures is presented. Advantages of both dry braiding and the resin transfer molding (RTM) process are discussed. Fatigue evaluation of one braided composite product is presented. Load carrying capability after thorough ballistic penetration is discussed and numerical comparison before and after ballistic damage is exhibited. Attention is also concentrated on the RTM fabrication of a dry preform. Author

A88-22792
MOISTURE EFFECTS OF POLYMETHACRYLIMIDE FOAM AND HONEYCOMB CORE IN SANDWICH/SKIN STRUCTURES
DANA M. GRANVILLE (U.S. Army, Materials Technology Laboratory, Watertown, MA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 907-914. refs

Typical sandwich/skin structures of polymethacrylimide (PMI) foam were processed to investigate the structural integrity, dimensional stability, and weight gain of this closed cell thermoplastic structural foam, in addition to the effects of moisture absorption on peel strength. Results were compared to results obtained with similar structures fabricated using honeycomb cores. Results indicated that water uptake in PMI foam core sandwich structures was much higher than that in honeycomb cores of similar structure. It is noted that facesheet-to-core peeling torques did not suffer due to this migration of moisture. R.R.

N88-15014*# Boeing Commercial Airplane Co., Seattle, Wash.
STUDY ON UTILIZATION OF ADVANCED COMPOSITES IN FUSELAGE STRUCTURES OF LARGE TRANSPORTS Final Report
R. W. JOHNSON, L. W. THOMSON, and R. D. WILSON Feb. 1985 144 p
(Contract NAS1-17417)
(NASA-CR-172406; NAS 1.26:172406) Avail: NTIS HC A07/MF A01 CSCL 11D

The potential for utilizing advanced composites in fuselage structures of large transports was assessed. Six fuselage design concepts were selected and evaluated in terms of structural performance, weight, and manufacturing development and costs. Two concepts were selected that merit further consideration for composite fuselage application. These concepts are: (1) a full depth honeycomb design with no stringers, and (2) an I section stringer stiffened laminate skin design. Weight reductions due to applying composites to the fuselages of commercial and military transports were calculated. The benefits of applying composites to a fleet of military transports were determined. Significant technology issues pertinent to composite fuselage structures were identified and evaluated. Program plans for resolving the technology issues were developed. Author

N88-15060*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIFE MODELING OF THERMAL BARRIER COATINGS FOR AIRCRAFT GAS TURBINE ENGINES
ROBERT A. MILLER 1988 11 p Prepared for the 33rd International Gas Turbine and Aeroengine Congress and Exposition, Amsterdam, The Netherlands, 5-9 Jun. 1988; sponsored by ASME
(NASA-TM-100283; E-3921; NAS 1.15:100283) Avail: NTIS HC A03/MF A01 CSCL 11F

Thermal barrier coating life models developed under the NASA Lewis Research Center's Hot Section Technology (HOST) program are summarized. An initial laboratory model and three design-capable models are discussed. Current understanding of coating failure mechanisms are also summarized. Author

N88-15840# Research Inst. of National Defence, Stockholm (Sweden).
EFFECTS OF AVIATION FLUIDS ON FIBER COMPOSITE MATERIAL
ELISE HALLOFF and BO HOLMBERG Sep. 1987 15 p In SWEDISH; ENGLISH summary Sponsored by the Swedish Material Administration of Armed Forces (Air Material Dept.)
(FOA-C-20674-2.6; ISSN-0347-3694; ETN-88-91399) Avail: NTIS HC A03/MF A01

Specimens of carbon fiber composite materials were exposed to 10 aircraft fluids: oils, fuels, hydraulic fluids, antiicing fluids, coolants, and fire retarding agents, at room temperature and at elevated temperatures. The effect was determined in terms of changes of the mechanical properties of the exposed specimens. This effect is very limited, and no important differences are noted

among the fluids in spite of their different chemical composition. ESA

N88-15875# Societe Nationale Industrielle Aerospatiale, Suresnes (France). Direction Centrale de la Qualite.
STUDY OF SELECTION CRITERIA FOR ADHESIVES USED IN AIRCRAFT STRUCTURE BONDING Final Report [RECHERCHE DE CRITERES DE SELECTION D'ADHESIFS EN VUE DU COLLAGE STRUCTURAL AERONAUTIQUE]
J. N. DEWAS 14 Apr. 1987 115 p In FRENCH
(Contract DRET-84-34-440-00-470-75-01)
(ETN-88-91619; TEST-REPT-DCQ/L-47-378/F) Avail: NTIS HC A06/MF A01

Modified epoxy structural adhesives used for aerospatial applications were investigated. The nonpolymerized state was studied using infrared absorption, liquid column chromatography, nuclear magnetic resonance, and thermomechanical tests. The polymerized state was characterized using torsion and tensile tests, creep tests, morphological studies and thermomechanical tests. The results show that the torsion tests are the most efficient, in combination with the chemical analysis, to furnish information on the structural characteristics of the polymer. ESA

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ENGINEERING

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

A88-20714
NITRILE PHENOLIC COMPOSITIONS AS SURFACE PROTECTION FOR GRAPHITE COMPOSITE STRUCTURES
GORDON L. FELLAND, WARREN C. PAGEL, and DAVID A. WANGSNESS (3M Co., Adhesives Coatings and Sealers Div., Saint Paul, MN) IN: Looking ahead for materials and processes; Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 18-21, 1987 . Amsterdam, Elsevier, 1987, p. 183-187.

Graphite composite structures are subject to damage from abrasion, exposure to environments, handling, etc., as encountered in normal use and maintenance activity. Protection is desired and may be achieved through use of protective layers attached to the exterior of these structures. This paper relates to special nitrile phenolic compositions used in this regard. They are co-cured with the composite structure. Important physical performance properties such as abrasion resistance, aircraft fluids resistance and grit blast cleaning resistance are examined in this paper. The comparative performance of various nitrile phenolic compositions in different thicknesses and to other compositions is made. Author

A88-20716
DESIGN OF A SYSTEM OF INSPECTION ASSISTED BY MICROPROCESSOR (SIAM) FOR MANUAL NON-DESTRUCTIVE TESTING OPERATIONS
J. L. ARNAUD, M. FLORET, and D. LECURU (Aerospatiale, Suresnes, France) IN: Looking ahead for materials and processes; Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 18-21, 1987 . Amsterdam, Elsevier, 1987, p. 213-218.

The System of Inspection Assisted by Microprocessor (SIAM) for manual NDT operations on such composite structures as aircraft flaps uses a formed sensing head, carrying several sensors, that is moved by an operator. The physical phenomena detected by the SIAM sensing head and analyzed by the microprocessor are defined on an inspection-report printout. Position identification, intensity measurement, and inspection management are thereby simultaneously conducted. A factor-of-ten reduction in inspection time has been achieved by SIAM. O.C.

A88-20778*# Purdue Univ., West Lafayette, Ind.
FUEL THERMAL STABILITY EFFECTS ON SPRAY CHARACTERISTICS
A. H. LEFEBVRE (Purdue University, West Lafayette, IN) and D. NICKOLAUS Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, Nov.-Dec. 1987, p. 502-507. NASA-supported research. refs

The propensity of a heated hydrocarbon fuel toward solids deposition within a fuel injector is investigated experimentally. Fuel is arranged to flow through the injector at constant temperature, pressure, and flow rate and the pressure drop across the nozzle is monitored to provide an indication of the amount of deposition. After deposits have formed, the nozzle is removed from the test rig and its spray performance is compared with its performance before deposition. The spray characteristics measured include mean drop size, drop-size distribution, and radial and circumferential fuel distribution. It is found that small amounts of deposition can produce severe distortion of the fuel spray pattern. More extensive deposition restores spray uniformity, but the nozzle flow rate is seriously curtailed. Author

A88-21825
LASER DIAGNOSTICS OF AMMONIA CONTAMINANTS IN THE ATMOSPHERE FROM AN AIRCRAFT [LAZERNAIA DIAGNOSTIKA PRIMESI AMMIAKA V ATMOSFERE S BORTA LETATEL'NOGO APPARATA]
V. V. BEREZOVSKII, A. L. GANDURIN, E. A. IGUMNOV, S. T. KORNILOV, V. A. PETRISHCHEV (Moskovskii Inzhenerno-Fizicheskii Institut, Moscow, USSR) et al. Kvantovaia Elektronika (Moscow) (ISSN 0368-7147), 14, Sept. 1987, p. 1917-1919. In Russian. refs

The differential absorption method is used in conjunction with heterodyne photorecording to develop a remote-controlled laser gas analyzer located aboard an aircraft. A waveguide CO2 laser with alternate switching of the lasing between the two nearest lines of the vibrational-rotational CO2 spectrum was used as the laser source. A site of gas leakage in an ammonia main was localized and the quantity of ammonia in industrial emissions was estimated using a gas analyzer aboard a helicopter. K.K.

A88-22033#
A NEW FINITE ELEMENT METHOD FOR COMPUTING TURBULENT FLOW NEAR A PROPELLER
DOMINIQUE PELLETIER, ANDRE GARON, ED., and RICARDO CAMARERO (Montreal, Universite, Montreal, Canada) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. Research supported by the Centre de Recherche Informatique de Montreal, U.S. Navy, and NSERC. refs
(AIAA PAPER 88-0048)

A numerical procedure based on the primitive variable Navier-Stokes equations is applied to the simulation of the three-dimensional axisymmetric flow near a propeller in a uniform flow. The Navier-Stokes equations are solved using both a mixed and a penalty function finite element method. A new model is developed to simulate the presence of the propeller by representing its effects on the flow field. This requires that the flow be tangent to the stream surfaces between the blades. The tangency condition is enforced by introducing a Lagrange multiplier that can be interpreted as the force applied by the blades on the fluid. Turbulence is modeled by a simple mixing length equation. Detailed comparison with wind tunnel measurements show good prediction of velocity and pressure. Author

A88-22081#
A FOURIER ANALYSIS APPROACH FOR SURFACE DEFINITION AND THE EFFECT OF ROUGHNESS ON THE LOCAL CONVECTIVE HEAT-TRANSFER COEFFICIENT AS RELATED TO ICE ACCRETION
M. R. PAIS and S. N. SINGH (Kentucky, University, Lexington) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(AIAA PAPER 88-0117)

Variations in the surface texture influence the flowfield, altering the aerodynamic characteristics and the ability to transfer heat. A method for determining, designating and controlling surface texture is proposed, and its effect on the heat-transfer coefficient is studied. A two-dimensional Fourier analysis is applied to experimentally determined surface profiles of a 15-minute glaze ice accretion on a cylinder. The roughness, k, is given in terms of the amplitude, the width and spacing between the elements being specified by the wavelength, which is the inverse of the frequency, a parameter of the Fourier series. Measurements of local Nusselt numbers on smooth and rough glaze ice accretions are presented along with velocity fields. The roughness shows an increase of up to 115 percent at the top of the horn of the glaze ice when compared to the smooth model. Author

A88-22100#
THE EFFECT OF WAVE-LIKE ROUGHNESS ON TRANSITION
TUNCER CEBECI (California State University, Long Beach) and DAVID A. EGAN AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(Contract NSF MEA-80-56237)
(AIAA PAPER 88-0139)

A combination of an interactive boundary-layer procedure and e exp n-method has been used to determine the locations of the onset of transition for flows over a flat plate with bumps or hollows. The details of the procedure are examined and the need for fine grid calculations in regions of strong adverse pressure gradients emphasized. The location of initial disturbance is shown to be unimportant provided it does not occur in the region where the critical Reynolds number is higher than the flow Reynolds number. The procedure allows good results for flows with and without separation. Possible means of improvement of the method are discussed. Author

A88-22165*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXTENSION OF THE JOHNSON-KING TURBULENCE MODEL TO THE 3-D FLOWS
RIDHA ABID (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(AIAA PAPER 88-0223)

A critical evaluation of the eddy viscosity model of Johnson and King extended to the three-dimensional case has been performed for three-dimensional boundary layer flows. The turbulence model is evaluated by a detailed comparison with available experimental data for incompressible flows over an infinite swept wing and near an idealized wing-body junction. The isotropic model of Johnson and King is found to work much better than the Cebeci-Smith model, especially in regions of strong cross flow. The significant decrease in the shear stress magnitude is almost reproduced. This means that this effect is as important as the nonisotropic eddy viscosity. The introduction of Rotta's modification to account for nonisotropic eddy viscosity in the Johnson-King formulation is found to have little effect on the predictions. The cross-flow properties are the most strongly affected. Author

A88-22207*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MEASUREMENT OF LOCAL CONVECTIVE HEAT TRANSFER COEFFICIENTS FROM A SMOOTH AND ROUGHENED NACA-0012 AIRFOIL - FLIGHT TEST DATA
G. JAMES VAN FOSSEN (NASA, Lewis Research Center, Cleveland, OH), KENNETH J. DE WITT (Toledo, University, OH), JAMES E. NEWTON, and PHILLIP E. POINSATTE AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 16 p. Previously announced in STAR as N88-13552. refs
(AIAA PAPER 88-0287)

Wind tunnels typically have higher free stream turbulence levels than are found in flight. Turbulence intensity was measured to be 0.5 percent in the NASA Lewis Icing Research Tunnel (IRT) with the cloud making sprays off and around 2 percent with cloud making equipment on. Turbulence intensity for flight conditions was found to be too low to make meaningful measurements for smooth air. This difference between free stream and wind tunnel conditions has raised questions as to the validity of results obtained in the IRT. One objective of these tests was to determine the effect of free stream turbulence on convective heat transfer for the NASA Lewis LEWICE ice growth prediction code. These tests provide in-flight heat transfer data for a NASA-0012 airfoil with a 533 cm chord. Future tests will measure heat transfer data from the same airfoil in the Lewis Icing Research Tunnel. Roughness was obtained by the attachment of small, 2 mm diameter hemispheres of uniform size to the airfoil in three different patterns. Heat transfer measurements were recorded in flight on the NASA Lewis Twin Otter Icing Research Aircraft. Measurements were taken for the smooth and roughened surfaces at various aircraft speeds and angles of attack up to four degrees. Results are presented as Frossling number versus position on the airfoil for various roughnesses and angles of attack. Author

A88-22210*# Dayton Univ., Ohio.
NAVIER-STOKES SOLUTIONS OF FLOWFIELD CHARACTERISTICS PRODUCED BY ICE ACCRETION
J. N. SCOTT, T. P. GIELDA, and W. L. HANKEY (Dayton, University, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(Contract NAG3-665)
(AIAA PAPER 88-0290)

The flowfield and resultant heat transfer rates over a series of ice accretion shapes have been obtained through numerical solutions of the Navier-Stokes equations. The influence of roughness is modeled by including blockage, form drag and stagnation heating effects as source terms in the governing equations. Using the flowfield information obtained from the Navier-Stokes equations the droplet impingement efficiencies are computed using a PNS-type solving scheme. Good agreement is achieved between the numerical results and experimental data. Author

A88-22212#
DETERMINATION OF THE LOCAL HEAT-TRANSFER CHARACTERISTICS ON SIMULATED SMOOTH GLAZE ICE ACCRETIONS ON A NACA 0012 AIRFOIL
M. R. PAIS, S. N. SINGH, and L. ZOU (Kentucky, University, Lexington) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p. USAF-supported research. refs
(AIAA PAPER 88-0292)

Convective local heat-transfer coefficients have been obtained in a subsonic wind tunnel for two ice models, a smooth NACA 0012 airfoil and a 5-min glaze-ice accretion on the same airfoil. Local Nusselt numbers have been obtained at various angles of attack. It is found that, when data from a 5-min glaze ice are compared with those for a smooth airfoil, a strong correlation exists in the local Nusselt numbers based on the distance from the nose tip along the surface. This suggests that smooth airfoil data can be used in the prediction of ice accretion at later stages in time. V.L.

A88-22260*# Toledo Univ., Ohio.
TRANSIENT TWO-DIMENSIONAL HEAT TRANSFER THROUGH A COMPOSITE BODY WITH APPLICATION TO DEICING OF AIRCRAFT COMPONENTS
W. B. WRIGHT, T. G. KEITH, JR., and K. J. DEWITT (Toledo, University, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. NASA-supported research. refs
(AIAA PAPER 88-0358)

Nine different numerical methods are examined for their ability to model the process of the melting and removal of ice from an airfoil using electrothermal heaters. A technique is presented for modeling the phase change which assumes a phase for each node. The technique allows solvers such as Alternating Direction Implicit, Alternating Direction Explicit, and Strongly Implicit Procedure to find a solution which can then be iterated to find the correct phase of each node. Comparisons made for a standard deicer pad comprised of five layers showed the ADI method to be superior to the other methods considered. R.R.

A88-22325*# Vigyan Research Associates, Inc., Hampton, Va.
A 3D-PNS COMPUTER CODE FOR THE CALCULATION OF SUPERSONIC COMBUSTING FLOWS
TAWIT CHITSOMBOON (Vigyan Research Associates, Inc., Hampton, VA) and G. BURTON NORTHAM (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(Contract NAS1-17919)
(AIAA PAPER 88-0438)

A computer code has been developed based on the three-dimensional parabolized Navier-Stokes (PNS) equations which govern the supersonic combusting flow of the hydrogen-air system. The finite difference algorithm employed was a hybrid of the Schiff-Steger algorithm and the Vigneron, et al., algorithm which is fully implicit and fully coupled. The combustion of hydrogen and air was modeled by the finite-rate two-step combustion model of Rogers-Chinitz. A new dependent variable vector was introduced to simplify the numerical algorithm. Robustness of the algorithm was considerably enhanced by introducing an adjustable parameter. The computer code was used to solve a premixed shock-induced combustion problem and the results were compared with those of a full Navier-Stokes code. Reasonably good agreement was obtained at a fraction of the cost of the full Navier-Stokes procedure. Author

A88-22327#
ANALYSIS OF OBLIQUE SHOCK-DETONATION WAVE INTERACTIONS IN THE SUPERSONIC FLOW OF A COMBUSTIBLE MEDIUM
B. C. FAN, M. SICHEL, and C. W. KAUFFMAN (Michigan, University, Ann Arbor) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(Contract DAAG29-83-K-0059)
(AIAA PAPER 88-0441)

Shock polar analysis is used to analyze the interaction which occurs when a detonation propagates past a bounding layer of inert or explosive gas. The oblique shock or detonation which is transmitted into the bounding medium is reflected from the lower bounding wall either regularly or as a Mach reflection. Such interactions occur in layered explosives and will also arise in supersonic combustors or in proposed detonative ramjet engines. Wave angles, velocities, and pressures are computed in the case of both regular and Mach reflection for a primary detonation propagating through a stoichiometric H2-O2 mixture bounded by an explosive mixture, also consisting of H2-O2 but with an equivalence ratio varying from 0 to 4.5. The computed results were in reasonable agreement with interaction parameters determined experimentally. Author

A88-22524#
MIXING CHARACTERISTICS OF SUPERSONIC SHROUDED JETS
K. J. WILSON, E. GUTMARK, E. AJDARI, K. C. SCHADOW, and R. A. SMITH (U.S. Navy, Research Dept., China Lake, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0699)

The entrainment characteristics of elliptic and rectangular jets, confined in a circular shroud, were compared to a circular shrouded jet. The entrainment ratio was determined in a closed shroud configuration and in an open shroud, for a Mach number range of 1 to 2.4. In the closed shroud, the pressure depression resulting from the jet entrainment was measured. In the open shroud, the velocity of the entrained secondary flow was measured in the shroud inlet. The measurements were done for different shroud diameters and lengths. The rectangular and elliptic primary jet gave a considerable improvement relative to the circular jet. The entrainment ratio increased with the duct length and the area ratio between the duct and the primary nozzle. The variation of the secondary flow velocity and the pressure depression with the primary jet Mach number was irregular and was shown to be related to the jet mode structure and to the duct acoustics. Author

A88-22538*# Engineering Analysis, Inc., Ames, Iowa.
AN UPWIND PARABOLIZED NAVIER-STOKES CODE FOR REAL GAS FLOWS
JOHN C. TANNEHILL, JOHN O. IEVALTS (Engineering Analysis, Inc., Ames, IA), and SCOTT L. LAWRENCE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 13 p. refs
(Contract NAS2-12552)
(AIAA PAPER 88-0713)

A real gas, upwind, parabolized Navier-Stokes (PNS) code has been developed to compute the two-dimensional/axisymmetric hypersonic flow of equilibrium air around various body shapes. The new code is an extension of the upwind (perfect gas) PNS code of Lawrence, Tannehill and Chaussee. The upwind algorithm is based on Roe's flux-difference splitting scheme which has been modified to account for real gas effects. Simplified curve fits are used to obtain the thermodynamic and transport properties of equilibrium air. The new code has been validated by computing the hypersonic laminar flow of air over a flat plate, a wedge, a ramp, and a cone. The results of these computations are compared with the results from a conventional centrally-differenced, real gas, PNS code and the agreement is excellent, except in the vicinity of shock waves where the present code exhibits far superior shock capturing capabilities. Author

A88-22601#
NUMERICAL SIMULATION OF COMPRESSIBLE NAVIER-STOKES FLOWS
M. O. BRISTEAU, R. GLOWINSKI (Institut National de Recherche en Informatique et en Automatique, Le Chesnay, France), J. PERIAUX (Avions Marcel Dassault Breguet Aviation, Vaucresson, France), and H. VIVIAND (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1987-151, 1987, 43 p.
(ONERA, TP NO. 1987-151)

Two test problems concerning the numerical simulation of compressible Navier-Stokes flows are addressed. One problem concerns external flows past an airfoil, while the other concerns internal flows in a double-throat nozzle. The quality of the computational results are commented on in both cases. C.D.

A88-22754
FINITE-ELEMENT STRESS ANALYSIS OF HELICOPTER PLANETARY GEARS
RAYMOND J. DRAGO and RAVI N. MARGASAHAYAM (Boeing Vertol Co., Philadelphia, PA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 359-373. refs

Using three-dimensional FEM techniques, full planet gear (PG) models with varying tooth rim proportions were developed and subjected to PG system loads. The FEM-predicted azimuthal stress distribution curve was used to identify the critical stress location as well as the conditions under which PG stresses may not be associated with tooth loading. Excellent correlation is shown in a comparison of FEM-predicted results and results of full-scale hardware tests. The ability of the FEM to evaluate complex interactions of bearing type, tooth rim proportions, bearing clearance, and PG system loads is demonstrated. In addition, an example of PG/bearing system optimization using the test-validated FEM tool is examined. B.J.

A88-22755
SUBSTANTIATION OF DAMAGE TOLERANT DESIGNS IN CIVIL HELICOPTERS
R. T. WEAVER (FAA, Rotorcraft Standards Staff, Fort Worth, TX) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 375-385. refs

An FAA rulemaking program began in 1983 to require both the provision of damage tolerance design features (where practical) and substantiation that the design features provide damage tolerance. It is noted that damage tolerance substantiation (DTS) methods are now mature enough for use in helicopter fatigue programs. Owing to the unique helicopter construction and load environment, helicopter DTS will not be as narrowly tied to linear fracture mechanics metallic crack growth methods as airplane DTS. Flaw tolerant safe life and other methods will be useful in assuring that durable flaw-tolerant structures are provided in future helicopters. B.J.

A88-22756
INVESTIGATION OF FATIGUE METHODOLOGY
WILLIAM FLANNELLY, CLIFFORD T. GUNSALLUS, EDWARD NAGY, and PATRICK G. STENNETT (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 387-395. refs
(Contract DAAJ02-85-C-0048)

The results of an evaluation of the influence of key parameters in helicopter component fatigue life calculation are presented, and the critical elements and combinations of elements of the problem are identified. The evaluation was performed using multivariate analysis of variance (MANOVA). It is recommended that baseline component lives be calculated using the current methodology with an industry standard mean S-N curve reduction formula and an industry standard cycle counting method for the reduction of flight data. In addition, it is found that rain flow or range-pair-range cycle counting is the only method currently used which describes the complete fatigue content of a load time history; this method is recommended as the industry standard. Finally, it is concluded that MANOVA is an effective way to clarify important factors in fatigue life calculations. B.J.

A88-22767
DAMAGE TOLERANCE OF COMPOSITE SHEAR PANELS
STEVEN LLORENTE (Boeing Vertol Co., Philadelphia, PA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 567-576.

An experimental study of the effects of impact damage on 36 AS4/3501-6 graphite/epoxy laminate test specimens loaded cyclically in shear is presented. The specimens were impacted at two different energy levels, corresponding to barely visible and easily visible impact damage. Results indicate that there is an impact damage threshold level below which damage growth does not occur in cyclic shear. Below 100 percent limit load and 8 ft-lb of impact energy, the test specimens survived one-million cycles and experienced little reduction in static strength. B.J.

A88-22772* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ENERGY ABSORPTION OF COMPOSITE MATERIAL AND STRUCTURE
GARY L. FARLEY (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 613-627. refs

Results are presented from a joint research program on helicopter crashworthiness conducted by the U.S. Army Aerostructures Directorate and NASA Langley. Through the ongoing research program an in-depth understanding has been developed on the cause/effect relationships between material and architectural variables and the energy-absorption capability of composite material and structure. Composite materials were found to be efficient energy absorbers. Graphite/epoxy subfloor structures were more efficient energy absorbers than comparable structures fabricated from Kevlar or aluminum. An accurate method of predicting the energy-absorption capability of beams was developed. Author

A88-22780
DESIGN AND EXPERIMENTAL STUDIES OF COMPOSITE POWER TRANSMISSION SHAFTING
ROBERT F. KRAUS and MARK S. DARLOW (Rensselaer Polytechnic Institute, Troy, NY) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 733-738. refs
(Contract DAAG29-82-K-0093)

The design of power transmission shafting systems of least weight is undertaken. To facilitate weight reduction, graphite/epoxy composite material is used, and the number of midspan bearings is reduced. Due to the relatively long distance between shaft supports, the lightweight shaft systems under consideration run supercritically. Benefits of composite driveshafts supported by relatively few bearings are: (1) the drive system weight is reduced; and (2) the system reliability should increase and maintenance costs should decrease due to a reduction in the number of components. Author

A88-22790
ROBOTIC COMPOSITES TRIMMING
THOMAS G. KLINGLER (McDonnell Douglas Helicopter Co., Culver City, CA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 897-899.

The development and implementation of a robotic trimming cell for AH-64A and Model 500 composite helicopter parts are discussed. The present method provided significant labor savings, with a 50 percent reduction in trimming cycle times as compared to the usual manual method. The parts trimmed by the robotic method were also found to be closer to the nominal dimensions. No rework operation was necessary, and trim template rework was reduced. R.R.

A88-22791
AUTOMATION OF WIRE PREPARATION FOR WIRE HARNESS MANUFACTURING
DEBORAH J. MCCULLEY (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 901-906.

Application of an automated wire processing system to the production of wire harnesses for the AH-64A Apache Attack Helicopter is discussed. The phase one system can accommodate any wire type having an outer diameter of less than 0.125 in, and

the modular nature of the system allows equipment to be customized. Issues involved in the integration of automation, including production planning, the coordination of software interfaces, schedules, and work flow are considered. Phase two automation goals include the processing of shielded and multiconductor wires, in addition to the development of a system for first-end insertion. R.R.

A88-22804#
A STATISTICAL ANALYSIS TO ASSESS THE RELIABILITY OF A ROTORCRAFT COMPONENT IN FATIGUE
S. P. VISWANATHAN, V. TATA (Bell Helicopter Textron, Mirabel, Canada), R. BOORLA, G. MCLEOD, and J. SLACK (Bell Helicopter Textron, Inc., Fort Worth, TX) AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Paper. 10 p. refs

The paper presents an analytical procedure to assess the probability that a given rotorcraft componet will not fail in fatigue as a function of the life of the component. This procedure considers variations in strength of the components due to standard manufacture, manufacturing anomaly, mishandling, degradation due to environment, etc., through probabilistic distribution functions. Variations in flight loads and usage rate of the rotorcraft are also considered probabilistically. The paper highlights the differences between this type of approach and the conventional fatigue methodology, and presents an example problem. A concerted research program will help develop the necessary input data at high confidence level and make the statistical reliability analysis a viable and useful tool. Author

A88-23191#
USING INTEGRAL TEMPERATURE CRITERION TO PREDICT SCUFFING FAILURE OF BEVEL GEARS FOR AIRCRAFT
SHENGCAI PAN, LINFENG WU, SUIXIANG ZHONG, and ZUXING OUYANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Aug. 1987, p. B370-B376. In Chinese, with abstract in English. refs

This paper describes the characteristics of the integral temperature criterion that predicts scuffing failure of bevel gears. It also provides the results of scuffing on lubricating oil for aircraft engines and the scuffing temperatures of bevel gears. The integral temperature criterion is applied to verification on a few dozen bevel gears used for a variety of aircraft on active service. The calculation results are essentially coincident with the practice. Author

A88-23219#
THE APPLICATION OF RELIABILITY THEORY TO THE INNOVATION IN THE REGULAR REPAIRS SYSTEM FOR A CERTAIN TYPE OF PLANE
XUANTAO QIOU (Air Force, Engineering Dept., Nanjing, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Oct. 1987, p. B519-B524. In Chinese, with abstract in English.

A88-23268
COMPUTER AIDED DYNAMIC ANALYSIS OF ELECTRO HYDRAULIC ACTUATORS
D. A. COWLING and R. STIRLING (Bristol, University, England) IN: Computer applications in aircraft design and operation; Proceedings of the First International Conference on Computer Aided Design, Manufacture and Operation in the Aeronautics and Space Industries, Paris, France, June 16-18, 1987 . Billerica, MA, Computational Mechanics Publications, 1987, p. 121-131. Research supported by the Royal Aircraft Establishment. refs

Nonlinear models of an electrohydraulic servo valve-controlled actuation system for primary flight control of a fighter-type aircraft and a similar system controlled by a brushless dc torque motor are described. An integrated systems design and analysis package called TSIM2 is used to compare the dynamic performances of the two actuators. Results of nonlinear gain and phase transfer function analysis are presented. These indicate that the torque motor system has a significantly degraded performance, suggesting that some modifications of basic motor parameters are required in this case. Author

A88-23862
THE RING LASER GYROSCOPE AND ITS APPLICATION TO GUIDED FLIGHT
M. J. MARSHALL (Ferranti, PLC, Navigation Systems Div., Edinburgh, Scotland) IN: Applications of light in guided flight; Proceedings of the Symposium, London, England, Jan. 22, 1987 . London, Royal Aeronautical Society, 1987, p. 87-94.

The operational principles of ring laser gyroscopes (RLGs) are reviewed, and the some of their applications are discussed. The technology of the electromechanical gyroscope (EMG) is compared to that of the RLG, and the roles of the laser and mirrors in RLGs are reviewed. Resonance, detection, lock-in, and dither in RLGs are discussed. The use of gyros in strapdown applications is addressed, and strapdown systems are briefly compared with gimballed systems. Error sources in RLGs and EMGs are compared. Guided flight applications of RLGs are briefly considered, and undesirable features of RLGs in their present form are discussed. C.D.

A88-23875
MONOPOLE ELEMENTS ON CIRCULAR GROUND PLANES
MELVIN M. WEINER, STEPHEN P. CRUZE, CHO-CHOU LI, and WARREN J. WILSON Norwood, MA, Artech House, Inc., 1987, 317 p. refs

Analytical techniques for predicting the electrical properties of a monopole antenna element at the center of a circular ground plane of finite radius are presented in a practical introduction. Chapters are devoted to circuit representation, models with known and unknown element current distribution, and comparisons with experimental data. Extensive graphs and tables of numerical data are provided, and listings of computer programs (for integral equations, the method of moments, oblate spheroid wavefunctions, the variational method, and the method of moments combined with the geometrical theory of diffraction) are included. The applicability of the methods developed to the design of optimally efficient electronically tunable antennas for airborne radio communication is indicated. T.K.

A88-23980#
CALCULATION OF SHEAR LOADING AND STIFFNESSES OF FIBER-REINFORCED COMPOSITE ROTOR BLADES [BERECHNUNG DER SCHUBBEANSPRUCHUNG UND DER STEIFIGKEITEN VON FASERVERBUND-ROTORBLAETTERN]
RUDOLF WOERNDLE (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) DGLR, Symposium, Berlin, Federal Republic of Germany, May 14, 15, 1987, Paper. 37 p. In German. refs
(MBB-UD-504-87)

Specialized two-dimensional finite elements are developed analytically to determine shear stress distributions and stiffnesses in bearingless fiber-reinforced composite helicopter rotor blades. The design advantages and primary components of composite rotors are reviewed; the derivation of the governing equations for homogeneous and inhomogeneous beams is explained in detail; the FEM solution procedure is outlined; and numerical results for the GFRP twist element of a rotor for the Bo 105 are presented graphically. It is shown that the computational efficiency of the present FEM approach facilitates determination of peak stresses and hence the redesign of the blade to avoid these peaks. In the case of the Bo 105 rotor, reduction of the torsional shear stress and stiffness made it possible to shorten the twist element significantly. T.K.

A88-24362#
AN OPTIMAL DYNAMIC DESIGN OF AEROENGINE ROTORS WITH FREQUENCY CONSTRAINTS
XIAOLEI TENG, HONGFEI TENG (Dalian Institute of Technology, People's Republic of China), and LIANXIANG ZHANG (Shenyang Aeroengine Research Institute, People's Republic of China) Journal of Aerospace Power, vol. 2, July 1987, p. 246-248, 284. In Chinese, with abstract in English.

The present paper deals with the following optimization: given the structural natural frequency constraints and certain constraints on the design variables, finding the minimum weight of the rotor consistent with the above constraints. By using the method of mathematical programming combined with the perturbation converse solution, this problem can be solved. The combined method reduces times of reanalyses, and is simple and easy to understand. A practical example of dynamic design of an aircraft-engine rotor is given. The results may be useful for practical engineering. Author

A88-24443#
CALIBRATION OF THE CONSTANT TEMPERATURE HOT-WIRE ANEMOMETER IN TRANSONIC FLOW
BAISEN RONG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 5, Dec. 1987, p. 374-382. In Chinese, with abstract in English. refs

The calibration of a constant-temperature normal and inclined hot-wire anemometer in transonic flow is described. The purpose of the calibration is to measure wire sensitivities to mass flow rate, density, and direction. The experiments were performed in the nozzle of a variable-density blow-down supersonic wind tunnel at Mach numbers ranging from 0.5 to 1.36, wire Reynolds numbers of 100 to 320, and overheat ratios of about 1.0. It was found that the mass flow rate and density sensitivities are almost equal and essentially independent of Mach number and Reynolds number; the direction sensitivity is also independent of Reynolds number.At the same time, the empirical relation of Behrens (1971) is used to estimate the density and velocity sensitivities. After comparing with experimental results, the trends of both are found to be consistent. Author

A88-24760
AN ENGINEERING ALGORITHM FOR THE DESIGN OF BEAM STRUCTURES WITH SPECIFIED FREQUENCY CHARACTERISTICS [INZHENERNYI ALGORITM PROEKTIROVANIIA BALOCHNYKH KONSTRUKTSII S ZADANNYMI CHASTOTNYMI KHARAKTERISTIKAMI]
A. I. DANILIN and V. V. DMITRIEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1987, p. 39-42. In Russian.

The paper is concerned with the design of thin-walled structures with bounds on the natural vibration frequencies. An optimality criterion is derived and used to develop an engineering algorithm for determining the material distribution which would provide the specified frequency characteristics. The algorithm is demonstrated by an example. V.L.

A88-24774
A MOIRE STUDY OF DAMAGE IN AIRCRAFT STRUCTURAL ELEMENTS [ISSLEDOVANIE POVREZHDENII V ELEMENTAKH AVIATSIONNYKH KONSTRUKTSII METODOM MUAROV]
V. V. NOVITSKII, S. N. EGOROV, and A. N. SUKHOCHEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1987, p. 88, 89. In Russian.

A method and equipment are presented for obtaining moire patterns of damage in structural elements resulting from large deformations and crack growth. The method described here is based on a deflection measuring technique whereby moire patterns are produced by superposing two scan images at different angles on the surface of the structure investigated. Moire patterns of the surfaces of an aircraft landing gear strut are shown as an example. V.L.

N88-14950*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLIGHT RESEARCH ON NATURAL LAMINAR FLOW
B. J. HOLMES, C. C. CROOM, E. C. HASTINGS, JR., C. J. OBARA, and C. P. VANDAM (Vigyan Research Associates, Inc., Hampton, Va.) *In its* Langley Symposium on Aerodynamics, Volume 1 p 461-474 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 20D

Five decades of flight experiences with natural laminar flow (NLF) have provided a basis of understanding how this technology can be used for reduction of viscous drag on modern practical aircraft. The effects of cruise unit Reynolds number on NLF achievability and maintainability; compressibility effects on Tollmein-Schlichting growth; flight experiment on the Cessna Citation III business jet; flight instrumentation on Lear 28/29; OV-I NLF engine nacelle experiments; and viscous drag reduction are examined. B.G.

N88-14952*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LAMINAR FLOW INTEGRATION: FLIGHT TESTS STATUS AND PLANS
R. D. WAGNER, D. F. FISHER, M. C. FISCHER, D. W. BARTLETT, and R. R. MEYER, JR. (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.) *In its* Langley Symposium on Aerodynamics, Volume 1 p 485-518 Dec. 1986
Avail: NTIS HC A25/MF A01 CSCL 20D

Under the Aircraft Energy Efficiency - Laminar Flow Control Program, there are currently three flight test programs under way to address critical issues concerning laminar flow technology application to commercial transports. The Leading-Edge Flight Test (LEFT) with a JetStar aircraft is a cooperative effort with the Ames/Dryden Flight Research Facility to provide operational experience with candidate leading-edge systems representative of those that might be used on a future transport. In the Variable Sweep Transition Flight Experiment (VSTFE), also a cooperative effort between Langley and Ames/Dryden, basic transition data on an F-14 wing with variable sweep will be obtained to provide a data base for laminar flow wing design. Finally, under contract to the Boeing Company, the acoustic environment on the wing of a 757 aircraft will be measured and the influence of engine noise on laminar flow determined with a natural laminar flow glove on the wing. The status and plans for these programs are reported. Author

N88-15224*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFICIENCY TESTING OF A HELICOPTER TRANSMISSION PLANETARY REDUCTION STAGE
ROBERT F. HANDSCHUH and DOUGLAS A. ROHN Feb. 1988 18 p Prepared in cooperation with Army Aviation Research and Development Command, Cleveland, Ohio
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TP-2795; E-3770; NAS 1.60:2795; AVSCOM-TR-87-C-28)
Avail: NTIS HC A03/MF A01 CSCL 13I

A parametric study of the efficiency of a 310-kW (420-hp) helicopter transmission planetary test section (four planets) was performed. The purpose was to determine the planetary contribution to the overall transmission power loss. Test parameters varied were oil flow rate, oil inlet temperature, lubricant type, shaft speed, and applied torque. The measured efficiency over all the test variables ranged from 99.44 to 99.75 percent. These experimental results were compared with other experimental and computational results. Author

N88-15802*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ROTORCRAFT TRANSMISSION
JOHN J. COY *In its* Aeropropulsion '87. Session 5: Subsonic Propulsion Technology 9 p Nov. 1987
Avail: NTIS HC A08/MF A01 CSCL 13I

The NASA Lewis Research Center and the U.S. Army Aviation Systems Command share an interest in advancing the technology for helicopter propulsion systems. In particular, this presentation outlines that portion of the program that applies to the drive train and its various mechanical components. The major goals of the program are to increase the life, reliability, and maintainability; reduce the weight, noise, and vibration; and maintain the relatively high mechanical efficiency of the gear train. The current activity emphasizes noise reduction technology and analytical code development followed by experimental verification. Selected significant advances in technology for transmissions are reviewed, including advanced configurations and new analytical tools. Finally, the plan for transmission research in the future is presented.
Author

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A88-21332
METEOROLOGICAL SUPPORT OF VOYAGER WORLD FLIGHT, 14-23 DECEMBER 1986
LEONARD W. SNELLMAN (Utah, University, Salt Lake City) American Meteorological Society, Bulletin (ISSN 0003-0007), vol. 68, Nov. 1987, p. 1403-1416.

The meteorological criteria demanded by the restrictions for the Voyager aircraft nonstop nine-day flight around the world in December 1986 are discussed together with the meteorological support rendered before and throughout the flight and the meteorological tools and facilities used. The aircraft had to fly generally below 3000 m and had to have a mean tail-wind factor of greater than 6 kt. Precipitation was unacceptable, and turbulence was to be minimized. For evaluation of large-scale flow, regular DIFAX 500-mb analyses and 500-mb prognoses were used, with DIFAX charts and alpha-numeric data supplied by the Satellite Information Services. For specific flight-track forecasts and short-term forecasts, global sea-level 700-mb and 250-mb analyses and surface and upper-air observations from stations along the flight track were used, supplemented with Voyager pilot reports.
I.S.

A88-22440#
THREE DIMENSIONAL REPRESENTATION OF A MULTIPLE-VORTEX MICROBURST FOR CORPORATE AVIATION SIMULATORS
ARNAB LAHIRI (Singer Co., SimuFlite Training International Div., Dallas, TX) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 5 p.
(AIAA PAPER 88-0584)

A three-dimensional microburst encompasses a broad spectrum of adverse weather phenomena: wind shears, precipitation-reduced visibility, increased rain noise, vortices, up- and down-flows, turbulence, and pressure/temperature changes. Attention is presently given to the compilation of data useful in the characterization of a microburst encounter that will be applicable to corporate aviation flight crew training flight simulators. The greater simulation realism thus obtained will enhance the effectiveness of training, improving crews' cue recognition and cockpit management performance. O.C.

A88-22441#
SEVERE WEATHER PROGRAM FOR THE AVIATION COMMUNITY IN NEVADA
LARRY E. JENSEN (NOAA, National Weather Service Forecast Office, Reno, NV) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p.
(AIAA PAPER 88-0589)

A88-22442#
ARE CWSUS FORECASTING AT THE STATE OF THE SCIENCE?
ELIZABETH A. MORSE (NOAA, National Weather Service, Salt Lake City, UT) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p.
(AIAA PAPER 88-0590)

Center Weather Service Units (CWSUs) provide up-to-date forecasts and advisories tailored for making effective air traffic flow control decisions at Air Route Traffic Control Centers. No attempt has been made to measure how well their duties are accomplished or how shortcomings should be addressed on a multi-CWSU basis. During 1987, the National Weather Service Western Region began verifying the timeliness and accuracy of Center Weather Advisories produced by four CWSUs. Although only four months of data are available, enough information has been received to support the contention that CWSUs are doing a creditable job.
Author

A88-22443#
EFFECTIVE HAZARDOUS WEATHER WARNINGS FOR THE GENERAL AVIATION COMMUNITY
AMY LYNN KAUFFMAN (Aircraft Owners and Pilots Association, Frederick, MD) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p.
(AIAA PAPER 88-0591)

It is suggested that weather services have deteriorated (in spite of the National Airspace System Plan to improve weather sources), and measures to improve the situation are proposed. Problems in the implementation of weather automation programs such as the Flight Service Station Modernization/Automation Program and the Color Weather Graphics program are discussed. A comprehensive plan for the integration of data from new sensors being developed is proposed which would aid in deriving the maximum benefits of safety and efficiency from these technologies. The future application of advanced weather radar, and the automation and consolidation of flight service stations, are also considered. R.R.

A88-22510#
NATIONAL AVIATION WEATHER ADVISORY UNIT OPERATIONS AND RECENT DEVELOPMENTS
MELVIN D. MATHEWS (NOAA, National Severe Storms Forecast Center, Kansas City, MO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0681)

The National Aviation Weather Advisory Unit is responsible for the preparation of aviation area forecasts and in-flight advisories of weather conditions hazardous to flight operations for the conterminous United States. Weather elements included in these forecasts are discussed and examples presented. An overview of meteorological analytic and prognostic resources is given, with emphasis on the recent improvements in the display of manually digitized radar and pilot weather reports. The latest interactive techniques employed by the meteorologist in the display of information and product generation are described. Author

A88-22511*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A MULTIPLE-VORTEX-RING MODEL OF THE DFW MICROBURST
THOMAS A. SCHULTZ (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. refs
(AIAA PAPER 88-0685)

A multiple-vortex-ring model of the winds associated with a microburst is verified by matching the model-generated winds to those encountered at the Dallas-Ft. Worth (DFW) microburst. The basis of the model consists of time-invariant vortex ring filaments embedded in irrotational flow. Each ring's viscous core is modeled by distributing the vorticity over a small distance (relative to the ring diameter) radially from the filaments. Parameters such as the size and strength of the vortex rings are identified using a modified Newton-Raphson technique. The parameters identified from the analysis of the DFW microburst encounter indicate a large ring with a radius of 8500 ft and a smaller ring with a radius of 1700 ft. Author

A88-22519#
USE OF A SINGLE DOPPLER RADAR TO ESTIMATE THE RUNWAY WIND SHEAR COMPONENT IN MICROBURST OUTFLOWS
M. D. EILTS (NOAA, National Severe Storms Laboratory, Norman, OK) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 6 p. refs
(Contract DOT-FA01-80-Y-10524)
(AIAA PAPER 88-0694)

Data from a single Doppler radar are the input for the three microburst-asymmetry estimation techniques evaluated. Two simple techniques for estimating the magnitude and direction of maximum shear led to large errors for individual microbursts when compared with dual-Doppler radar data covering 12 different microbursts. Attention is given to the third technique, which estimates the wind speed and direction at grid points within a microburst by assuming that the wind direction is parallel-but-opposite to the reflectivity gradient; this microburst model allows estimation of the vector wind field in a microburst. O.C.

A88-22520#
THUNDERSTORM GENERATED SOLITARY WAVES - A WIND SHEAR HAZARD?
R. J. DOVIAK (NOAA, National Severe Storms Laboratory, Norman, OK) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(Contract DOT-RM-2A0702)
(AIAA PAPER 88-0695)

The internal steady state solitary wave, described by the solution of the Benjamin-Davis-Ono (BDO) equation, is compared with a boundary layer solitary wave observed with NSSL's Doppler radar, a network of eight meteorological stations, and a 444-m-tall instrumented (KTVY) tower. Wave-induced vertical transport of the horizontal momentum of the strongly sheared ambient air contributed much to the observed wind perturbations and horizontal wind shear. These observations suggest that solitary and other nonlinear waves might be a source of wind shear hazard to safe flight and thus should be studied both experimentally and theoretically. Author

A88-22521#
OBJECTIVE ANALYSIS OF TWO AVIATION HAZARDS USING NMC MODEL DATA AND GOES SOUNDERS
GARY ELLROD (NOAA, Satellite Applications Laboratory, Washington, DC) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0696)

The detection or short-range forecasting of atmospheric conditions conducive to the occurrence of such phenomena as microbursts and clear air turbulence are presently addressed by several indices that have been generated on the basis of both National Meteorological Center numerical model outputs and GOES satellite sounding retrievals. Wet and dry microwave indices are used; strong, straight-line winds occurred near minimum values of the former, and strong, gusty surface winds related to index values of the order of 200-260 on ten separate days were associated with the latter. O.C.

A88-22669
WIND MAPPING FOR TRANSPORT AIRCRAFT [WINDMAPPING FUER VERKEHRSFLUGZEUGE]
W. LECHNER (Hannover, Fachhochschule, Hanover, Federal Republic of Germany) and N. LOHL (Braunschweig, Luftfahrt-Bundesamt, Brunswick, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 11, July-Oct. 1987, p. 246-250. In German. refs

The wind situation encountered during a flight may deviate greatly from that forecast and may have a considerable effect on the economy of transport aircraft. Accurate representation of the actual wind situation is therefore of critical importance to any aviation concern. An up-to-date representation of the wind situation (wind mapping) can be obtained from data on horizontal position, wind, air pressure amd air temperature acquired by each individual aircraft's normal sensors. These data have to be filtered and transmitted to a ground station, where they are combined in an optimum manner. The range of the wind map is determined by the air/ground radio communication coverage (high-frequency, satellites) and by the number and position of the aircraft in the airspace. The wind map generated in the ground computer is particularly accurate, therefore, in the most important airway sections and in the vicinity of airports. The weather information contained in the wind map - such as the location of a shear wind zone - can then be made available to air traffic by means of ground-to-air communication. Author

A88-23931
METEOROLOGICAL SUPPORT FOR CIVIL AVIATION [METEOROLOGICHESKOE OBESPECHENIE GRAZHDANSKOI AVIATSII]
A. A. VASIL'EV and M. B. RUBINSHTEIN (Gidrometeorologicheskii Nauchno-Issledovatel'skii Tsentr SSSR, Moscow, USSR) Meteorologiia i Gidrologiia (ISSN 0130-2906), Nov. 1987, p. 20-27. In Russian.

Progress made in the USSR over the past 70 years in the area of aeronautical meteorology is discussed. The basic tasks of meteorological support for aviation over different periods are examined. Means of increasing the efficiency of meteorological support for civil aviation are presented. K.K.

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A88-20712
PAOMAD - AN INTEGRATED SOFTWARE FOR CIM IN COMPOSITES
P. MARECHAL (Aerospatiale, Departement Production-Recherches, Suresnes,France) IN: Looking ahead for materials and processes; Proceedings of the Eighth SAMPE (European Chapter) International Conference, La Baule, France, May 18-21, 1987. Amsterdam, Elsevier, 1987, p. 149-158.

PAOMAD is a CIM software which proceeeds from a paperless CAD definition of a composite structural element to automatically generate (1) the various NC programs for prepreg cutting and tape-laying operations, (2) estimations of processing times, (3) instruction sheets for machine operators, (4) quantities of requisite materials and their resulting scrap ratios, and (5) a graphic

simulation of the process, which may be useful in optimization. To date, PAOMAD has been applied in the manufacture of Airbus airliner spoilers and Mirage 2000 vertical stabilizers. O.C.

A88-21269#
PERFORMANCE EVALUATION OF MEDIUM ACCESS CONTROL PROTOCOLS FOR DISTRIBUTED DIGITAL AVIONICS
ASOK RAY (Pennsylvania State University, University Park) ASME, Transactions, Journal of Dynamic Systems, Measurement, and Control (ISSN 0022-0434), vol. 109, Dec. 1987, p. 370-377. Research supported by the Allied Bendix Aerospace Corp. refs
(ASME PAPER 87-WA/DSC-2)

The paper presents the results of an ongoing research project where the objectives are to evaluate medium access control (MAC) protocols in view of the requirements for distributed digital flight control systems (DDFCS) of advanced aircraft and to recommend a specific protocol for their prototype development. The selection of an appropriate MAC protocol is critical for the dynamic performance of an aircraft because the DDFCS, in addition to the sampling time delay, is subject to time-varying transport delays due to data latency of messages at different terminals of the control loop. The SAE linear token bus, SAE token ring and the conventional MIL-STD-1553B protocols have been analyzed using combined discrete-event and continuous-time simulation techniques. The impact of data latency on the dynamic performance of an advanced aircraft is illustrated by simulation of the closed loop DDFCS. Author

A88-21842
TIME OPTIMIZATION OF ALGORITHMS IN REAL-TIME SIMULATION SYSTEMS [VREMENNAIA OPTIMIZATSIIA ALGORITMOV V MODELIRUIUSHCHIKH SISTEMAKH REAL'NOGO VREMENI]
IGOR' EVGEN'EVICH EFIMOV (AN USSR, Institut Problem Modelirovaniia v Energetike, Kiev, Ukrainian SSR) Elektronnoe Modelirovanie (ISSN 0204-3572), vol. 9, Nov.-Dec. 1987, p. 14-18. In Russian. refs

The paper examines the definition of the optimal sequences of the execution of the steps of algorithms for the operation of real-time computing-control systems. The proposed approach is applied to the optimization of an algorithm for defining full-scale flight simulation control according to an accuracy criterion. B.J.

A88-22065#
COMPUTER-ENHANCED 3-DIMENSIONAL MACHINING OF WINGS AND OTHER AERODYNAMIC SHAPES
DANIEL G. HEFLIN (Wichita State University, KS) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 7 p.
(AIAA PAPER 88-0092)

This paper documents the procedures, techniques, and considerations used to create a FORTRAN computer program for the CNC milling machine. This program was designed for use in the WSU Engineering Shop, which specializes in wind tunnel models. The program was originally designed to cut wings of any geometry, including sections where the root and tip were different sizes and/or tapered wings in either direction, wings with twist at any point of incidence on the chord line, and wings made of different sections. Each section of the wing can have one or more of the traits listed above. The program includes a compensate routine, which enables the CNC to cut a finished product if desired. Though originally designed for wings, this program can be used for unilateral three-dimensional contouring, including other designs of aerodynamic significance. Author

A88-22142#
APPLICATION OF EXPERT SYSTEMS TECHNOLOGY TO WIND TUNNEL TESTING
W. E. DIETZ, JR. (Calspan Corp., Arnold AFB, TN) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p.
(AIAA PAPER 88-0194)

The applicability of knowledge-based expert systems to aeronautical testing problems encountered in wind-tunnel facilities has been investigated and used to develop one system that can assist in the design and placement of boundary-layer strips on wind tunnel models, and another that diagnoses problems associated with drying air used in a 16-ft transonic wind tunnel. These expert systems are rule-based; the domain knowledge is encoded as a set of rules that can be systematically applied to a given situation until a solution is achieved. O.C.

A88-22166*# Old Dominion Univ., Norfolk, Va.
A CONSERVATIVE APPROACH FOR FLOW FIELD CALCULATIONS ON MULTIPLE GRIDS
M. KATHONG, S. N. TIWARI (Old Dominion University, Norfolk, VA), and R. E. SMITH (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 15 p. refs
(Contract NCC1-68)
(AIAA PAPER 88-0224)

In the computation of flow fields about complex configurations, it is very difficult to construct body-fitted coordinate systems. An alternative approach is to use several grids at once, each of which is generated independently. This procedure is called the 'multiple grids' or 'zonal grids' approach and its applications are investigated in this study. The method follows the conservative approach and provides conservation of fluxes at grid interfaces. The Euler equations are solved numerically on such grids for various configurations. The numerical scheme used is the finite-volume technique with a three-stage Runge-Kutta time integration. The code is vectorized and programmed to run on the CDC VPS-32 computer. Some steady state solutions of the Euler equations are presented and discussed. Author

A88-22225#
THREE DIMENSIONAL ADAPTIVE GRID GENERATION ON A COMPOSITE BLOCK GRID
HYUN JIN KIM (Republic of Korea Air Force, Seoul) and JOE F. THOMPSON (Mississippi State University, MS) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 12 p. refs
(Contract F08635-84-C-02281)
(AIAA PAPER 88-0311)

The EAGLE 3D composite-block grid code has been extended to an adaptive grid to be coupled with a PDE solver. Both the adaptive control function formulation and the variational formulation were evaluated, and the former was found to be much faster and somewhat more effective. Results for the code coupled with an implicit Euler solver for a three-block configuration on a finite wing are compared with experimental data for transonic flow. Author

A88-22383#
INTERACTIVE DISPLAY OF THREE-DIMENSIONAL GEOMETRIES AND AERODYNAMIC DATA
DAVID M. SCHUSTER and JEFFREY A. MCCAULLEY (Lockheed Aeronautical Systems Co., Advanced Flight Sciences Dept., Marietta, GA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p.
(AIAA PAPER 88-0517)

This paper describes a computer program developed at the Lockheed Aeronautical Systems Company which interactively displays three-dimensional geometry and associated flowfield data. The program uses advanced hardware and software to quickly and accurately present three-dimensional data such as wire-frame grids, shaded solid models and filled color contours. The program is interactive and incorporates a relatively simple data input structure, making it applicable to a wide range of problems. The method was originally developed to aid in the display of

computational fluid dynamics data, but has since been applied to the presentation of experimental data as well. Author

A88-22384#
TWO AND THREE-DIMENSIONAL GRID OPTIMIZATION
G. F. CAREY (Texas, University, Austin) and A. L. PARDHANANI AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. Research supported by the Lockheed-Georgia Co. and NSF. refs
(AIAA PAPER 88-0518)

The problem of generating suitable numerical grids for computations in two and three dimensions is formulated using mathematical programming and optimization techniques. A composite objective function is introduced to control smoothness (mesh gradation), and orthogonality of the grid and permit adaptivity of the grid to the solution behavior. Both interior and exterior penalty functionals are also included to circumvent specific difficulties in the local mesh pattern near irregularly shaped boundaries. Numerical test examples have been computed and demonstrate that the approach yields good grids in few iterations. Author

A88-22593#
PANEL CODE SOLVERS
J. RYAN, T. H. LE, and Y. MORCHOISNE (ONERA, Chatillon-sous-Bagneux, France) (Gesellschaft fuer Angewandte Mathematik und Mechanik, Meeting, 7th, Louvain, Belgium, Sept. 9-11, 1987) ONERA, TP, no. 1987-139, 1987, 9 p.
(ONERA, TP NO. 1987-139)

Prediction of three-dimensional, incompressible, inviscid flow using panel methods require solving large, full matrices. In this paper, comparisons are first presented between various direct or iterative solvers for matrices resulting from discretization of several aerodynamic configurations. A new iterative resolution which generalizes gradient methods is then developed and shown to be as precise and at least twice as fast as the reviewed methods. C.D.

A88-22604*# *National Aeronautics and Space Administration.* Langley Research Center, Hampton, Va.
FAULT-TOLERANT CLOCK SYNCHRONIZATION VALIDATION METHODOLOGY
RICKY W. BUTLER, DANIEL L. PALUMBO, and SALLY C. JOHNSON (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, Nov.-Dec. 1987, p. 513-522. refs

A validation method for the synchronization subsystem of a fault-tolerant computer system is presented. The high reliability requirement of flight-crucial systems precludes the use of most traditional validation methods. The method presented utilizes formal design proof to uncover design and coding errors and experimentation to validate the assumptions of the design proof. The experimental method is described and illustrated by validating the clock synchronization system of the Software Implemented Fault Tolerance computer. The design proof of the algorithm includes a theorem that defines the maximum skew between any two nonfaulty clocks in the system in terms of specific system parameters. Most of these parameters are deterministic. One crucial parameter is the upper bound on the clock read error, which is stochastic. The probability that this upper bound is exceeded is calculated from data obtained by the measurement of system parameters. This probability is then included in a detailed reliability analysis of the system. Author

A88-22757
DEVELOPMENT OF A TOTALLY COMPUTERIZED INTERACTIVE FATIGUE LIFE ANALYSIS PROGRAM
MICHAEL D. JONES, ALAN P. STEWART, and BEN ALTMAN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 397-402.

The aim of the present study is to provide a fast flexible means of analyzing helicopter fatigue data that would not be tied to a particular vehicle usage spectrum or method of analysis. It is shown that the FAST (Fatigue Analysis of Structures) program provides capabilities to perform the analysis in several different ways. FAST provides an easy means of combining flight test data, material fatigue data, and loading spectrum information to formulate a fatigue life calculation. The command driven format with integrated help provides easy use and the provisions to expand the program as needs arise. The fatigue analyst has all the data at his disposal and avoids the long and complicated process of running data through several programs to obtain results. B.J.

A88-22798* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATIONS OF ARTIFICIAL INTELLIGENCE TO ROTORCRAFT
KATHY H. ABBOTT (NASA, Langley Research Center, Hampton, VA) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 2 . Alexandria, VA, American Helicopter Society, 1987, p. 1011-1019. refs

The application of AI technology may have significant potential payoff for rotorcraft. In the near term, the status of the technology will limit its applicability to decision aids rather than total automation. The specific application areas are categorized into onboard and nonflight aids. The onboard applications include: fault monitoring, diagnosis, and reconfiguration; mission and tactics planning; situation assessment; navigation aids, especially in nap-of-the-earth flight; and adaptive man-machine interfaces. The nonflight applications include training and maintenance diagnostics. Author

A88-22876
AN ARTIFICIAL INTELLIGENCE (AI)-SIMULATION BASED APPROACH FOR AIRCRAFT MAINTENANCE TRAINING
L. C. KESKEY and DAVID J. SYKES (Honeywell, Inc., Training and Controls Systems Div., West Covina, CA) IN: Simulators IV; Proceedings of the SCS Conference, Orlando, FL, Apr. 6-9, 1987 . San Diego, CA, Society for Computer Simulation, 1987, p. 285-290. refs

Pressures placed upon military training requirements resulting from such factors as the declining population of eligible youths for military training, the complexity of technical documentation, and job competition from private industry are considered. An AI simulation-based approach to maintenance training is presented. A system combining job performance aiding and on-the-job training to optimize resource use for maintenance aiding and training is described. K.K.

A88-23196#
THE APPLICATION OF FUZZY SETS THEORY TO OPTIMAL DESIGN OF PRELIMINARY PARAMETERS OF AIRCRAFT
YONGSHUN ZHANG and FAZIE WEI (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 8, Aug. 1987, p. B430-B435. In Chinese, with abstract in English.

In this paper, the membership functions are established based on fuzzy sets theory and the properties of preliminary parameters of aircraft. An index of the membership function is proposed to express quantitatively the extent to which a certain plan or property belongs to the 'satisfactory' set. Then, the calculating formula for synthetic evaluation is set up by the use of a weighting function method, and the optimal preliminary parameters of aircraft are obtained by means of an unrestrictive optimization method. An

illustrative example is also given in this paper, and its result is satisfactory. Author

A88-23269
THE APPLICATION OF CAD IN THE ELECTRICAL DESIGN AND DRAWING OFFICES OF A FLIGHT SIMULATOR MANUFACTURER - PAST, PRESENT, AND FUTURE
M. D. FOSTER (Rediffusion Simulation, Ltd., Crawley, England) IN: Computer applications in aircraft design and operation; Proceedings of the First International Conference on Computer Aided Design, Manufacture and Operation in the Aeronautics and Space Industries, Paris, France, June 16-18, 1987 . Billerica, MA, Computational Mechanics Publications, 1987, p. 137-155.

This paper charts the progress of CAD as an electrical engineering design tool, commencing with the events that directed the authors' attention to the possibility of automating at least some of the electrical drawing office activities of a flight simulator manufacturer. Applications principles, in-service development of the automated simulator system, and lessons learned during the system development are discussed. The potential for further integration of engineering and manufacturing activities through computerization is briefly considered. C.D.

A88-23273
A DATABASE ORIENTED SYSTEM FOR THE SUPPORT OF FLIGHT TESTS
O. VAN TEUNEBROEK and F. J. HEEREMA (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Computer applications in aircraft design and operation; Proceedings of the First International Conference on Computer Aided Design, Manufacture and Operation in the Aeronautics and Space Industries, Paris, France, June 16-18, 1987 . Billerica, MA, Computational Mechanics Publications, 1987, p. 209-228.

The strategy and methods applied in the realization of a database-oriented system that supports various activities related to flight tests are described. The system requirements are summarized and the system's information concept and software concept are described. The capabilities of the system are outlined, and operational experience with its use is reviewed. C.D.

N88-15454# Office of Naval Research, London (England).
HIGHLIGHTS OF THE 70TH FLIGHT MECHANICS PANEL SYMPOSIUM ON FLIGHT VEHICLE DEVELOPMENT TIME AND COST REDUCTION
DENNIS R. SADOWSKI 1 Sep. 1987 5 p Symposium held in Toulouse, France, May 1987
(AD-A185831; ONRL-7-026-C) Avail: NTIS HC A02/MF A01 CSCL 01C

Selected presentations given at this meeting, held in May 1987 in Toulouse, France, are reviewed. Topics of the papers include cost estimating, use of CAE-CAD-CAM, prototype manufacturing, and computer-integrated manufacturing. GRA

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PHYSICS

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

A88-22130#
SCATTERING OF ACOUSTIC AND ELECTROMAGNETIC WAVES BY AN AIRFOIL
R. T. LING and T. D. SMITH (Northrop Corp., Aircraft Div., Hawthorne, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0180)

The finite-difference approach based on the generalized scattering amplitude concept is applied to the scattering of acoustic and electromagnetic waves by a two-dimensional (2-D) airfoil. The transformed Helmholtz equation and associated boundary conditions, in terms of the generalized scattering amplitude, are solved in numerically generated, body-fitted, curvilinear coordinate systems. These are obtained by grid generation procedures commonly used for airfoil aerodynamic computations. Numerical results are obtained for normal incidence of acoustic and electromagnetic waves on a modified NACA 4418 airfoil with a chord length approximately equal to the wavelength of incident waves. The directivity of the scattered sound pressure intensity in the far field is presented in the form of bistatic scattering cross sections. Induced surface current of electromagnetic scattering is also presented. The results of the finite-difference method are in good agreement with those obtained by the method-of-moments. Author

A88-22192*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NOISE OF A MODEL COUNTERROTATION PROPELLER WITH REDUCED AFT ROTOR DIAMETER AT SIMULATED TAKEOFF/APPROACH CONDITIONS (F7/A3)
RICHARD P. WOODWARD (NASA, Lewis Research Center, Cleveland, OH) and ELIOTT B. GORDON (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 29 p. Previously announced in STAR as N88-13961. refs
(AIAA PAPER 88-0263)

A model high-speed advanced counterrotation propeller, F7/A3, was tested in the NASA Lewis Research Center 9 by 15 foot Anechoic Wind Tunnel at simulated takeoff/approach conditions of 0.2 Mach number. Acoustic measurements were taken with an axially translating microphone probe, and with a polar microphone probe which was fixed to the propeller nacelle and could take both sideline and circumferential acoustic surveys. Aerodynamic measurements were also made to establish propeller operating conditions. The propeller was run at two setting angles (front angle/rear angle) of 36.4/43.5 and 41.1/46.4 degrees, forward rotor tip speeds from 165 to 259 m/sec, rotor spacings from 8.48 to 14.99 cm based on pitch change axis separation, and angles of attack to 16 degrees. The aft rotor diameter was 85 percent of the forward rotor diameter to reduce tip vortex-aft rotor interaction as a major interaction noise source. Results are compared with equal diameter F7/A7 data which was previously obtained under similar operating conditions. The aft rotor-alone tone was 7 dB lower for the reduced diameter aft rotor, due to reduced tip speed at constant rpm. Interaction tone levels for the F7/A3 propeller were higher at minimum row spacing and lower at maximum spacing. Author

A88-22193*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH SPEED PROPELLER PERFORMANCE AND NOISE PREDICTIONS AT TAKEOFF/LANDING CONDITIONS
M. NALLASAMY (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH), R. P. WOODWARD, and J. F. GROENEWEG (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 17 p. Previously announced in STAR as N88-13960. refs
(AIAA PAPER 88-0264)

The performance and noise of a high speed SR-7A model propeller under takeoff/landing conditions are considered. The blade loading distributions are obtained by solving the three-dimensional Euler equations and the sound pressure levels are computed using a time domain approach. At the nominal takeoff operating point, the blade sections near the hub are lightly or negatively loaded. The chordwise loading distributions are distinctly different from those of cruise conditions. The noise of the SR-7A model propeller at takeoff is dominated by the loading noise, similar to that at cruise conditions. The waveforms of the acoustic pressure signature are nearly sinusoidal in the plane of the propeller. The computed directivity of the blade passing frequency tone agrees fairly well with the data at nominal takeoff blade angle. Author

A88-22194#
AN OPTIMIZATION METHOD FOR THE REDUCTION OF PROPELLER UNSTEADY FORCES
THOMAS S. MAUTNER (U.S. Naval Ocean Systems Center, San Diego, CA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. Navy-supported research. refs
(AIAA PAPER 88-0265)

Based on the work of Greenblatt (1978), an enhanced optimization technique for the reduction of propeller unsteady forces and the determination of skew distributions has been developed. The current method provides an efficient propeller design tool capable of determining a variety of cubic or quadratic skew distributions, subject to constraints, which minimize the unsteady forces produced by the various harmonic components of the input wake. The original skew optimization method was extended to include higher order harmonics, and the original force calculation method was replaced by an extended version of the method developed by Thompson (1976). Calculation of forces and skew distributions associated with a representative propeller show that acceptable reduction of unsteady forces can be obtained without having to place severe restrictions on the model constraints. Author

A88-22197*# PRC Kentron, Inc., Hampton, Va.
THE PREDICTION OF EN ROUTE NOISE LEVELS FOR A DC-9 AIRCRAFT
DONALD S. WEIR (PRC Kentron, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(Contract NAS1-18000)
(AIAA PAPER 88-0268)

En route noise for advanced propfan powered aircraft has become an issue of concern for the Federal Aviation Administration. The NASA Aircraft Noise Prediction Program (ANOPP) is used to demonstrate the source noise and propagation effects for an aircraft in level flight up to 35,000 feet altitude. One-third octave band spectra of the source noise, atmospheric absorption loss, and received noise are presented. The predicted maximum A-weighted sound pressure level is compared to measured data from the Aeronautical Research Institute of Sweden. ANOPP is shown to be an effective tool in evaluating the en route noise characteristics of a DC-9 aircraft. Author

A88-22758
PREDICTION OF HELICOPTER ROTOR IMPULSIVE NOISE USING MEASURED BLADE PRESSURES
KLAUS-J. SCHULTZ and WOLF R. SPLETTSTOESSER (DFVLR, Institut fuer Entwurfs-Aerodynamik, Brunswick, Federal Republic of Germany) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 405-420. refs

Measured model-rotor blade-pressure data in conjunction with a semiempirical relation combining the blade surface pressures with a momentum thickness are used as source input data for a noncompact prediction code including all of the three source terms of the Ffowcs-Williams/Hawkings equation. The measured blade pressure data serve as direct input to the loading term, and are further used in a more indirect manner to compute an approximate quadrupole term by means of the momentum thickness. The predicted impulsive noise characteristics are compared with the far and near field acoustic data, measured simultaneously with the blade pressure data. Good agreement in terms of amplitude, wave form, and directivity is demonstrated for different simulated flight conditions including hover. B.J.

A88-22759
ROTOR NOISE PREDICTION AND VALIDATION
D. S. JANAKIRAM and H. TADGHIGHI (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 421-436. refs

The state-of-the-art linear rotor rotational noise prediction models are evaluated using the state-of-the-art rotor aerodynamic codes and high-confidence acoustic flight test data on an MD-500E helicopter. The noise prediction models ranged from the LRN compact line source model to the RTN noncompact full surface model. It is shown that the prediction models, especially the noncompact source models, were effective in predicting the noise for shallow observer angles when the helicopter is approaching the observer. For the overhead observer angle and the angle corresponding to the observer position behind the helicopter, the noise levels (especially at frequencies corresponding to higher tail rotor noise harmonics) were grossly underpredicted both for the centerline and the sideline observer positions. B.J.

A88-22760
ACOUSTIC CHARACTERISTICS OF TAIL ROTORS AND THE EFFECTS OF EMPENNAGE INTERACTIONS
ERIC W. JACOBS, JAMES M. FITZGERALD, and RAJARAMA K. SHENOY (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AHS, Annual Forum, 43rd, Saint Louis, MO, May 18-20, 1987, Proceedings. Volume 1 . Alexandria, VA, American Helicopter Society, 1987, p. 437-451. refs

Acoustic and aerodynamic measurements were performed on a four-bladed 0.597-m-diameter scale model tail rotor in the Acoustic Research Tunnel. Initial tests were performed with isolated pusher and tractor tail rotor configurations to determine the operational parameters significantly affecting tail rotor acoustic levels. Subsequent tests incorporated a pylon and stabilizer to investigate tail rotor-empennage interaction effects. The primary determinant of near field tail rotor OASPL and dBD levels was found to be the advancing blade tip Mach number (M sub 1,90). Multiple linear regression analyses of the isolated tail rotor acoustic data indicated that in-plane noise was dominated by thickness noise and scaled approximately as M super 12.5 sub 1,90 and that the out-of-plane (45 deg) noise was significantly affected by higher harmonic and/or broadband 'vortex' noise scaling approximately as M super 8.2 sub 1,90, with rotational blade passage harmonic noise scaling approximately as M super 6.7 sub 1,90. B.J.

A88-23856
APPLICATIONS OF LIGHT IN GUIDED FLIGHT; PROCEEDINGS OF THE SYMPOSIUM, LONDON, ENGLAND, JAN. 22, 1987
Symposium sponsored by the Royal Aeronautical Society. London, Royal Aeronautical Society, 1987, 118 p. For individual items see A88-23857 to A88-23862.

Various papers on the application of light in guided flight are presented. The individual topics addressed include: present projects and future trends in TV optical guided weapons; airship flight control: an application of fly-by-light; optical technology aspects of fiber optic guided weapons duplex links; optical processing for guided flight systems; fiber optic sensors for aircraft flight controls; optical communication, signal processing, and computation; the BAe (Bracknell) automatic detection, tracking, and classification system; the ring laser gyroscope and its application to guided flight; and the evolution of airborne reconnaissance systems. C.D.

A88-23859
OPTICAL PROCESSING FOR GUIDED FLIGHT SYSTEMS
P. V. GATENBY, R. BOWMAN, and D. L. SWITZER (Marconi Defence Systems, Ltd., Stanmore, England) IN: Applications of light in guided flight; Proceedings of the Symposium, London, England, Jan. 22, 1987 . London, Royal Aeronautical Society, 1987, p. 32-41. Research supported by the Ministry of Defence Procurement Executive. refs

Two types of optical delay line based on the optical fiber and the acoustooptic Bragg cell are discussed. Significant advances in the performance of Bragg cell devices made in recent years are outlined. The application of Bragg cells in spectrum analysis is addressed, and aspects of fiber delay line performance and delay line architectures are discussed. C.D.

A88-24303* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ADVANCED TURBOPROP NOISE PREDICTION BASED ON RECENT THEORETICAL RESULTS
F. FARASSAT, S. L. PADULA (NASA, Langley Research Center, Hampton, VA), and M. H. DUNN (PRC Kentron International, Inc., Hampton, VA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 119, Nov. 22, 1987, p. 53-79. Previously announced in STAR as N86-31338. refs

The development of a high speed propeller noise prediction code at Langley Research Center is described. The code utilizes two recent acoustic formulations in the time domain for subsonic and supersonic sources. The structure and capabilities of the code are discussed. Grid size study for accuracy and speed of execution on a computer is also presented. The code is tested against an earlier Langley code. Considerable increase in accuracy and speed of execution are observed. Some examples of noise prediction of a high speed propeller for which acoustic test data are available are given. A brisk derivation of formulations used is given in an appendix. Author

N88-15798*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FIBER OPTICS FOR CONTROLS
GARY T. SENG *In its* Aeropropulsion '87. Session 4: Instrumentation and Controls Research 14 p Nov. 1987
Avail: NTIS HC A05/MF A01 CSCL 20F

The challenge of those involved in control-system hardware development is to accommodate an ever-increasing complexity in aircraft control, while limiting the size and weight of the components and improving system reliability. A technology that displays promise towards this end is the area of fiber optics for controls. The primary advantages of employing optical fibers, passive optical sensors, and optically controlled actuators are weight and volume reduction, immunity from electromagnetic effects, superior bandwidth capabilities, and freedom from short circuits and sparking contacts. Since 1975, NASA Lewis has performed in-house, contract, and grant research in fiber optic sensors, high-temperature electro-optic switches, and fly-by-light control-system architecture. Passive optical sensor development is an essential yet challenging area of work and has therefore received much attention during this period. A major effort to develop fly-by-light control-system technology, known as the Fiber-Optic Control System Integration (FOCSI) program, was initiated in 1985 as a cooperative effort between NASA and DOD. Phase 1 of FOCSI, completed in 1986, was aimed at the design of a fiber-optic integrated propulsion/flight control system. Phase 2, yet to be initiated, will provide subcomponent and system development, and a system engine test. In addition to a summary of the benefits of fiber optics, the FOCSI program, sensor advances, and future directions in the NASA Lewis program will be discussed. Author

N88-16510*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SHOCK STRUCTURE AND NOISE OF SUPERSONIC JETS IN SIMULATED FLIGHT TO MACH 0.4
THOMAS D. NORUM and JOHN G. SHEARIN Feb. 1988
187 p
(NASA-TP-2785; L-16341; NAS 1.60:2785) Avail: NTIS HC A09/MF A01 CSCL 20A

Measured jet plume static pressure distributions and far-field acoustic spectra are presented for underexpanded jets in simulated flight up to a Mach number of 0.4. A gradual stretching of the downstream shock cells is found as the Mach number increases, with no perceptible change in the shock strength. There appears to be little effect of flight on the broadband shock noise amplitudes, and the small changes in its peak frequency for the same emission angle are correlated with the slightly longer shock cells in flight. The larger changes in the broadband peak frequency found at the same angle in wind tunnel coordinates are attributable to convection. Jet mixing noise production decreases significantly with increasing flight speed. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A88-22719
RECENT DEVELOPMENTS IN AVIATION CASE LAW
MICHAEL J. SEHR (Haskell and Perrin, Chicago, IL) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 53, Fall 1987, p. 85-188. refs

In the present article, the concept of 'aviation case law' encompasses those areas of the law which most directly affect the concerns of attorneys practicing in the area of aviation tort law. The case law arising under the Foreign Sovereign Immunities Act is given particular attention since it may be significant to aviation practitioners. Recent developments are essentially those occurring during November 1, 1985 to February 15, 1987. A number of specific cases are discussed. K.K.

A88-23260
THE TEACHING OF AIRCRAFT DESIGN COMPUTER APPLICATIONS
J. P. FIELDING (Cranfield Institute of Technology, England) IN: Computer applications in aircraft design and operation; Proceedings of the First International Conference on Computer Aided Design, Manufacture and Operation in the Aeronautics and Space Industries, Paris, France, June 16-18, 1987 . Billerica, MA, Computational Mechanics Publications, 1987, p. 1-13.

Current work in aircraft conceptual design analysis, aircraft visualization, and detail design being done at the College of Aeronautics at Cranfield Institute of Technology is described. A multinational project to develop an expert system for civil aircraft design is described, and analytical methods being used in design are breifly considered. Design visualization and detail design work at Cranfield are summarized, and the use of computers in a group design project is discussed. C.D.

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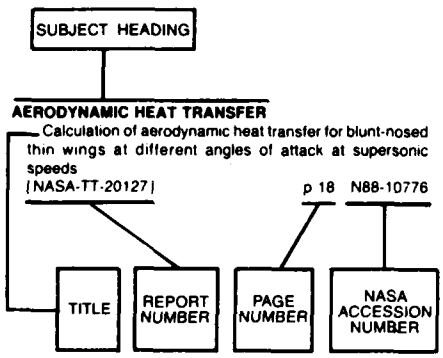
GENERAL

A88-21000#
AEROSPACE HIGHLIGHTS 1987
Aerospace America (ISSN 0740-722X), vol. 25, Dec. 1987, p. 12-16, 18-24, 26-35 (26 ff.).

The present comprehensive evaluation of developments in the aerospace sciences and industries during 1987 encompasses aeroacoustics, aerodynamic decelerator and balloon technology, maintenance, electrical power sources, air-breathing propulsion, air transportation, aircraft design, applied aerodynamics, astrodynamics, the atmospheric environment, flight mechanics, C3I, communications, computer systems, design engineering, digital avionics, electric propulsion, flight simulation, flight testing, fluid dynamics, general aviation, and ground testing. Also discussed are interactive computer graphics, life support systems, LTA vehicles, liquid-fuel rockets, advanced materials, missiles, lasers, propellants, sensors, software, solid-fuel rockets, space systems and operations, space transportation, structural dynamics, advanced structures, support systems, thermophysics, and system effectiveness and safety. O.C.

Typical Subject Index Listing



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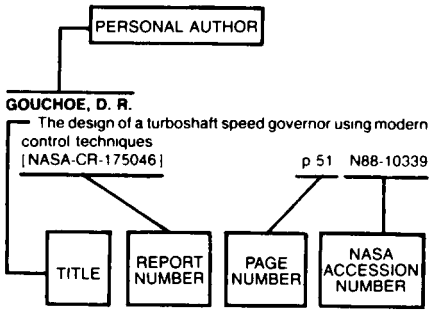

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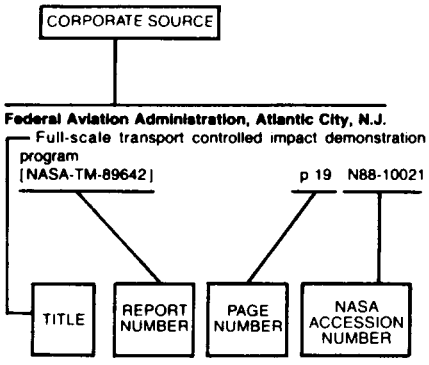

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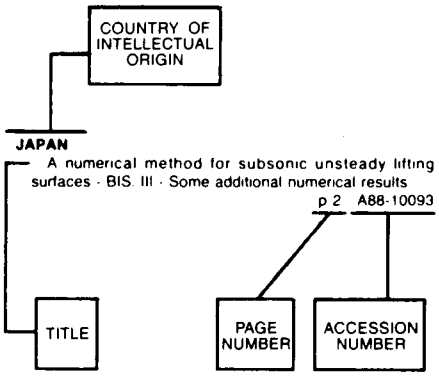

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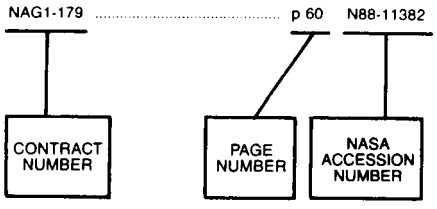

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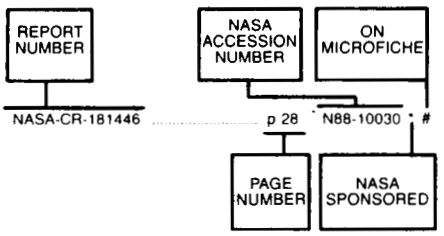

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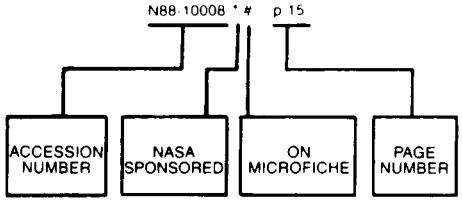

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