NASA

Aeronautical Engineering A Continuing Bibliography with Indexes

NASA SP-7037(236)
February 1989

National Aeronautics and Space Administration

ACCESSION NUMBER RANGES

Accession numbers cited in this Supplement fall within the following ranges.

STAR (N-10000 Series)	N89-10001 — N89-11688
IAA (A-10000 Series)	A89-10001 — A89-12760

This bibliography was prepared by the NASA Scientific and Technical Information Facility operated for the National Aeronautics and Space Administration by RMS Associates.

NASA SP-7037(236)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 236)

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 January 1989 in

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

National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Division
Washington, DC 1989

This supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161, price code A06.

INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 430 reports, journal articles and other documents originally announced in January 1989 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 12 Engineering 43
Includes engineering (general); communications and radar; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

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

Category 14 Life Sciences 57
Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.

Category 15 Mathematical and Computer Sciences 57
Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

Category 16 Physics 59
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

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

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

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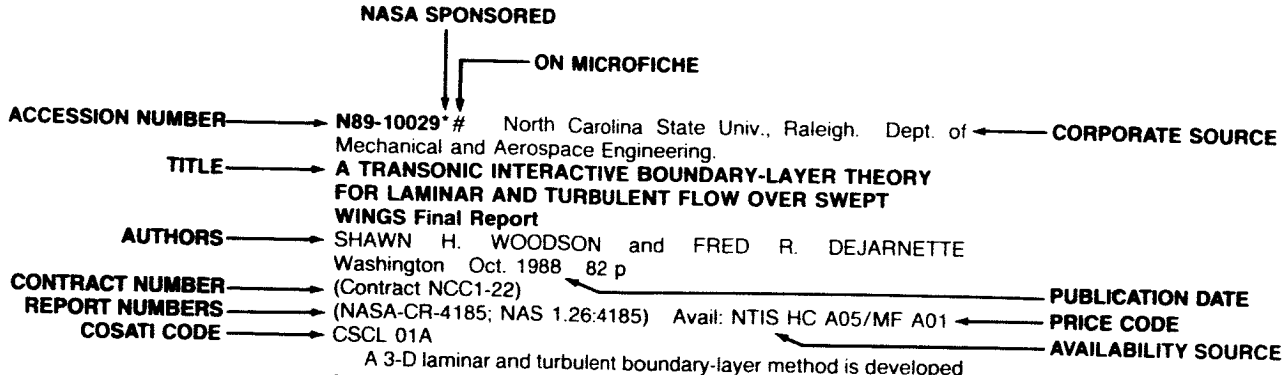
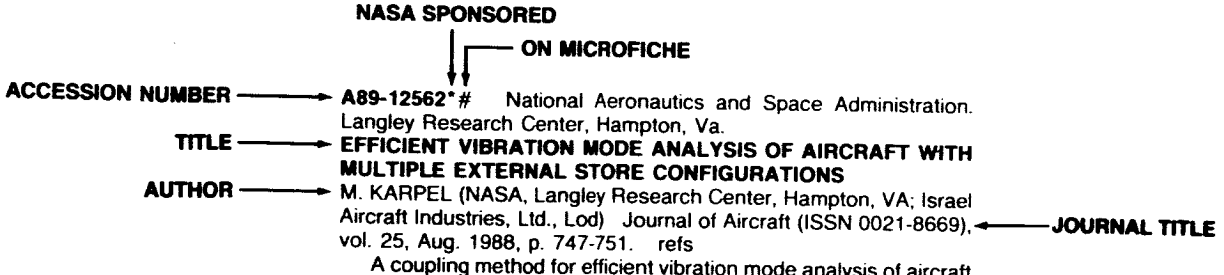
TYPICAL REPORT CITATION AND ABSTRACT



A 3-D laminar and turbulent boundary-layer method is developed for compressible flow over swept wings. The governing equations and curvature terms are derived in detail for a nonorthogonal, curvilinear coordinate system. Reynolds shear-stress terms are modeled by the Cebeci-Smith eddy-viscosity formulation. The governing equations are descretized using the second-order accurate, predictor-corrector finite-difference technique of Matsuno, which has the advantage that the crossflow difference formulas are formed independent of the sign of the crossflow velocity component. The method is coupled with a full potential wing/body inviscid code (FLO-30) and the inviscid-viscous interaction is performed by updating the original wing surface with the viscous displacement surface calculated by the boundary-layer code. The number of these global iterations ranged from five to twelve depending on Mach number, sweep angle, and angle of attack. Several test cases are computed by this method and the results are compared with another inviscid-viscous interaction method (TAWFIVE) and with experimental data. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



A coupling method for efficient vibration mode analysis of aircraft with multiple external store configurations is presented. A set of low-frequency vibration modes, including rigid-body modes, represent the aircraft. Each external store is represented by its vibration modes with clamped boundary conditions, and by its rigid-body inertial properties. The aircraft modes are obtained from a finite-element model loaded by dummy rigid external stores with fictitious masses. The coupling procedure unloads the dummy stores and loads the actual stores instead. The analytical development is presented, the effects of the fictitious mass magnitudes are discussed, and a numerical example is given for a combat aircraft with external wing stores. Comparison with vibration modes obtained by a direct (full-size) eigensolution shows very accurate coupling results. Once the aircraft and stores data bases are constructed, the computer time for analyzing any external store configuration is two to three orders of magnitude less than that of a direct solution. Author

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 236)

FEBRUARY 1989

01

AERONAUTICS (GENERAL)

A89-10538
AIRCRAFT DYNAMIC STABILITY - DEVELOPMENTAL HISTORY ASPECTS [DIE EIGENSTABILITAET VON FLUGZEUGEN - EIN BEITRAG ZUR GESCHICHTLICHEN ENTWICKLUNG]
ANDREAS HAFER, GOTTFRIED SACHS (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany), and XAVER HAFER (Darmstadt, Technische Hochschule, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 450-459. In German. refs
(DGLR PAPER 87-057)

The history of flight-stability analysis in the 19th and early 20th centuries is recalled in an analytical review. Consideration is given to the contributions of Cayley, Penaud, Lanchester, Langley, Prandtl, Ahlborn, Zahm, Runge, Lilienthal, and the Wright brothers. Diagrams, drawings, graphs, and photographs are provided. T.K.

A89-10627
INTERNATIONAL PACIFIC AIR AND SPACE TECHNOLOGY CONFERENCE, MELBOURNE, AUSTRALIA, NOV. 13-17, 1987, PROCEEDINGS
Conference sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE Proceedings P-208), 1988, 563 p. For individual items see A89-10628 to A89-10673.
(SAE P-208)

Papers are presented on such topics as a conceptual study of the H-II Orbiting Plane, V/STOL aircraft configurations and opportunities in the Pacific basin, Boeing 7J7 technology and design, space transporation systems for the future, propulsion-airframe integration for commercial and military aircraft, and X-29A forward-swept-wing flight research. Consideration is also given to the mission-adaptive wing, large space structures, boundary layer control for drag reduction, the interoperability of military and civil air-cargo systems, maintenance and airline safety, forward error correction techniques for mobile satellite communications, spacecraft mechanisms technology, modern techniques for the control of RPVs, and Space Station utilization. B.J.

A89-10628
FROM KITTY HAWK TO THE YEAR 2000
SAMUEL J. SMYTH IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 1-21. refs
(SAE PAPER 872395)

The evolution of aerospace vehicles is traced from the Wright Brother's first flights to a glimpse into the future. Some highlights of the discussion are the Fokker T-2, the DC-3, the Lockheed twin engines, VTOL, the Bell X-1, the Boeing 707, the Boeing 747, the Mercury project, the Mariner spacecraft, the Apollo program, Skylab, and the Space Shuttle. B.J.

A89-10629* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNIQUE RESEARCH CHALLENGES FOR HIGH-SPEED CIVIL TRANSPORTS
CHARLIE M. JACKSON, JR. and E. K. MORRIS, JR. (NASA, Langley Research Center, Hampton, VA) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 29-34. Previously announced in STAR as N87-27651. refs
(SAE PAPER 872400)

Market growth and technological advances are expected to lead to a generation of long-range transports that cruise at supersonic or even hypersonic speeds. Current NASA/industry studies will define the market windows in terms of time frame, Mach number, and technology requirements for these aircraft. Initial results indicate that, for the years 2000 to 2020, economically attractive vehicles could have a cruise speed up to Mach 6. The resulting research challenges are unique. They must be met with technologies that will produce commercially successful and environmentally compatible vehicles where none have existed. Several important areas of research were identified for the high-speed civil transports. Among these are sonic boom, takeoff noise, thermal management, lightweight structures with long life, unique propulsion concepts, unconventional fuels, and supersonic laminar flow. Author

A89-10646
MILITARY AEROSPACE TECHNICAL DEVELOPMENT IN AUSTRALIA
I. T. SUTHERLAND (Royal Australian Air Force, Canberra, Australia) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 225-233. refs
(SAE PAPER 872426)

The paper identifies the requirements for and strengths of Australia's military aerospace technologies, with emphasis on the self-reliance policy of Australian Defence. Particular attention is given to government policy reviews, current technologies and future support needs, the economic environment, and mechanisms for technological development. Specific reference is made to the F/A-18 Hornet Aircraft Project. B.J.

A89-10657
A WORLD LEADER IN ENGINEERING AND MAINTENANCE
W. M. RYAN (Qantas Airways, Ltd., Sydney, Australia) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 369-373.
(SAE PAPER 872444)

Aspects of the Qantas engineering and maintenance program are discussed. The history of Qantas is briefly reviewed, and the reasons for the success of the airline are summarized. Its manpower and training programs are described, and its maintenance

philosophy is discussed. Quality control and strategic planning at Qantas are addressed. C.D.

A89-10689
OVER THE RAINBOW
RICHARD G. DESIPIO (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: Aerospace avionics equipment and integration; Proceedings of the Second Conference, Dallas, TX, Nov. 2-4, 1987. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 139-145.
(SAE PAPER 872499)

The paper addresses advanced avionics architectures as well as a transitionary means of attaining these goals and objectives. An 'Avionics System Index' is presented to define and specify the make-up of a partitioned avionics configuration based upon a framework of multiplex data buses, backplane buses, and matrix switches. It is noted that the standardization of an intraplatform network was begun with the introduction and implementation of the DOD MIL-STD-1553B and its NATO equivalent STANAG-3838 bus network; MIL-STD-1553B provided a significant step forward relative to avionics system integration. K.K.

A89-11450
TORNADO - THE FIRST EIGHT YEARS
WILLIAM RICHARDSON (RAF, London, England) Aerospace (UK) (ISSN 0305-0831), vol. 15, Sept. 1988, p. 6-12.

The engineering support necessary to maintain the Tornado aircraft is discussed, focusing on the work in-service. The Torndao is a day and night, all-weather, ultralow-level attack aircraft capable of using both conventional and nuclear weapons. The development and production program for the aircraft and the organization of Tornado engineering support are outlined. Arrangements for the repair and overhaul of Tornado and in- service operation of the aircraft are examined. Organizational and technical problems which have occurred in the development process are presented and efforts to overcome these problems are discussed. R.B.

A89-12319
A CANADIAN GOVERNMENT LOOK AT AIRWORTHINESS
JOHN F. MEW and JAMES A. TORCK (Transport Canada, Ottawa) SAE, Aerospace Vehicle Conference, Annapolis, MD, Apr. 18-20, 1988. 6 p.
(SAE PAPER 880935)

The paper traces the development of the approach to airworthiness taken by Canadian government authorities from its origin through to current practices. It describes the Aerospace industry, the carriers and general aviation in statistical terms, indicates the impact of economic regulatory reform and suggests the way ahead for Canadian and other authorities lies in the attitude and methodologies practiced by the European authorities in their development of JARs. Author

A89-12320
EUROPEAN AIRWORTHINESS CONTROL FOR THE 1990S
J. W. SAULL SAE, Aerospace Vehicle Conference, Annapolis, MD, Apr. 18-20, 1988. 11 p.
(SAE PAPER 880936)

Key developments and problems in European airworthiness matters for the 1990s are addressed. Efforts being given to the harmonization of requirements within Europe are reviewed. Developments occurring in the control of maintenance standards are examined, and the importance of making the best use of technical resources is stressed. C.D.

A89-12322* National Aeronautics and Space Administration, Washington, D.C.
THE WINNING EDGE
CECIL C. ROSEN, III and LOUIS J. WILLIAMS (NASA, Washington, DC) SAE, Aerospace Vehicle Conference, Annapolis, MD, Apr. 18-20, 1988. 13 p.
(SAE PAPER 880945)

Aeronautics research at NASA is reviewed, stressing NASA's leading role in the development of technological advances. The Aircraft Energy Efficiency program for improving transport aircraft and the Natioanl Aerospace Plane program are examined. NASA research facilities and wind tunnels, and research in materials and structures and aviation safety and automation are discussed. R.B.

A89-12401
AUTOMATION APPLICATIONS FOR ROTORCRAFT; PROCEEDINGS OF THE NATIONAL SPECIALISTS' MEETING, ATLANTA, GA, APR. 4-6, 1988
Meeting sponsored by AHS. Alexandria, VA, American Helicopter Society, 1988, 148 p. For individual items see A89-12402 to A89-12418.

The present conference on the application of automation to helicopter systems discusses automatic C3I for target data dissemination, the nonlinear control of a twin-lift helicopter system, the development of a rule-based demonstration prototype expert system for inflight emergencies, automated VTOL RPVs, digital autopilots for unmanned helicopters, and knowledge-based target recognition. Also discussed are speech recognition in advanced helicopters, a tactics expert for a scout/attack helicopter, novel concepts in helicopter machinery prognostics, a hybrid knowledge-based approach to AH-64 fault isolation, and the implementation of knowledge-based systems for helicopter machinery fault prognosis. O.C.

A89-12408#
NEW CONCEPTS IN HELICOPTER MACHINERY PROGNOSTICS
KENNETH PIPE and IAN CHEESEMAN (Stewart Hughes, Ltd., Southampton, England) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 12 p.

Technologies that have been developed for rotorhead transmission and power plant diagnostics are presented. Practical results are discussed for these processing-intensive techniques, as well as the implications for flight safety, maintenance optimization, and battle damage recovery of the use of this technology. The hardware required to implement these techniques is noted, both for inboard and carry-onboard systems. Author

A89-12409#
A HYBRID KNOWLEDGE-BASED APPROACH TO AH-64A FAULT ISOLATION
BRIAN P. MILLETT and RICHARD K. MABY (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 10 p. Army-supported research. refs

The increasing complexity of state-of-the-art military rotorcraft, in conjunction with greater aircraft availability requirements and the limited pool of skilled maintenance personnel, have prompted the development of an Intelligent Fault Locator (IFL) expert system for AH-64A helicopter fault diagnosis. The IFL combines maintenance data with AI; in order to enhance its operating characteristics and capabilities, a 'shell' has been devised which encompasses user-interface and diagnostic modules, as well as a learning module and fuel/flight control subsystem graphics. Fault location downtimes for the AH-64A have been reduced by almost 47 percent by means of the IFL system. O.C.

A89-12412#
IMPLEMENTATION OF KNOWLEDGE-BASED SYSTEMS FOR HELICOPTER MACHINERY FAULT PROGNOSIS
IAN CHEESEMAN and KENNETH PIPE (Stewart Hughes, Ltd., Southampton, England) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 8 p.

Knowledge-based systems have been developed for the automation of helicopter gas turbine powerplant fault-finding procedures, helicopter transmission system vibration-signature

analyses, and rotor head-smoothing tasks. An account is presently given of the development process for these techniques, giving attention to the problems encountered in the extension of these diagnostic capabilities into fully prognostic ones. A powerful interface between the FORTRAN and C languages and either PROLOG or LISP is an essential feature of the development system. O.C.

A89-12537
BITING THE BULLET ON AVIATION SAFETY
ROBERT L. CRANDALL (American Airlines, Inc., Dallas, TX) Issues in Science and Technology (ISSN 0748-5492), vol. 4, Winter 1988, p. 93-95.

It is presently proposed that the U.S. Secretary of Transportation should constitute a blue-ribbon commitee, headed by the FAA and encompassing representatives from all concerned groups, to conduct a detailed study of the ATC system's current status and prospects for expansion to handle the increase to 600 million passengers, from the current 415 million passengers, expected by 1992. For the time being, the FAA is noted to be proceeding with the hiring and training of 955 more ATC operators. Difficulties are likely to emerge from the need to override environmentalist concerns and undertake the construction of additional airports, and more runways for existing airports, which will be capable of handling expanded future traffic.

A89-12538
UP IN THE AIR ON AIR TRAFFIC CONTROL
GUY V. MOLINARI (U.S. Congress, House Public Works and Transportation Committee, Washington, DC) Issues in Science and Technology (ISSN 0748-5492), vol. 4, Winter 1988, p. 96-99. refs

The FAA's answer to currently experienced ATC computer and communications equipment malfunctions and outages is the National Airspace System (NAS) plan, which will spend several billion dollars in equipment modernization. It is presently noted that in the seven years since the plan was announced, little has been accomplished; the plan's costs, moreover, which were originally envisioned as of the order of $9 billion over a 10-year period, have with persistent overruns come to be projected at $17 billion over a 20-year period. Although the NAS plan originally envisioned a reduction of necessary staff due to advanced systems' high degree of automation, it is noted to be essential that the FAA hire additional technician trainees in order to stay even with attrition. O.C.

A89-12716
BIRD HAZARDS IN AVIATION; PROCEEDINGS OF THE SYMPOSIUM, LONDON, ENGLAND, OCT. 14, 1987
London, Royal Aeronautical Society, 1987, 94 p. For individual items see A89-12717 to A89-12723.

The present conference discusses such aircraft birdsdstrike effect-related issues as the British civil aviation birdstrike record, RAF experience with birdstrikes, the design and testing of aircraft engines in order to minimize hazards from birds, and birdstrike-anticipating design and testing for airframes. Also discussed are the design and testing of cockpit windscreens, airline safety- and economy-related implications of birdstrikes, the responsibility of regulatory authorities for birdstrike effect minimization, the work of the British Ministry of Agriculture, Fisheries and Food 'Aviation Bird Unit', and bird control methods applicable beyond the boundaries of airports. O.C.

A89-12723
THE WORK OF THE AVIATION BIRD UNIT
T. BROUGH (Ministry of Agriculture, Fisheries and Food, Worplesdon Laboratory, Guilford, England) IN: Bird hazards in aviation; Proceedings of the Symposium, London, England, Oct. 14, 1987. London, Royal Aeronautical Society, 1987, p. 66-73. Research supported by Ministry of Defence and Civil Aviation Authority. refs

The UK's Aviation Bird Unit (ABU) consists of Ministry of Agriculture biologists specializing in the ornithological aspects of the aircraft birdstrike problem and its alleviation. ABU activities have concentrated in and around airfields, in keeping with the occurrence of nearly 90 percent of birdstrikes at altitudes below 900 ft; observations at nocturnal roost sites as much as 50 km away from major airports have been required, however, for such birdstrike problem-causing species as seagulls. Other ABU activities extend to bird habitat management, bird-scaring, advisory work, and the charting of migratory bird routes in order to facilitate their avoidance by aircraft. O.C.

N89-10003# Royal Aerospace Establishment, Farnborough (England).
AEROSPACE SYSTEMS AND TECHNOLOGY: THE ROLE OF THE RAE
G. G. POPE Jun. 1988 38 p Presented at RAE Handley Page Memorial Lecture, London, United Kingdom, 21 Apr. 1988 Original contains color illustrations
(RAE-TR-88042; RAE-DR/55/07; ETN-88-93140) Avail: NTIS HC A03/MF A01; Defence Research Information Centre, 65 Brown Street, Glasgow, G2 8EX, United Kingdom

The evolution and role of the U.K. Royal Aerospace Establishment are reviewed and research in night and all-weather operations, flight control systems for ASTOVL aircraft, computational fluid dynamics, airframe materials, weapon aim-point refinement, remote sensing, and systems assessment is summarized. ESA

N89-10830# Politecnico di Torino (Italy). Dipartimento di Ingegneria Aeronautica e Spaziale.
ORIGIN, OBJECTIVES AND ACTIVITIES OF THE DEPARTMENT OF AEROSPACE ENGINEERING Annual Report, 1985
Nov. 1986 38 p
Avail: NTIS HC A03/MF A01

The research activities of the Department of Engineering of the Turin Polytechnic are reported. Department activities are concerned with both teaching and research. The research is broadly based and covers all traditional disciplines of aeronautical and aerospatial engineering. Allied research themes are also developed, such as industrial aerodynamics, material science, biofluidynamics, laser matter interaction and other topics where one can find new application fields for the methodologies and the knowledge of aerospace disciplines. Brief summaries are given of research activities for 1985. E.R.

N89-10831# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
COMPUTING SYSTEMS CONFIGURATION FOR HIGHLY INTEGRATED GUIDANCE AND CONTROL SYSTEMS
Jun. 1988 164 p Lectures held in Bourges, France, 20-21 Jun. 1988, in Neubiberg, West Germany, 23-24 Jun. 1988, and in Seattle, Wash., 6-7 Jul. 1988
(AGARD-LS-158; ISBN-92-835-0464-X) Avail: NTIS HC A08/MF A01

Modern military air vehicles have to comply with sophisticated performance requirements. As a result, full advantage must be taken of the rapid advances in computer hardware/software and future micro-electronics technologies. New design and development strategies must be implemented in order to obtain the overall performance benefits offered by advanced integrated systems for guidance and control, avionics, weapon delivery and tactical performance management. In a two-day program this Lecture Series addresses issues which have demonstrated notable and outstanding advances in the field of computing system design, design tools and techniques, computers, data buses, and architectures. In particular, the second day's program will show how technological advances have enabled the design of a modern computing system architecture. Future trends and new directions will be subjects for round table discussions.

N89-10839# Centre National d'Etudes Spatiales, Toulouse (France).
FLIGHT MECHANICS AND AEROTHERMODYNAMIC SOFTWARE
J. C. AGNESE, P. SAINTPE, and T. VOIRON 6 Mar. 1988 35 p In FRENCH; ENGLISH summary
(CNES-CT/DTI/MS/MN/069; CNES-DLA/SDT/ED/SA; ETN-88-93094) Avail: NTIS HC A03/MF A01

Aerothermodynamics software for heat flow computation on an axisymmetric structure, plane sheet, arrow cylinder; wall heating with or without ablation; thrust nozzle free jet computation and its interaction with a wall (plane or truncated segment); and flight mechanics software for Ariane takeoff and booster separation is described. ESA

02

AERODYNAMICS

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

A89-10102#
INVESTIGATIONS ON HIGH REYNOLDS NUMBER LAMINAR FLOW AIRFOILS
G. REDEKER, K. H. HORSTMANN, H. KOESTER, and A. QUAST (DFVLR, Institut fuer Aerodynamik, Brunswick, Federal Republic of Germany) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 1, p. 73-85) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 583-590. Previously cited in issue 24, p. 3529, Accession no. A86-48983. refs

A89-10104*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFICIENT ALGORITHM FOR SOLUTION OF THE UNSTEADY TRANSONIC SMALL-DISTURBANCE EQUATION
JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 598-605. Previously cited in issue 08, p. 1033, Accession no. A87-22420. refs

A89-10105*# Texas A&M Univ., College Station.
WING LAMINAR BOUNDARY LAYER IN THE PRESENCE OF A PROPELLER SLIPSTREAM
STAN J. MILEY (Texas A & M University, College Station), RICHARD M. HOWARD (U.S. Naval Postgraduate School, Monterey, CA), and BRUCE J. HOLMES (NASA, Langley Research Center, Hampton, VA) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 1413-1420) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 606-611. Previously cited in issue 24, p. 3533, Accession no. A86-49122. refs
(Contract NAG1-344)

A89-10106#
BOUNDARY-LAYER MEASUREMENTS ON AN AIRFOIL AT LOW REYNOLDS NUMBERS
M. BRENDEL and T. J. MUELLER (Notre Dame, University, IN) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 612-617. Research supported by the University of Notre Dame. Previously cited in issue 08, p. 1041, Accession no. A87-22672. refs
(Contract N00014-83-K-0239)

A89-10108*# PRC Kentron, Inc., Hampton, Va.
ENGINEERING ANALYSIS OF SLENDER-BODY AERODYNAMICS USING SYCHEV SIMILARITY PARAMETERS
MICHAEL J. HEMSCH (PRC Kentron, Inc., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 625-631. Previously cited in issue 08, p. 1036, Accession no. A87-22522. refs
(Contract NAS1-18000)

A89-10114#
TWO-DIMENSIONAL MODEL FOR AIRFOIL UNSTEADY DRAG BELOW STALL
J. G. LEISHMAN (Maryland, University, College Park) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 665, 666. refs

A computationally efficient method for computing the unsteady pressure drag on a two-dimensional airfoil undergoing arbitrary motion in compressible flow has been developed. It is shown that the unsteady pressure drag variation on a nonstationary airfoil is relatively significant. Inclusion of the method within helicoptor rotor aeroelasticity analyses may provide a better definition of higher harmonics of the blade lag excitation and improve prediction of aeroelastic coupling affects. R.R.

A89-10116#
THICK AIRFOIL AT LOW REYNOLDS NUMBER AND HIGH INCIDENCE
S. RAGHUNATHAN (Belfast, Queen's University, Northern Ireland), J. R. HARRISON, and B. D. HAWKINS Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 669-671. refs

Experimental results on an NACA 0021 airfoil at a blade chord Reynolds number of 260,000 and over a range of incidence of 0-90 deg were obtained in a closed-circuit low-speed wind tunnel. The results are compared with previous data on other airfoils and with the predictions of momentum theory. At low Reynolds numbers and for symmetric airfoil sections the maximum value of the lift coefficient is between 0.8 and 1.0, the stall angle is between 10 and 15 deg, and after stalling, the lift coefficient decreases with incidence much more rapidly than for thicker airfoils. R.R.

A89-10160* High Technology Corp., Hampton, Va.
COMPUTATIONAL AND EXPERIMENTAL STUDIES OF LEBUS AT HIGH DEVICE REYNOLDS NUMBERS
ARILD BERTELRUD (High Technology Corp., Hampton, VA) and R. D. WATSON (NASA, Langley Research Center, Hampton, VA) IN: Turbulence management and relaminarisation; Proceedings of the IUTAM Symposium, Bangalore, India, Jan. 13-23, 1987. Berlin and New York, Springer-Verlag, 1988, p. 85-96. refs

The present paper summarizes computational and experimental studies for large-eddy breakup devices (LEBUs). LEBU optimization (using a computational approach considering compressibility, Reynolds number, and the unsteadiness of the flow) and experiments with LEBUs at high Reynolds numbers in flight are discussed. The measurements include streamwise as well as spanwise distributions of local skin friction. The unsteady flows around the LEBU devices and far downstream are characterized by strain-gage measurements on the devices and hot-wire readings downstream. Computations are made with available time-averaged and quasi-stationary techniques to find suitable device profiles with minimum drag. Author

A89-10167
THREE-DIMENSIONAL BOUNDARY LAYER TRANSITION ON A CONCAVE-CONVEX CURVED WALL
Y. KOHAMA (Tohoku University, Sendai, Japan) IN: Turbulence management and relaminarisation; Proceedings of the IUTAM Symposium, Bangalore, India, Jan. 13-23, 1987. Berlin and New York, Springer-Verlag, 1988, p. 215-226. refs

The transition to turbulence over a NASA 998A supercritical

LFC wing is investigated experimentally in the 400 x 400-mm working section of the open-jet wind tunnel at DFVLR Goettingen at velocities up to 12 m/sec. The results are presented in extensive graphs and flow visualizations and discussed in detail. It is shown that the primary destabilizing mechanism in the boundary layer is a Taylor-Goertler instability in the concave region, resulting in formation of a counterrotating Taylor-Goertler vortex; this vortex is transformed to a corotating cross-flow vortex in the convex region at sweep angles greater than 47 deg. T.K.

A89-10171
SUPPRESSION OF UNSTABLE OSCILLATIONS IN A BOUNDARY LAYER
A. I. DERZHAVINA, O. S. RYZHOV, and E. D. TERENT'EV (AN SSSR, Vychislitel'nyi Tsentr, Moscow, USSR) IN: Turbulence management and relaminarisation; Proceedings of the IUTAM Symposium, Bangalore, India, Jan. 13-23, 1987. Berlin and New York, Springer-Verlag, 1988, p. 271-284. refs

A theoretical study is made of the excitation of Tollmien-Schlichting waves by a mechanical vibrator or thermal source that heats a small part of a surface in subsonic stream. According to results of most practical concern, it is possible to reduce essentially the amplitude of forced oscillations and even to attain their full attenuation by changing the form of a membrane. The similar effect is reached when the temperature of the heated part varies. Hence, a possibility arises to damp traveling Tollmien-Schlichting waves using different devices of both mechanical and thermal nature. Author

A89-10192* Boston Univ., Mass.
BEM FOR WAVE EQUATION WITH BOUNDARY IN ARBITRARY MOTION AND APPLICATIONS TO COMPRESSIBLE POTENTIAL AERODYNAMICS OF AIRPLANES AND HELICOPTERS
LUIGI MORINO, BALA K. BHARADVAJ, MARVIN I. FREEDMAN (Boston University, MA), and KADIN TSENG (United Technologies Research Center, East Hartford, CT) IN: Advanced boundary element methods; Proceedings of the IUTAM Symposium, San Antonio, TX, Apr. 13-16, 1987. Berlin and New York, Springer-Verlag, 1988, p. 267-277. refs
(Contract NAS1-17317; DAAG29-83-K-0050; DAAL03-87-K-0022)

The wave equation for an object in arbitrary motion is investigated analytically using a BEM approach, and practical applications to potential flows of compressible fluids around aircraft wings and helicopter rotors are considered. The treatment accounts for arbitrary combined rotational and translational motion of the reference frame and for the wake motion. The numerical implementation as a computer algorithm is demonstrated on problems with prescribed and free wakes, the former in compressible flows and the latter for incompressible flows; results are presented graphically and briefly characterized. T.K.

A89-10509
AN INVERSE, SUBSONIC TWO-DIMENSIONAL PANEL METHOD FOLLOWING THE METHOD OF SMALLEST QUADRATE FOR THE DESIGN AND MODIFICATION OF MULTIPLE ELEMENT PROFILES [EIN INVERSES, SUBSONISCHES 2D-PANELVERFAHREN NACH DER METHODE DER KLEINSTEN QUADRATE ZUM ENTWURF UND ZUR MODIFIKATION VON MEHRELEMENTPROFILEN]
H. SCHWARTEN (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 163-170. In German. refs
(DGLR PAPER 87-061)

A calculative procedure is presented which, by coupling a computational code with a minimization algorithm, enables a single and multielement profile to be designed. The profile is developed using a special basis function. This method guarantees a flat outline and permits partial and full outlines, significantly increasing the input flexibility. Five practical examples are used to demonstrate the quality of the procedure. C.D.

A89-10510
STUDY OF THE ENGINE INFLUENCE ON WINGS WITH MODERN HIGH-BYPASS PROPULSION CONCEPTS [UNTERSUCHUNG DES TRIEBWERKEINFLUSSES AN FLUEGELN MIT MODERNEN HOCHBYPASS-ANTRIEBSKONZEPTEN]
G. SAUER (Berlin, Technische Universitaet, Federal Republic of Germany) and J. SZODRUCH (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 171-179. In German. Research supported by the Technische Universitaet Berlin, DFG, and BMFT. refs
(DGLR PAPER 87-063)

The use of modern high-bypass engines permits increasing wind tunnel research on capacity optimization of wing-propulsion systems. Numerical procedures are needed for the aerodynamic preoptimization of configurations of advanced engine concept configurations. To this end, a three-dimensional engine panel method for flow calculations was developed. The inlet flow and its effects on the flow around a nacelle are shown for the subsonic regime and for various engine states. Lift distributions are studied using wing panel methods in wing-engine systems with individual and twin engines with regard to deviations from undisturbed wing lift. The concept of variable wing camber as a potential compensation for the engine influence on the wing is presented. C.D.

A89-10511
IMPROVEMENT OF A DESIGN CODE FOR AIRFOILS AT TRANSONIC REGIME
F. MONGE (Instituto Nacional de Tecnica Aerospacial, Madrid, Spain) and H. KOESTER (DFVLR, Institut fuer Entwurf-saerodynamik, Brunswick, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 180-189. refs
(DGLR PAPER 87-064)

Investigations on the design code of McFadden have been carried out in order to improve agreement between the design pressure distribution and the analysis pressure distribution of the designed airfoil. This has been achieved by modifying the artificial viscosity term used in the existing McFadden code. The new term has a more realistic meaning, as it is now proportional to the truncation error included in the finite differences scheme used to solve the full potential equation. In some cases it has also been necessary to carry out a weighted smoothing of the curvature for modelling with more accuracy the desired pressure distribution. At the same time, the convergence has been accelerated and the arbitrariness of some input parameters avoided. The improved method has been checked on various airfoil designs which are discussed in the paper. Author

A89-10513
PROFILE DEVELOPMENT RESULTS FOR ADVANCED CIRCULATION-GUIDED ROTOR SYSTEMS IN FAST HELICOPTERS [ERGEBNISSE DER PROFILENTWICKLUNG FUER FORTSCHRITTLICHE ZIRKULATIONSGESTEUERTE ROTORSYSTEME SCHNELLER HUBSCHRAUBER]
A. WEIGAND (Stuttgart, Universitaet, Federal Republic of Germany) and H. ZIMMER (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 199-216. In German. refs
(Contract BMFT-T/RF-41/F0013/G2232)
(DGLR PAPER 87-086)

Alternative rotor systems designed to achieve greater speed increases for helicopters with smaller blade tip Mach numbers are considered. In particular, a modified calculative procedure involving the Coanda effect is used to design improved circulation-guided rotor (CGR) systems. A CG profile with three interchangeable

Coanda surfaces was designed, constructed, and tested in a wind tunnel. The theoretical and experimental results demonstrate a significant advance over the present state of the art. Further research on the flow behavior on a three-dimensional CGR using a curved lifting line blade element vortex wake method is used to define a blade form suitable for a fast CGR helicopter. C.D.

A89-10542#
A NUMERICAL SOLUTION OF TRANSONIC FLOW USING DISCONTINUOUS SHOCK RELATION
MASAYOSHI NAKAMURA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 414, 1988, p. 333-342. In Japanese, with abstract in English. refs

The purpose of this study is to obtain solutions, which contain complete discontinuities of shock waves, of the potential equations for transonic airfoils using numerical techniques. For iterative calculations, the potential equations are transformed into a more convenient form of simultaneous equations with two variables of velocity potential and Mach number. The solutions with the complete discontinuities of shock waves satisfying Prandtle's relationship are obtained by the iterative calculations without divergencies or height frequencies under a grid system in the physical plane. Numerical results of the present techniques and of another method for the transonic flow over an airfoil of NACA 0012 with shock wave are used as test cases for comparisons. Author

A89-10544#
AN EXPERIMENTAL STUDY ON AERODYNAMIC PERFORMANCE OF LIPPISCH-TYPE GEW
FUMIHARU OTAGIRI, SHIGENORI ANDO, TORU NOHISA, HIROSHI TAKASAKI, and TATSUYA TSUJIMOTO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 414, 1988, p. 351-356. In Japanese, with abstract in English. refs

Experimental research on some aerodynamic performance of Lippisch-type Ground Effect Wing is presented. This type has a reverse-Delta wing with some cathedral angles (CA) along the leading edge. Based upon the comparison between experiment I (CA = 16.3 deg) and II (CA = 8.1 deg), it is concluded that there are some increments of L/D caused from the ground effect both in experiment I and II, but the latter has higher C(L) than the former, caused by a modification of the model I. Author

A89-10547#
ANALYTICAL AND EXPERIMENTAL RESEARCH ON AERODYNAMICAL EFFECTS OF WIND SHEAR ON AIRCRAFT
HARUO KIMURA (Kyushu University, Fukuoka, Japan) and HAMID BASSIRI Kyushu University, Faculty of Engineering, Memoires (ISSN 0023-6160), vol. 48, June 1988, p. 105-124. refs

The aerodynamical effects of wind shear on aircraft are discussed with both theoretical and experimental viewpoints. In the theoretical section the influence of wind distribution over the aircraft on the pitching moment which had been formulated in a previous paper is reviewed briefly and is followed by a detailed study of the effects of temporal variation of wind. Based on a theory regarding the accelerated motion of an airfoil in a fluid, the equations for obtaining the acceleration derivatives are derived. It is shown that the influence of these derivatives on the aircraft stability and response is not negligible. In the experimental section the results obtained in a wind shear tunnel on the spatial and temporal effects of wind variation are presented. The tests are carried out using a two-dimensional wing and tail combination with the horizontal stabilizer adjustable at different vertical positions, showing the experimental confirmation of the related theories. Author

A89-10568#
A NUMERICAL SIMULATION OF SEPARATED FLOW AROUND TWO-DIMENSIONAL WING BY A DISCRETE VORTEX METHOD
MASANORI HAYASHI, SHIGERU ASO, and NAOKI FUTATSUDERA Kyushu University, Technology Reports (ISSN 0023-2718), vol. 61, June 1988, p. 287-292. In Japanese, with abstract in English. refs

Separated flows around wing sections are calculated by a discrete vortex method combined with a panel method. The potential flow around the wing section is expressed by vortex sheets, and separated shear layers are expressed by discrete vortices. In the calculation a separation point is determined by solving the boundary layer equations. The strength of a shed vortex is estimated using the local velocity near the separation point. Modifications for the estimation of pressure coefficients around the wing section are also proposed. The results show good agreement with experiments. Author

A89-10569#
NUMERICAL EXPERIMENTS FOR SEPARATION FLOWS AROUND TRAPEZOIDAL CYLINDERS BY A DISCRETE VORTEX METHOD
MASANORI HAYASHI, SHIGERU ASO, and TOMONORI TAGUCHI Kyushu University, Technology Reports (ISSN 0023-2718), vol. 61, June 1988, p. 293-300. In Japanese, with abstract in English. refs

Separated flows around several trapezoidal cylinders are calculated by a discrete vortex method combined with a panel method. The potential flow around trapezoidal cylinders are expressed by vortex sheets and separated shear layers by discrete vortices. In the calculation five types of trapezoidal cylinders whose shape parameter b/h (b is a front body length normal to the freestream and h is rear body length normal to the freestream) are 0.0, 0.25, 0.5, 0.75, and 1.0, are used. The strength of a shed vortex is estimated using local velocity near a separation point. The strengths of shed vortices are changed remarkably with shape parameters. Those results agree with the previous results that the separation point moves from a rear corner to a front corner as the shape parameter, b/h, increases. Also modifications for the estimation of pressure coefficients around wing section are proposed. The results show good agreement with experiments. Author

A89-10607
A SECOND-ORDER NUMERICAL METHOD FOR THE ANALYSIS OF TWO-DIMENSIONAL FLOW OF IDEAL FLUID THROUGH A CASCADE WITH SUPERSONIC INPUT
JAROSLAV PELANT Zprava VZLU, no. Z-55, 1988, p. 1-9.

A second-order numerical method for modeling flow of an ideal fluid through a cascade in a plane with supersonic imput is developed assuming the validity of matter, energy, and momentum conservation laws only. The method admits discontinuities in state values and entropy and does not require prior definitions of subsonic and supersonic regions. The numerical procedure, which uses a moving net, is described. V.L.

A89-10651* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
BOUNDARY-LAYER CONTROL FOR DRAG REDUCTION
WILLIAM D. HARVEY (NASA, Langley Research Center, Hampton, VA) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 287-311. refs
(SAE PAPER 872434)

Although the number of possible applications of boundary-layer control is large, a discussion is given only of those that have received the most attention recently at NASA Langley Research Center to improve airfoil drag characteristics. This research concerns stabilizing the laminar boundary layer through geometric shaping (natural laminar flow, NLF) and active control involving the removal of a portion of the laminar boundary layer (laminar flow control, LFC) either through discrete slots or a perforated surface. At low Reynolds numbers, a combination of shaping and forced transition has been used to achieve the desired run of laminar flow and control of laminar separation. In the design of both natural laminar flow and laminar flow control airfoils and

wings, boundary layer stability codes play an important role. A discussion of some recent stability calculations using both incompressible and compressible codes is given. Author

A89-10652
THE FORMATION MECHANISM OF THE ASYMMETRIC SPATIAL VORTEX OF SLENDER BODIES AT HIGH ANGLE OF ATTACK
ZI-XING WANG (Nanjing Aeronautical Institute, People's Republic of China) and DAI SU (East China Institute of Technology, People's Republic of China) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 313-318.
(SAE PAPER 872435)

The fluorescent minituft method is used to study the formation mechanism of the asymmetric spatial vortex of slender bodies at high angles of attack in a low-speed tunnel without sideslip. When the width of the lee side (governed by the potential flow) is insufficient for the free development of both side vortices, the weak vortex is pushed upward by the strong vortex. Consideration is given to the effect of turbulence and adverse pressure. K.K.

A89-10659* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
COMPUTATIONAL FLUID DYNAMICS IN AEROSPACE
PAUL KUTLER, JOSEPH L. STEGER, and F. R. BAILEY (NASA, Ames Research Center, Moffett Field, CA) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 385-400. refs
(SAE PAPER 872446)

The status of computational fluid dynamics (CFD) is addressed in terms of methods, examples of CFD solutions, and computer technology. The examples are divided into aerospace applications and fluid physics applications, with the aerospace applications section being further divided into internal and external flows. The role CFD is expected to play in supporting the goals set forth by the Aeronautical Policy Review Committee established by the Office of Science and Technology Policy is noted. K.K.

A89-10660
UNIFIED COMPUTATION METHOD OF UNSTEADY SUPERSONIC/HYPERSONIC FLOW PAST TWO DIMENSIONAL FLAT PLATE AND RECTANGULAR WINGS
JING-SONG CHEN, HAN-MIN YANG, and CAI-WEN ZHANG (Nanjing Aeronautical Institute, People's Republic of China) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 401-414. refs
(SAE PAPER 872447)

Using a perturbation method for the frequency to solve the two-dimensional unsteady Euler equations, solutions are obtained for a flat-plate airfoil in pitching and plunging oscillations which are a set of power series, including up to the sixth-order frequency term. The solutions are valid for low- and higher-frequency cases. With the aid of that solution and using supersonic linearized theory, the closed approximate expression of unsteady loading distribution is given for rectangular wings in pitching and plunging oscillations. Author

A89-10661
NUMERICAL APPROACH OF ADVANCED TURBOPROP WITH THREE-DIMENSIONAL EULER EQUATIONS
SHIGERU SAITO, HIROSHI KOBAYASHI, YASUHIRO WADA (National Aerospace Laboratory, Tokyo, Japan), and YUICHI MATSUO (Tokyo, University, Japan) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 415-424. refs
(SAE PAPER 872448)

Numerical analysis by solving the three-dimensional Euler equations has been performed in order to investigate the complicated flow patterns or aerodynamic characteristics of the advanced turboprop (ATP) propeller with two types of spinner configuration. The governing equations are written for a rotating Cartesian coordinate system in terms of absolute flow variables. The solution algorithm used is an implicit approximate factorization method and resultant matrices are efficiently solved by a LUADI scheme. This solver has been applied to study the effect of interference between highly swept blades and axisymmetrical spinner on the aerodynamic performance of the ATP propeller. Numerical results show that the selection of an area-ruled spinner is important for the aerodynamic design of an efficient turboprop. Author

A89-11036#
FLOW PERFORMANCE OF REVERSED TANDEM CASCADES WITH DOUBLE-CIRCULAR ARC PROFILE FOR COMPRESSOR STATOR
BIAONAN ZHUANG (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, April 1988, p. 153-157, 189. In Chinese, with abstract in English.

Blowing experiments have been completed on 21 kinds of reversed tandem cascades with different geometrical parameters. The cascades were designed by the aid of a computer program with reference to the configurations of the tandem cascades of Turmo-IIIc, J69 and J85 compressor stators. The main flow performances were obtained in the form of a group of curves. Three conclusions are drawn as follows: (1) the turning angle of the reversed tandem cascade is larger than that of a single blade cascade, while the pressure loss coefficient is smaller, (2) the reversed cascades still possess a better performance even if the incident angle is about -13 deg, and (3) the relative displacement and the relative axial distance of reversed tandem cascades should be matched well. Author

A89-11053#
APPLICATION OF AN ARTIFICIAL DENSITY SCHEME OF POTENTIAL STREAM FUNCTION METHOD TO DESIGN OF AIRFOIL
BO LIU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, July 1988, p. 223-226, 282. In Chinese, with abstract in English.

A potential stream-function method is applied to designing transonic airfoils. The flowfield is computed by solving the full potential equations with the aid of a relaxation method. An artificial-density scheme has been developed to replace the type-related scheme. As compared with the latter, the artificial-density scheme employs an identical scheme in whole field and converges steadily. Numerical results show that this method is applicable to the initial design of compressor airfoils and provides a better approximation of the actual conditions by taking into account the effect of the axial velocity ratio. Author

A89-11056#
TWO-DIMENSIONAL SUBSONIC DIFFUSER FLOW WITH UNIFORM SHEAR VELOCITY PROFILE AT INLET
XIJUN HUANG, JINZHONG DONG, SHIXIN FAN, and CHENGSHU SHIO (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, July 1988, p. 235-238, 283. In Chinese, with abstract in English.

A prediction method has been developed for average parameters of a two-dimensional subsonic diffuser with a uniform shear velocity profile at the inlet. A complete solution of all flow parameters can be obtained by interacting the zonal models and coupling them on common boundaries. The momentum integral and the entrainment equations are used for the boundary-layer zone. The equations are closed by use of Cole's improved wall-wake velocity profile. Due to different development of the boundary layers on the upper and lower walls of the diffuser under conditions of the shear velocity profile in core flow, different

equations are employed. Three actual diffusers are calculated by this method and evaluated experimentally. The predictions by this method for the streamwise distribution of the pressure coefficient, the velocity of the core flow, and the location of detachment are in good agreement with the test data. Author

A89-11059#
EXPERIMENTAL STUDY OF ROTATING STALL IN SINGLE-STAGE AXIAL COMPRESSOR
WEIYANG QIAO and ZONGYUAN WANG (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, July 1988, p. 253-255, 285. In Chinese, with abstract in English.

A three-hole dynamic probe is described which can measure the unsteady flow direction, flow velocity, and total and static pressures of a two-dimensional flow field. Three miniature pressure transducers are mounted in the probe to detect the pressure fluctuation of the unsteady flow. The dynamic pressure signals are recorded with a digital data-acquisition system controlled by a microcomputer. The flowfield in the rotating stall regime of a single-stage axial compressor can be studied by means of this probe and the system. Author

A89-11060#
EXPERIMENTAL INVESTIGATION OF CONVERGENT EJECTOR NOZZLE/AFTERBODY IN WIND TUNNEL
RONGHUA ZHANG (Chengdu Aircraft Co., People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, July 1988, p. 256-258, 285. In Chinese, with abstract in English.

The work is aimed at determining the overall performance of a convergent ejector nozzle/afterbody with or without fixed auxiliary inlet doors. The experimental Mach numbers range from 0.6 to 1.2. The nozzle pressure ratio extends from 2.6 to 4.3. The corrected secondary weight flow ratio is 3.5 percent. The testing technique presented gives the correlation of the axial momentum tare forces of bellows with the pressure measured in the bellows. The wind-tunnel test data can be revised in timely manner with the tare forces computed. The tests show that, due to the effect of the tertiary flow, the nozzle thrust coefficient and efficiency of the ejector nozzle with fixed auxiliary inlet doors increase by 1-1.6 and 1.6-2.8 percent, respectively, compared with a nozzle without these doors. Author

A89-11061#
DYNAMIC DISTORTION IN FLOWFIELD DOWNSTREAM OF TRANSONIC SHOCK-BOUNDARY LAYER INTERACTION
ZHONGWEI HE (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, July 1988, p. 259-261, 286. In Chinese, with abstract in English. refs

The dynamic distortions in a flowfield under transonic-shock/turbulent-boundary-layer interactions of different intensities are investigated in a two-dimensional convergent-divergent duct. The power spectrum and probability-density functions of the total pressure signals are analyzed. A control technique for this dynamic distortion is also presented. Author

A89-11064#
A NEW APPROACH TO IMPROVEMENT OF FANS
HANSHOU SU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, July 1988, p. 271-273, 287. In Chinese, with abstract in English.

This paper presents experimental results on three-dimensional flowfields in the fan tip region for two actual fans. It is shown that the fan performance can be significantly improved as proplets are attached to the blade tips. The improvement mechanisms have been studied and can be stated as follows: the proplets retain the tip vortex, and thus the tip-induced loss is reduced remarkably; additional propulsion moment is gained because the proplets partly balance the drag moment due to profile loss in the tip section. The conclusions presented in this paper may be applied to the tip sections of propellers or helicopter rotors for performance improvement. Author

A89-11073
NUMERICAL SIMULATION OF STEADY TRANSONIC FLOW PAST AN 8-PERCENT DCA CASCADE AT A FREESTREAM MACH NUMBER OF ABOUT 1 [NUMERICKE MODELOVANI STACIONARNIHO TRANSSONICKEHO OBTEKANI 8 PERCENT DCA MRIZE S FREESTREAM M OF ABOUT 1]
KAREL KOZEL and MIROSLAVA VAVRINCOVA Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1988, p. 109-119. In Czech. refs

Two-dimensional transonic flow past an 8-percent DCA cascade at a freestream Mach number of about 1 was simulated numerically by solving a two-dimensional system of Euler equations by the finite-volume method using the Mac Cormack explicit difference scheme. Computed and measured results are compared for freestream Mach numbers of 0.91-1.15. B.J.

A89-11080#
A FURTHER IMPROVEMENT IN THE NUMERICAL METHOD OF SUPERSONIC INFINITESIMAL HORSESHOE VORTEX DISTRIBUTION
SHOUQIN YU and QINGBING ZHANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, Sept. 1988, p. 324-332. In Chinese, with abstract in English. refs

A new smoothing operation is developed in this paper. This smoothing operation effectively eliminates large oscillations in the lifting-pressure coefficient distribution which can occur in numerical computations of supersonic infinitesimal horseshoe vortex distribution. The lifting-pressure coefficient distribution, as compared with the analytical results, is satisfactory at various freestream Mach numbers. This new operation makes the present numerical method suitable for complex supersonic configurations. Author

A89-11081#
INVESTIGATION ON WALL INTERFERENCE OF LOW-SPEED WIND TUNNEL WITH SLOTTED WALLS
JIECHUAN FAN and QIUSHENG YANG (Harbin Aerodynamics Research Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, Sept. 1988, p. 333-340. In Chinese, with abstract in English. refs

The paper shows the results of measuring force for calibration model DBM-01 and measuring wall static pressure in the DFVLR low-speed wind tunnel with slotted walls and dimensions 3.25 x 2.8 m. The effects of the main slot parameters (such as slot configuration and open area ratio) on wall interference have been discussed and compared with computation results. It has been concluded that the slotted walls have various effects on reducing wall interference. The test section with slotted walls can effectively reduce not only longitudinal but also lateral wall interference; the real effect of slots is smaller than that predicted theoretically. Author

A89-11082#
MEASUREMENTS OF UNSTEADY PRESSURE DISTRIBUTION ON A NACA 0012 PROFILE IN TRANSONIC FLOW
QIAOSEN WANG and CHUNHUA ZHU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, Sept. 1988, p. 341-349. In Chinese, with abstract in English. refs

Steady and unsteady pressure measurements on a two-dimensional wing model in the NH-1 transonic wind tunnel of Nanjing Aeronautical Institute are described. The profile of the model is NACA 0012. The model was oscillated in pitch about its 1/4 axis to generate the unsteady aerodynamic pressure. The measurement system and technology are quite good. Author

A89-11083#
THE VAPOR-SCREEN TECHNIQUE OF FLOW VISUALIZATION IN THE INTERMITTENT TRANSONIC AND SUPERSONIC WIND TUNNEL
JINSEN HONG (Beijing Institute of Aerodynamics, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, Sept. 1988, p. 350-357. In Chinese, with abstract in English.

Equipment and test results of a vapor-screen flow visualization method developed for an intermittent transonic and supersonic wind tunnel are discussed. The optimum density of fog in the working section for obtaining high-quality vapor-screen photographs has been determined for the Mach number range 0.6-2.0 at model angles of attack up to 25 deg. Static pressures were obtained along the wall of a Laval nozzle as a function of the absolute humidity. Vapor-screen photographs for various flow pattern have been obtained for a typical missile configuration. R.R.

A89-11084#
ANALYSIS OF TRANSONIC WINGS INCLUDING VISCOUS INTERACTION
ZIQIANG ZHU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) and H. SOBIECZKY (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, Federal Republic of Germany) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, Sept. 1988, p. 358-364. In Chinese, with abstract in English. refs

Transonic flow computations past aerodynamic configuratons are complicated by interactions between the outer inviscid flow (usually containing shock waves) and effects created by the viscous flow near the surface and the wake. In an effort to improve computational tools, some potential-flow methods have been coupled with a three-dimensional integral boundary-layer method for wings. This coupling models a weak interaction between viscous and inviscid flow; some examples have been calculated and compared with experimental data. Author

A89-11085#
NUMERICAL SIMULATION OF COMPACT SCHEMES IN SUPER-SONIC VISCOUS FLOWS
YANWEN MA and DEXUN FU (Beijing Institute of Aerodynamics, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, Sept. 1988, p. 365-369. In Chinese, with abstract in English. refs

Supersonic viscous flow around a sphere-cone is simulated numerically by solving the compressible Navier-Stokes equations. The viscous part of the equations is treated using a correction with operator addition (Fu and Ma, 1984). The normal derivatives of the inviscid part are approximated with central differences. The streamwise derivatives are approximated with compact differences. The compact scheme has fourth-order accuracy. Jacobian matrix splitting and approximate factorization are used for solving the resulting implicit difference equations. With specially chosen matrix splitting, the solutions of the implicit difference scheme can be expressed explicitly. The scheme used in present paper has the advantages of both implicit and explicit schemes, and the comparison of the computed results with those obtained by Srivastava et al. (1978) is satisfactory. Author

A89-11086#
RESEARCH ON THE COMPUTATIONAL METHOD OF AERODYNAMIC CHARACTERISTICS OF WING WITH VORTEX BREAKDOWN AT HIGH ANGLE OF ATTACK
GUOHUA BAO (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, Sept. 1988, p. 370-375. In Chinese, with abstract in English. refs

The longitudinal and lateral aerodynamic characteristics of a wing with low aspect ratio are calculated, considering the effect of vortex and vortex breakdown. On the basis of the lifting-surface theory of Purvis (1981 and 1982) and the suction simulation method developed by Polhamus (1966), with reference to Lan's (1982) method, the aerodynamic characteristics at high angle of attack are corrected. Several wings with different plane shape are calculated. Calculation results are relatively close to the experiment results. Author

A89-11088#
FINITE ELEMENT METHOD FOR CALCULATING TRANSONIC POTENTIAL FLOW AROUND AIRFOIL FROM PRESSURE MINIMUM INTEGRATION
QI LU, GUOFU ZHANG, and ZUOSHENG YANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 6, Sept. 1988, p. 382-387. In Chinese, with abstract in English.

The transonic flow field around a NACA 0012 airfoil is calculated using the FEM from pressure-minimum integration of the full potential equation. The artificial viscosity is introduced by way of using artificial density. The computational mesh is generated automatically in terms of analytical/numerical transformation. SLOR and a pseudotime iterative method are employed for solving the finite-element equation. Several numerical solutions are given. Author

A89-11105#
NUMERICAL SIMULATION OF SUPERSONIC FLOW OVER A THREE-DIMENSIONAL CAVITY
DONALD P. RIZZETTA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452), vol. 26, July 1988, p. 799-807. Previously cited in issue 18, p. 2806, Accession no. A87-42363. refs

A89-11106*# Iowa State Univ. of Science and Technology, Ames.
A NEW PNS CODE FOR CHEMICAL NONEQUILIBRIUM FLOWS
D. K. PRABHU, J. C. TANNEHILL (Iowa State University of Science and Technology, Ames), and J. G. MARVIN (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 26, July 1988, p. 808-815. Research supported by Iowa State University of Science and Technology. Previously cited in issue 08, p. 1036, Accession no. A87-22535. refs
(Contract NAG2-245)

A89-11108*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MULTIGRID SOLUTION OF THE TWO-DIMENSIONAL EULER EQUATIONS ON UNSTRUCTURED TRIANGULAR MESHES
D. J. MAVRIPLIS (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 26, July 1988, p. 824-831. Previously cited in issue 08, p. 1037, Accession no. A87-22577. refs

A89-11109# United Technologies Research Center, East Hartford, Conn.
ANALYSIS OF COMPLEX HYPERSONIC FLOWS WITH STRONG VISCOUS/INVISCID INTERACTION
G. D. POWER and T. J. BARBER (United Technologies Research Center, East Hartford, CT) AIAA Journal (ISSN 0001-1452), vol. 26, July 1988, p. 832-840. Research supported by the United Technologies Corp., and NASA-DARPA NASP Program Office. Previously cited in issue 18, p. 2803, Accession no. A87-42309. refs

A89-11110*# Cornell Univ., Ithaca, N.Y.
DIAGONAL IMPLICIT MULTIGRID ALGORITHM FOR THE EULER EQUATIONS
DAVID A. CAUGHEY (Cornell University, Ithaca, NY) AIAA Journal (ISSN 0001-1452), vol. 26, July 1988, p. 841-851. Previously cited in issue 08, p. 1037, Accession no. A87-22578. refs
(Contract NAG3-645; NAG2-373)

A89-11115#
PROPULSIVE VORTICAL SIGNATURE OF PLUNGING AND PITCHING AIRFOILS
PETER FREYMUTH (Colorado, University, Boulder) AIAA Journal

(ISSN 0001-1452), vol. 26, July 1988, p. 881-883. Previously cited in issue 07, p. 932, Accession no. A88-22235. refs
(Contract F49620-84-C-0065)

A89-11116#
ON NONLINEAR ASPECTS OF HYPERSONIC BOUNDARY-LAYER STABILITY
KENNETH F. STETSON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452), vol. 26, July 1988, p. 883-885. refs

Experimental results obtained using hot-wire anemometry are used to explore nonlinear effects in the application of linear stability theory to hypersonic problems. The results demonstrate the presence of high-frequency disturbances (presumably nonlinear disturbances), and show that the rapidly growing second-mode disturbances can achieve relatively large amplitudes which may exceed the limits of a small-disturbance assumption. The present nonlinear theory is not able to predict the measured disturbance growth rates. R.R.

A89-11152* Vigyan Research Associates, Inc., Hampton, Va.
NUMERICAL SIMULATION OF THE VORTICAL FLOW OVER A ROUND-EDGED DOUBLE-DELTA WING
C.-H. HSU (Vigyan Research Associates, Inc., Hampton, VA) and C. H. LIU (NASA, Langley Research Center, Hampton, VA) IN: Developments in theoretical and applied mechanics. Volume 14; Proceedings of the Fourteenth Southeastern Conference on Theoretical and Applied Mechanics, Biloxi, MS, Apr. 18, 19, 1988. University, MS, University of Mississippi, 1988, p. 28-36. refs

Simulations of three-dimensional vortical flows over a thin double-delta wing with an aspect ratio of 2.05 have been performed. Steady-state solutions to the unsteady incompressible Navier-Stokes equations are obtained using a new implicit upwind-relaxation finite-difference scheme. The method is second-order accurate spatially and naturally dissipative. Numerical results indicate that key features of both vortical interaction and vortex breakdown are successfully simulated. The computed lift coefficients and lateral trajectories of the vortical cores are in good agreement with the experimental data. Author

A89-11153* Old Dominion Univ., Norfolk, Va.
UNSTEADY TRANSONIC AIRFOIL COMPUTATION USING IMPLICIT EULER SCHEME ON BODY-FIXED GRID
OSAMA A. KANDIL and H. ANDREW CHUANG (Old Dominion University, Norfolk, VA) IN: Developments in theoretical and applied mechanics. Volume 14; Proceedings of the Fourteenth Southeastern Conference on Theoretical and Applied Mechanics, Biloxi, MS, Apr. 18, 19, 1988. University, MS, University of Mississippi, 1988, p. 37-46. refs
(Contract NAG1-648)

The unsteady Euler equations have been derived for the flow relative motion with respect to a frame of reference that is rigidly attached to the moving airfoil. The grid is generated once by an elliptic solver without a need for dynamic grid computation. An implicit factored finite-volume scheme has been developed and implemented through a fully vectorized computer program. Implicit second-order and explicit second and fourth-order dissipations are added to the scheme. The boundary conditions are explicitly satisfied. The scheme is applied to steady and unsteady transonic airfoil flows and the results are in good agreement with the experimental data. For forced harmonic airfoil motions, periodic solutions are achieved within the third cycle of oscillation. Author

A89-11157
APPROXIMATE CALCULATIONS OF VISCOUS DRAG AND AERODYNAMIC HEATING
T. F. ZIEN (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD) IN: Developments in theoretical and applied mechanics. Volume 14; Proceedings of the Fourteenth Southeastern Conference on Theoretical and Applied Mechanics, Biloxi, MS, Apr. 18, 19, 1988. University, MS, University of Mississippi, 1988, p. 79-87. refs

An approximate computational procedure for estimating the friction drag and heating rates on aerodynamic bodies is described in this paper along with its applications to three-dimensional boundary layer flows and transient ablation problems. The procedure is an integral approach, and the basic idea lies in the use of integral expressions for various aerodynamic quantities on the body surface. The approximate solutions are compared with available exact solutions, and the comparisons are remarkably favorable. Author

A89-11481
PANEL METHODS IN AERODYNAMICS - SOME HIGHLIGHTS
H. W. M. HOEIJMAKERS (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Panel methods in fluid mechanics with emphasis on aerodynamics; Proceedings of the Third GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 16-18, 1987. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 1-34. refs

A survey is presented of several aspects of the use and further development of panel methods in aerodynamics. Aspects discussed include possible types of boundary conditions, low versus higher-order formulations, simulation of subsonic and supersonic flow and modeling of wakes as well as of leading-edge vortex separation. Also discussed are computational aspects of panel methods and possible directions for new developments. The latter include the extension of the domain of applicability to compressible flow and the coupling with viscous flow methods, as well as ways to improve the efficiency of the panel method. Author

A89-11484
HISSS - A HIGHER-ORDER PANEL METHOD FOR SUBSONIC AND SUPERSONIC ATTACHED FLOW ABOUT ARBITRARY CONFIGURATIONS
L. FORNASIER (Messerschmitt-Boekow-Blohm GmbH, Munich, Federal Republic of Germany) IN: Panel methods in fluid mechanics with emphasis on aerodynamics; Proceedings of the Third GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 16-18, 1987. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 52-70. refs

A panel method is derived to produce stable results in solving the Prandtl-Glauert equations for supersonic flow. The origin of the previously encountered inconsistent surface pressure fluctuations is discussed. The present method employs higher-order surface singularity distributions. A very general boundary value specification capability allows either subsonic or supersonic flow problems around geometrically complex three-dimensional configurations to be treated. Results are provided for a cone-cylinder-cone configuration and a NASA TM 78792 supersonic cruise wing-body configuration. R.R.

A89-11487
THE PREDICTION OF TRANSONIC INTERFERENCE FLOW BY MEANS OF A HYBRID METHOD
H. JAKOB (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) IN: Panel methods in fluid mechanics with emphasis on aerodynamics; Proceedings of the Third GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 16-18, 1987. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 91-100.

A hybrid method combining a panel method with a finite difference method has been developed to calculate inviscid transonic interference flow in space. An H-type computation grid is established around a wing section profile in order to approximately solve the full potential equation governing transonic spatial flow in a specified wing section. The panel method determines the cross flow in all nodes, and includes interference effects from the fuselage or nacelle. The finite difference method for planar flow then provides transonic flow results, taking into account oblique shocks on the contours. Appropriate compressibility corrections and the computation of second derivatives of the velocity potential are considered. Wing-fuselage results are compared with wind tunnel findings. R.R.

A89-11488* Old Dominion Univ., Norfolk, Va.
INTEGRAL EQUATION SOLUTION FOR TRANSONIC AND SUBSONIC AERODYNAMICS
OSAMA A. KANDIL and HONG HU (Old Dominion University, Norfolk, VA) IN: Panel methods in fluid mechanics with emphasis on aerodynamics; Proceedings of the Third GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 16-18, 1987. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 101-109. refs
(Contract NAG1-648)

Two methods are presented to solve for the subsonic and transonic flows around airfoils. The first method is based on the integral solution of the full-potential equation with a shock-capturing technique only or with shock capturing-shock fitting technique. In the second method, the integral soluton of the full potential equation is coupled with an embedded region of Euler equations around the shock location. The second method is a computationally efficient technique for flows with strong shocks where the entropy increase and vorticity production across the shock are not small. Several numerical examples are presented and compared with the experimental data and other computational results. Author

A89-11489
STEADY AND UNSTEADY POTENTIAL FLOWS AROUND AXISYMMETRIC BODIES AND RING AIRFOILS
E. KATZER (DFVLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IN: Panel methods in fluid mechanics with emphasis on aerodynamics; Proceedings of the Third GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 16-18, 1987. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 110-119. refs

A higher-order BEM is used to calculate steady and unsteady incompressible potential flows around axisymmetric bodies and thin ring airfoils. A Fourier decomposition of the flow field reduces the problem by one dimension, resulting in a very efficient algorithm. A stable fast algorithm for determining special elliptic integrals is described. A quadrature formula for the integration of strong and weak singularities is introduced which is exact for the leading terms of the expansion. The exclusive representation of the flow by a vorticity distribution makes possible a simple implementation of the Kutta condition. R.R.

A89-11496
ON THE EVALUATION OF AERODYNAMIC INFLUENCE COEFFICIENTS
H. SCHIPPERS (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Panel methods in fluid mechanics with emphasis on aerodynamics; Proceedings of the Third GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 16-18, 1987. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 210-219. refs

A panel method has been developed to solve the boundary integral equation for the vorticity distribution at an airfoil. The boundary integral operator is decomposed by splitting the contour integration, taking into account the singular behavior of the kernel function near the trailing edge. The decomposition results in a compact operator and a contractive operator. The compact operator contains a smooth kernel function which is approximated by piecewise linear interpolation. It is found that the accuracy decreases significantly for a fixed number of panels. R.R.

A89-11497
A DOUBLET POINT METHOD FOR THE CALCULATION OF UNSTEADY PROPELLER AERODYNAMICS
J. SCHOENE (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) IN: Panel methods in fluid mechanics with emphasis on aerodynamics; Proceedings of the Third GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 16-18, 1987. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 220-231. refs

A lifting surface theory for unsteady flowfields of propellers in an incompressible medium has been developed. The governing integral equation relating the pressure loadings and induced effects is first obtained. The method involves dividing the lifting surface into panels on which one doublet and one upwash point are located. A set of linear algebraic equations is derived based on the tangential flow condition at every upwash point and the time dependent strength of the singularity which is represented in a Fourier series. A parametric study reveals the influence of discretization. R.R.

A89-11498
CALCULATION OF UNSTEADY TRANSONIC FLOW ABOUT OSCILLATING WINGS BY A FIELD PANEL METHOD
R. VOSS (DFVLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IN: Panel methods in fluid mechanics with emphasis on aerodynamics; Proceedings of the Third GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 16-18, 1987. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 232-242. refs

A field panel method is described for calculating unsteady transonic perturbation flows about harmonically oscillating wings. The flow is modelled by dipole distributions on the mean wing and wake surfaces and a source distribution in the flow field to account for the nonhomogeneous compressibility effects in the near field of the wing. The aerodynamic influence coefficients can be calculated largely analytically, and the resulting system of equations is solved by a quickly converging block iteration. Coupling with finite difference methods can further increase the computation speed. Author

A89-11499
A VORTEX-LATTICE METHOD FOR THE CALCULATION OF WING-VORTEX INTERACTION IN SUBSONIC FLOW
S. WAGNER, CH. URBAN, and R. BEHR (Muenchen, Universitaet der Bundeswehr, Neubiberg, Federal Republic of Germany) IN: Panel methods in fluid mechanics with emphasis on aerodynamics; Proceedings of the Third GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 16-18, 1987. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 243-251. refs

A vortex lattice method based on a time-dependent discrete procedure with zero-order doublet distributions is proposed for the study of basic wing-vortex interactions in subsonic flow. A continuous velocity distribution at the shear layers is obtained by spline functions and a differencing scheme. The method is applied to single or coupled, plane, thin wings with or without vortex separation at the sharp wing edges. Potential flow effects and their influence on the wing loads and the velocity field are found to be in good agreement with experimental results. R.R.

A89-11500
APPROXIMATION OF FREE AND BOUNDED VORTEX SHEETS AT DELTA-WINGS
P. WIEMER, K. HAAG, and J. BALLMANN (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: Panel methods in fluid mechanics with emphasis on aerodynamics; Proceedings of the Third GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 16-18, 1987. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 252-260. refs

A higher-order panel method is used to investigate the influence of free vortex sheets on the pressure distribution of delta-wings. In the present method, the bounded vortex sheets are represented by isoparametric elements in order to obtain a continuous doublet distribution without singular vortex lines for the wing itself. Free vortex layers are represented by panels along the vortex lines specified by the wing doublet distribution. Employing two independent geometry parameters for each panel, the method is shown to successfully model the free vortex sheets. R.R.

A89-12130* University Coll. of Swansea (Wales).
FINITE ELEMENT EULER COMPUTATIONS IN THREE DIMENSIONS
JAIME PERAIRE, JOAQUIN PEIRO, LUCA FORMAGGIA, KEN MORGAN, and OLGIERD C. ZIENKIEWICZ (Swansea, University College, Wales) International Journal for Numerical Methods in

Engineering (ISSN 0029-5981), vol. 26, Oct. 1988, p. 2135-2159. Research supported by the Research Corp. refs
(Contract NAGW-478)

A two-step explicit FEM solution algorithm for the three-dimensional compressible Euler and Navier-Stokes equations based on unstructured triangular and tetrahedral grids is described and demonstrated. The method represents an extension and refinement of the algorithms presented by Loehner et al. (1984 and 1985), Peraire et al. (1987), and Morgan et al. (1987). The formulation and numerical implementation are outlined; the mesh generation, data structures, and adaptive remeshing are explained; and results for a two-dimensional airfoil, a three-dimensional engine air intake, a B747 in landing configuration, and a generic fighter aircraft are presented in extensive graphics and discussed in detail. T.K.

A89-12135* Purdue Univ., West Lafayette, Ind.
PREDICTION OF INCIDENCE EFFECTS ON OSCILLATING AIRFOIL AERODYNAMICS BY A LOCALLY ANALYTICAL METHOD
HSIAO-WEI D. CHIANG and SANFORD FLEETER (Purdue University, West Lafayette, IN) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 26, Oct. 1988, p. 2227-2238. NASA-USAF-supported research. refs

A complete mathematical model is formulated to analyze the effects of mean-flow incidence angle on the unsteady aerodynamics of an oscillating airfoil in an incompressible flow field. A velocity potential formulation is utilized. The steady flow is independent of the unsteady flow field but coupled to it through the boundary conditions on the oscillating airfoil. The numerical solution technique for both the steady and unsteady flow fields is based on a locally analytical method. The flow model and solution method are then verified through the excellent correlation obtained with the Theodorsen oscillating-flat-plate and Sears transverse-gust classical solutions. The effects of mean flow incidence on the steady and oscillating airfoil aerodynamics are then investigated. Author

A89-12316
AEROTHERMODYNAMICS - THE REQUIRED TOOLS
A. J. WAKE (British Aerospace, PLC, London, England) SAE, Aerospace Vehicle Conference, Annapolis, MD, Apr. 18-20, 1988. 12 p. refs
(SAE PAPER 880928)

HOTOL is a single-stage-to-orbit vehicle which will be marketed as an economic launch system for placing payloads in low earth orbit at about one-fifth of the cost of an equivalent Space Shuttle launch. This paper discusses how HOTOL will cope with the problems of aerodynamic heating and force/moments/control powers. A program of technology development covering theoretical methods, wind tunnel experiments, and free-flight models is described. C.D.

A89-12551*# Naval Ship Research and Development Center, Bethesda, Md.
TRANSONIC CHARACTERISTICS OF A HUMPED AIRFOIL
TSZE C. TAI, GREGORY G. HUSON (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD), RAYMOND M. HICKS (NASA, Ames Research Center, Moffett Field, CA), and GERALD M. GREGOREK (Ohio State University, Columbus) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 673, 674. Abridged. Previously cited in issue 18, p. 2804, Accession no. A87-42336.

A89-12552*# Vigyan Research Associates, Inc., Hampton, Va.
INCOMPRESSIBLE NAVIER-STOKES COMPUTATIONS FOR A ROUND-EDGED DOUBLE-DELTA WING
C.-H. HSU, P.-M. HARTWICH (Vigyan Research Associates, Inc., Hampton, VA), and C. H. LIU (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 675, 676. Abridged. Previously cited in issue 19, p. 2941, Accession no. A87-44933. refs

A89-12553#
TRANSONIC COMPUTATIONS ABOUT COMPLEX CONFIGURATIONS USING COUPLED INNER AND OUTER FLOW EQUATIONS
UNO G. NAVERT and YNGVE C-J. SEDIN (Saab-Scania, AB, Linkoping, Sweden) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 1, p. 303-312) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 677-683. Previously cited in issue 24, p. 3530, Accession no. A86-49008. refs

A89-12554#
NUMERICAL SOLUTIONS OF INDUCED VELOCITIES BY SEMI-INFINITE TIP VORTEX LINES
YIHWAN DANNY CHIU and DAVID A. PETERS (Georgia Institute of Technology, Atlanta) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 684-694. refs
(Contract DAAG29-83-K-0133; DAAG29-85-K-0228)

The method of Rand and Rosen (1984) for improving convergence on computed axial induced velocity for a helical wake is extended to include all velocity components, all points in the wake, and nonhelical vortex lines (contraction). The method is based on finding upper and lower bounds on the truncated integral. Comparisons with other methods show that the present approach is efficient and accurate. Further, it avoids the errors associated with discretization of the vortex lines. Convergence occurs in only three to five revolutions, about 10 percent of the normal requirement. Author

A89-12557*# Dayton Univ., Ohio.
NAVIER-STOKES SOLUTION TO THE FLOWFIELD OVER ICE ACCRETION SHAPES
J. N. SCOTT, W. L. HANKEY, F. J. GIESSLER, and T. P. GIELDA (Dayton, University, OH) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 710-716. Previously cited in issue 08, p. 1033, Accession no. A87-22414. refs
(Contract NAG3-665)

A89-12559#
LOW-REYNOLDS-NUMBER AIRFOIL DESIGN FOR THE M.I.T. DAEDALUS PROTOTYPE - A CASE STUDY
MARK DRELA (MIT, Cambridge, MA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 724-732. Research supported by MIT and Smithsonian Institution. refs

An account is given of the design rationale that led to the use of three different airfoil profiles in the wing of the Light Eagle human-powered aircraft prototype. The profiles were chosen for Re numbers of 500,000, 375,000, and 250,000 using numerical simulation, and optimized in such a way as to both minimize transitional separation bubbles and accommodate structural and fabricational constraints. The numerical model employed represents inviscid flow by means of the Euler equations, and viscous flow by means of an integral boundary layer formulation; transitional separation bubbles and their associated losses are calculated by the inclusion of strong viscous-inviscid coupling and an amplification transition criterion in the overall equation system. O.C.

A89-12566#
GENMAP - COMPUTER CODE FOR MISSION ADAPTIVE PROFILE GENERATION
S. C. GUPTA (Institute of Armament Technology, Poona, India) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 766-768.

Optimum leading-edge flap (LEF) and trailing-edge flap (TEF) deflections constitute a Mission-Adaptive Profile (MAP) wing system. The 'GENMAP' computer code has been developed to generate minimum-drag MAP deflections of wing LEF and TEF for both subsonic and supersonic freestream conditions, as functions of both Mach number and angle-of-attack. Drag reductions of as much as 55 percent are achievable in the subsonic regime. Compressibility is noted to deteriorate the optimization effort. O.C.

N89-10004# National Aerospace Lab., Tokyo (Japan).
MEASUREMENT OF AERODYNAMIC CHARACTERISTICS OF A HANG-GLIDER-WING BY GROUND RUN TESTS USING A TEST VEHICLE
KOKI HOZUMI, MASAKI KOMODA, TAKATSUGU ONO, and YUKICHI TSUKANO 1987 29 p In JAPANESE; ENGLISH summary
(NAL-TR-953; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

In order to investigate longitudinal force and moment characteristics of a hang-glider-wing, ground run tests were conducted using a test vehicle. A hang-glider-wing was installed on a test vehicle using a six-components-balance for wing tunnel use. Aerodynamic force and moment were measured during the vehicle run at various constant speeds. Geometrical twist distribution along the wing span was recorded as well. Measured force and moment data were corrected for possible ground effect and upwash effect due to movement of the vehicle. The lift curve slope was about 23 percent smaller than that predicted by theory for a rigid wing of the same geometry. An abrupt increase in the pitching moment was measured as C sub L decreased from positive to negative. These particular features indicate that aeroelastic deformations affect the aerodynamic characteristics of hang-gliders and/or motor-hang-gliders are mandatory for their flight safety. Using the Moriya method, aeroelastic camber variations at typical spanwise stations were estimated for each combination of dynamic pressure and section angle of attack. Applying the Weissinger method, lift and pitching moment characteristics were analyzed twist distributions. By comparing these analysis with the measured data, geometrical deformations of the flexible wing were elucidated. Author

N89-10005# Aeronautical Research Labs., Melbourne (Australia).
A POTENTIAL THEORY FOR THE STEADY SEPARATED FLOW ABOUT AN AEROFOIL SECTION
TRAN-CONG TON Feb. 1988 31 p
(ARL-AERO-R-176; AR-004-596) Avail: NTIS HC A03/MF A01

An incompressible potential flow theory is used to determine the steady separated flow about an airfoil. The theory permits a continuous variation from fully-attached (Joukowski) flow to fully-separated (Helmholtz) flow, with the Kutta condition always satisfied at the trailing edge, and with the position of the separation point as an assignable parameter to determine the flow configuration. The method is also applicable to other flows such as that about a flat plate with a rear free-stream flap. Author

N89-10006# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Panel.
AGARD MANUAL ON AEROELASTICITY IN AXIAL-FLOW TURBOMACHINES. VOLUME 2: STRUCTURAL DYNAMICS AND AEROELASTICITY
MAX F. PLATZER, ed. and FRANKLIN O. CARTA, ed. (United Technologies Research Center, East Hartford, Conn.) Jun. 1988 266 p
(AGARD-AG-298-VOL-2; ISBN-92-835-0467-4) Avail: NTIS HC A12/MF A01

An overview of structural dynamics characteristics and analysis methods applicable to single blades and bladed assemblies is presented. The blade fatigue problem and its assessment methods, and life-time predictions are considered. Aeroelastic topics covered include: the problem of blade-disc shroud aeroelastic coupling, formulations and solutions for tuned and mistuned rotors, and instrumentation on test procedures to perform a fan flutter test. The effect of stagnation temperature and pressure on flutter is demonstrated and currently available forced vibration and flutter design methodology is reviewed.

N89-10017*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
WAVE DRAG AND HIGH-SPEED PERFORMANCE OF SUPERSONIC STOVL FIGHTER CONFIGURATION
DONALD A. DURSTON and RONALD K. STONUM Jan. 1988 19 p Presented at the International Powered Life Conference in Santa Clara, Calif., 7-10 Dec. 1987
(NASA-TM-100061; A-88072; NAS 1.15:100061) Avail: NTIS HC A03/MF A01 CSCL 01A

A supersonic STOVL fighter aircraft aerodynamic research program is under way at NASA Ames Research Center. The research focuses on technology development for this type of aircraft and includes generating an extensive aerodynamic database and resolving particular aerodynamic uncertainties for various twin- and single-engine aircraft concepts. Highlights of the results from this program are presented. The highlights include propulsion-induced effects on the aircraft drag, prediction capabilities, volume integration for minimizing drag, and wave drag and aerodynamic efficiency comparisons. Results indicate that estimated STOVL fighter performance is roughly comparable to the performance of modern conventional fighters in terms of wave drag and aerodynamic efficiency. Author

N89-10020*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WEAK-WAVE ANALYSIS OF SHOCK INTERACTION WITH A SLIPSTREAM
RAYMOND L. BARGER Nov. 1988 20 p
(NASA-TP-2848; L-16469; NAS 1.60:2848) Avail: NTIS HC A03/MF A01 CSCL 01A

A weak wave analysis of shock interaction with a slipstream is presented. The theory is compared to that for the acoustic case and to the exact nonlinear analysis. Sample calculations indicate that the weak wave theory yields a good approximation to the exact solution when the shock waves are sufficiently weak that the associated entropy increase is negligible. A qualitative discussion of the case of counterflowing streams is also included. Author

N89-10022*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NAVIER-STOKES SIMULATION OF TRANSONIC WING FLOW FIELDS USING A ZONAL GRID APPROACH
NEAL M. CHADERJIAN Jan. 1988 26 p
(NASA-TM-100039; A-88020; NAS 1.15:100039) Avail: NTIS HC A03/MF A01 CSCL 01A

The transonic Navier-Stokes code was used to simulate flow fields about isolated wings for workshop wind-tunnel and free-air cases using the thin-layer Reynolds-averaged Navier-Stokes equations. An implicit finite-difference scheme based on a diagonal version of the Beam-Warming algorithm was used to integrate the governing equations. A zonal grid approach was used to allow efficient grid refinement near the wing surface. The flow field was sensitive to the turbulent transition model, and flow unsteadiness was observed for a wind-tunnel case but not for the corresponding free-air case. The specification of experimental pressure at the wind-tunnel exit plane is the primary reason for the difference of these two numerical solutions. Author

N89-10024*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VALIDATION OF A PAIR OF COMPUTER CODES FOR ESTIMATION AND OPTIMIZATION OF SUBSONIC AERODYNAMIC PERFORMANCE OF SIMPLE HINGED-FLAP SYSTEMS FOR THIN SWEPT WINGS
HARRY W. CARLSON (PRC Systems Services Co., Hampton, Va.) and CHRISTINE M. DARDEN Washington Nov. 1988 118 p
(NASA-TP-2828; L-16428; NAS 1.60:2828) Avail: NTIS HC A06/MF A01 CSCL 01A

Extensive correlations of computer code results with experimental data are employed to illustrate the use of linearized theory attached flow methods for the estimation and optimization of the aerodynamic performance of simple hinged flap systems. Use of attached flow methods is based on the premise that high levels of aerodynamic efficiency require a flow that is as nearly attached as circumstances permit. A variety of swept wing configurations are considered ranging from fighters to supersonic transports, all with leading- and trailing-edge flaps for enhancement

of subsonic aerodynamic efficiency. The results indicate that linearized theory attached flow computer code methods provide a rational basis for the estimation and optimization of flap system aerodynamic performance at subsonic speeds. The analysis also indicates that vortex flap design is not an opposing approach but is closely related to attached flow design concepts. The successful vortex flap design actually suppresses the formation of detached vortices to produce a small vortex which is restricted almost entirely to the leading edge flap itself. Author

N89-10025*# Pratt and Whitney Aircraft, East Hartford, Conn.
TURBOFAN FORCED MIXER LOBE FLOW MODELING. PART 3: APPLICATION TO AUGMENT ENGINES Final Report
T. BARBER, G. C. MOORE, and J. R. BLATT Washington NASA Oct. 1988 32 p
(Contract NAS3-23039)
(NASA-CR-4147; E-4085; NAS 1.26:4147) Avail: NTIS HC A03/MF A01 CSCL 01A

Military engines frequently need large quantities of thrust for short periods of time. The addition of an augmentor can provide such thrust increases but with a penalty of increased duct length and engine weight. The addition of a forced mixer to the augmentor improves performance and reduces the penalty, as well as providing a method for siting the required flame holders. In this report two augmentor concepts are investigated: a swirl-mixer augmentor and a mixer-flameholder augmentor. Several designs for each concept are included and an experimental assessment of one of the swirl-mixer augmentors is presented. Author

N89-10026# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
LA RECHERCHE AEROSPATIALE, BIMONTHLY BULLETIN, NUMBER 1987-4, 239/JULY-AUGUST
ESA Jun. 1988 74 p Transl. into ENGLISH of La Recherche Aerospatiale, Bulletin Bimestriel (Paris, France, ONERA), no. 1987-4, 239/Jul.-Aug., 1987
(ESA-TT-1088; ETN-88-93051) Avail: NTIS HC A04/MF A01

Particle approximation of the two-dimensional Navier-Stokes equations; infrared system evaluation apparatus; strong coupling between inviscid fluid and boundary layer for airfoils with sharp leading edge (two-dimensional incompressible steady case); continuum damage mechanics and its applicaton to structural lifetime predictions; unsteady three-dimensional stall on a rectangular wing; and Fourier condition in integral methods: application to thin bodies, are discussed.

N89-10027# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
UNSTEADY THREE-DIMENSIONAL STALL ON A RECTANGULAR WING
J. J. COSTES *In its* La Recherche Aerospatiale, Bimonthly Bulletin, Number 1987-4, 239/July-August p 55-69 Jun. 1988 Transl. into ENGLISH from La Recherche Aerospatiale, Bimestriel (Paris, France, ONERA), no. 1987-4, 239/Jul.-Aug., 1987
Avail: NTIS HC A04/MF A01

Steady and unsteady stall are studied on a rectangular wing in normal flow. The wing is allowed to oscillate in pitch around the fore quarter chord. Experiments performed at the S 2 wind-tunnel in Chalais-Meudon with a rectangular wing and a wind velocity of 95 m/s are in good agreement with the results obtained from the theory developed. Author

N89-10028*# De Havilland Aircraft Co. of Canada Ltd., Downsview (Ontario).
PHASE 4 STATIC TESTS OF THE J-97 POWERED, EXTERNAL AUGMENTOR V/STOL MODEL AT THE NASA, AMES RESEARCH CENTER, NOVEMBER 1983
D. B. GARLAND Dec. 1985 87 p
(Contract NASW-2797)
(NASA-CR-177395; NAS 1.26:177395) Avail: NTIS HC A05/MF A01 CSCL 01A

A large-scale, ejector-lift V/STOL Model, powered by a J-97 engine, was tested at the NASA Ames Research Center Outdoor Aerodynamics Research Facility. The model incorporated the external augmentor concept developed by DHC. Since the first test at Ames in 1979, the fuselage augmentor nozzle array has been redesigned with a larger pitch and notched nozzles instead of plain slot nozzles. Thrust augmentation of the ejector as measured at Ames Research Center was lower than that measured in the DHC laboratory. It is believed that this difference is due to the high temperature of the primary jet flow as compared to the DHC blown-down rig. An ejector-lift/vectored thrust configuration was also included in the recent tests. This is an arrangement where the fuselage augmentor is shortened in the chordwise direction and the extra thrust is generated with a vectorable, ventral nozzle. In free air the shortened fuselage augmentor produced the same augmentation as the long augmentor. In ground proximity, at a height of 27 in, and with zero pitch angle, a negative ground effect was measured equal to 6.5 percent of the free-air lift.
Author

N89-10029*# North Carolina State Univ., Raleigh. Dept. of Mechanical and Aerospace Engineering.
A TRANSONIC INTERACTIVE BOUNDARY-LAYER THEORY FOR LAMINAR AND TURBULENT FLOW OVER SWEPT WINGS Final Report
SHAWN H. WOODSON and FRED R. DEJARNETTE Washington Oct. 1988 82 p
(Contract NCC1-22)
(NASA-CR-4185; NAS 1.26:4185) Avail: NTIS HC A05/MF A01 CSCL 01A

A 3-D laminar and turbulent boundary-layer method is developed for compressible flow over swept wings. The governing equations and curvature terms are derived in detail for a nonorthogonal, curvilinear coordinate system. Reynolds shear-stress terms are modeled by the Cebeci-Smith eddy-viscosity formulation. The governing equations are descretized using the second-order accurate, predictor-corrector finite-difference technique of Matsuno, which has the advantage that the crossflow difference formulas are formed independent of the sign of the crossflow velocity component. The method is coupled with a full potential wing/body inviscid code (FLO-30) and the inviscid-viscous interaction is performed by updating the original wing surface with the viscous displacement surface calculated by the boundary-layer code. The number of these global iterations ranged from five to twelve depending on Mach number, sweep angle, and angle of attack. Several test cases are computed by this method and the results are compared with another inviscid-viscous interaction method (TAWFIVE) and with experimental data. Author

N89-10034*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE PROS AND CONS OF CODE VALIDATION
PERCY J. BOBBITT Jul. 1988 49 p Presented at the 6th AIAA Applied Aerodynamic Conference, Williamsburg, Va., 6-8 Jun. 1988 Previously announced in IAA as A88-42125
(NASA-TM-100657; NAS 1.15:100657; AIAA-PAPER-88-2535)
Avail: NTIS HC A03/MF A01 CSCL 01A

Computational and wind tunnel error sources are examined and quantified using specific calculations of experimental data, and a substantial comparison of theoretical and experimental results, or a code validation, is discussed. Wind tunnel error sources considered include wall interference, sting effects, Reynolds number effects, flow quality and transition, and instrumentation such as strain gage balances, electronically scanned pressure systems, hot film gages, hot wire anemometers, and laser velocimeters. Computational error sources include math model equation sets, the solution algorithm, artificial viscosity/dissipation, boundary conditions, the uniqueness of solutions, grid resolution, turbulence modeling, and Reynolds number effects. It is concluded that, although improvements in theory are being made more quickly than in experiments, wind tunnel research has the advantage of the more realistic transition process of a right turbulence model in a free-transition test. Author

N89-10840# Sandia National Labs., Albuquerque, N. Mex.
AN APPROXIMATE, MAXIMUM TERMINAL VELOCITY DESCENT TO A POINT
G. RICHARD EISLER and DAVID G. HULL (Texas Univ., Austin.) 1987 15 p Presented at the Guidance, Navigation and Control Conference, Minneapolis, Minn., 15 Aug. 1988
(Contract DE-AC04-76DP-00789)
(DE88-000349; SAND-87-3011C; CONF-880818-2) Avail: NTIS HC A03/MF A01

No closed form control solution exists for maximizing the terminal velocity of a hypersonic glider at an arbitrary point. As an alternative, this study uses neighboring extremal theory to provide a sampled data feedback law to guide the vehicle to a constrained ground range and altitude. The guidance algorithm is divided into two parts: (1) computation of a nominal, approximate, maximum terminal velocity trajectory to a constrained final altitude and computation of the resulting unconstrained groundrange, and (2) computation of the neighboring extremal control perturbation at the sample value of flight path angle to compensate for changes in the approximate physical model and enable the vehicle to reach the on-board computed groundrange. The trajectories are characterized by glide and dive flight to the target to minimize the time spent in the denser parts of the atmosphere. The proposed on-line scheme successfully brings the final altitude and range constraints together, as well as compensates for differences in flight model, atmosphere, and aerodynamics at the expense of guidance update computation time. Comparison with an independent, parameter optimization solution for the terminal velocity is excellent. DOE

N89-10841# Sandia National Labs., Albuquerque, N. Mex.
AERODYNAMIC DESIGN CONSIDERATIONS FOR A FREE-FLYING DUCTED PROPELLER
ROBERT J. WEIR Jan. 1988 32 p Presented at the AIAA Atmospheric Flight Mechanics Conference, Minneapolis, Minn., 15 Aug. 1988
(Contract DE-AC04-76DP-00789)
(DE88-006867; SAND-88-0021C; CONF-880836-1) Avail: NTIS HC A03/MF A01

The design philosophy for a free-flying vehicle powered by a ducted propeller is presented from an aerodynamic viewpoint. Airframe design concentrates on duct inlet lip curvature, diffuser angle, and methods of vehicle control. Wind tunnel test results are given to evaluate two inlet designs, two exit designs, and the effect of external appendages such as a camera pod or a forebody. Finally, a simple, analytic method of ducted propeller blade design is presented and the results compared with an existing ducted propeller blade. DOE

N89-10842*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIMENTAL RESULTS FOR THE EPPLER 387 AIRFOIL AT LOW REYNOLDS NUMBERS IN THE LANGLEY LOW-TURBULENCE PRESSURE TUNNEL
ROBERT J. MCGHEE, BETTY S. WALKER, and BETTY F. MILLARD Oct. 1988 232 p
(NASA-TM-4062; L-16430; NAS 1.15:4062) Avail: NTIS HC A11/MF A01 CSCL 01A

Experimental results were obtained for an Eppler 387 airfoil in the Langley Low Turbulence Pressure Tunnel. The tests were conducted over a Mach number range from 0.03 to 0.13 and a chord Reynolds number range for 60,000 to 460,000. Lift and pitching moment data were obtained from airfoil surface pressure measurements and drag data for wake surveys. Oil flow visualization was used to determine laminar separation and turbulent reattachment locations. Comparisons of these results with data on the Eppler 387 airfoil from two other facilities as well as the Eppler airfoil code are included. Author

N89-10844*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THREE COMPONENT LASER ANEMOMETER MEASUREMENTS IN AN ANNULAR CASCADE OF CORE TURBINE VANES WITH CONTOURED END WALL
LOUIS J. GOLDMAN and RICHARD G. SEASHOLTZ Nov. 1988 44 p
(NASA-TP-2846; E-4183; NAS 1.60:2846) Avail: NTIS HC A03/MF A01 CSCL 20D

The three mean velocity components were measured in a full-scale annular turbine stator cascade with contoured hub end wall using a newly developed laser anemometer system. The anemometer consists of a standard fringe configuration using fluorescent seed particles to measure the axial and tangential components. The radial component is measured with a scanning confocal Fabry-Perot interferometer. These two configurations are combined in a single optical system that can operate simultaneously in a backscatter mode through a single optical access port. Experimental measurements were obtained both within and downstream of the stator vane row and compared with calculations from a three-dimensional inviscid computer program. In addition, detailed calibration procedures are described that were used, prior to the experiment, to accurately determine the laser beam probe volume location relative to the cascade hardware. Author

N89-10847# National Aeronautical Lab., Bangalore (India). Aerodynamics Div.
TESTS ON 3 NACA 0012 AIRFOIL MODELS OF DFVLR IN THE NAL 0.3 TUNNEL: AN ASSESSMENT OF 2-D WALL INTERFERENCE
R. GOPINATH, SANTHA KUMARI, and R. SRIDHARAN Dec. 1987 117 p
(TM-AE-8705) Avail: NTIS HC A06/MF A01

Tests were conducted on three NASA 0012 airfoil models. A range of Mach numbers from 0.6 to 0.9 and incidence of the model from 0 degrees to 7 degrees with both free and fixed transition on the airfoil model, was covered. Flow visualization studies were also carried out at a few Mach numbers and incidence. Interference corrections were computed from wall pressures measured along the slat on the top and bottom liners of the modified test section and the corrected data compared with those from other tunnels. An analysis of the data on the three models of chord lengths 100mm, 150mm and 200mm respectively, from the standpoint of interference due to tunnel walls, is presented. Author

N89-10849*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE 1987 GROUND VORTEX WORKSHOP
RICHARD J. MARGASON, ed. Feb. 1988 216 p Workshop held at Moffett Field, Calif., 22-23 Apr. 1987
(NASA-CP-10008; A-88008; NAS 1.55:10008) Avail: NTIS HC A10/MF A01 CSCL 01A

The purpose of this workshop was to discuss the current understanding of the ground vortex phenomena and their effects on aircraft, and to establish directions for further research on advanced, high-performance aircraft designs, particularly those concepts utilizing powered-lift systems; e.g., V/STOL. ASTOVL, and STOL aircraft.

N89-10850*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE CHARACTERISTICS OF THE GROUND VORTEX AND ITS EFFECT ON THE AERODYNAMICS OF THE STOL CONFIGURATION
VEARLE R. STEWART *In its* The 1987 Ground Vortex Workshop p 1-38 Feb. 1988
Avail: NTIS HC A10/MF A01 CSCL 01A

The interaction of the free stream velocity on the wall jet formed by the impingement of deflected engine thrust results in a rolled up vortex which exerts sizable forces on a short takeoff (STOL) airplane configuration. Some data suggest that the boundary layer under the free stream ahead of the configuration may be important

in determining the extent of the travel of the wall jet into the oncoming stream. Here, early studies of the ground vortex are examined, and those results are compared to some later data obtained with moving a model over a fixed ground board. The effect of the ground vortex on the aerodynamic characteristics are discussed. Author

N89-10852*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
GROUND VORTEX FLOW FIELD INVESTIGATION
RICHARD E. KUHN, JOHN H. DELFRATE, and JAMES E. ESHLEMAN (Lockheed-California Co., Burbank.) *In its* The 1987 Ground Vortex Workshop p 61-90 Feb. 1988
Avail: NTIS HC A10/MF A01 CSCL 01A

Flow field investigations were conducted at the NASA Ames-Dryden Flow Visualization Facility (water tunnel) to investigate the ground effect produced by the impingement of jets from aircraft nozzles on a ground board in a STOL operation. Effects on the overall flow field with both a stationary and a moving ground board were photographed and compared with similar data found in other references. Nozzle jet impingement angles, nozzle and inlet interaction, side-by-side nozzles, nozzles in tandem, and nozzles and inlets mounted on a flat plate model were investigated. Results show that the wall jet that generates the ground effect is unsteady and the boundary between the ground vortex flow field and the free-stream flow is unsteady. Additionally, the forward projection of the ground vortex flow field with a moving ground board is one-third less than that measured over a fixed ground board. Results also showed that inlets did not alter the ground vortex flow field. Author

N89-10853*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
F-15 SMTD LOW SPEED JET EFFECTS WIND TUNNEL TEST RESULTS
WILLIAM B. BLAKE *In* NASA, Ames Research Center, The 1987 Ground Vortex Workshop p 91-119 Feb. 1988
Avail: NTIS HC A10/MF A01 CSCL 01A

Key results from low speed wind tunnel testing of the F-15 STOL and Maneuver Technology Demonstrator (SMDT) with thrust reversers are presented. Longitudinally, the largest induced increments in the stability and control occur at landing gear height. These generally reflect an induced lift loss and a nose-up pitching moment, and vary with sideslip. Directional stability is reduced at landing gear height with full reverse thrust. Nonlinearities in the horizontal tail effectiveness are found in free air and at landing gear height. Author

N89-10854*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN ASSESSMENT OF GROUND EFFECTS DETERMINED BY STATIC AND DYNAMIC TESTING TECHNIQUES
JOHN W. PAULSON, JR. and GUY T. KEMMERLY *In* NASA, Ames Research Center, The 1987 Ground Vortex Workshop p 121-146 Feb. 1988
Avail: NTIS HC A10/MF A01 CSCL 01A

A new testing technique was developed wherein the rate of descent can be included as a parameter in ground effects investigations. This technique simulates the rate of descent by horizontal motion of a model over an inclined ground board in the Langley Vortex Research Facility (VRF) During initial evaluations of the technique, dynamic ground effects data were obtained over the inclined ground board, steady state ground effects data were obtained over a flat portion of the ground board, and the results were compared to conventional static wind tunnel ground effect data both with and without a moving belt ground plane simulation. Initial testing and analysis led to the following conclusions: the moving belt ground plane had little effect on static ground effects for the configurations tested unless thrust reversers were employed; in general, rate-of-descent reduced ground effects to the point that for reversed thrust cases an expected loss of lift due to ground effects was eliminated at approach conditions; and, in general, the steady state results from the VRF matched static results obtained from the wind tunnel once the flow field stabilized over the flat portion of the ground board. Author

N89-10855*# Florida State Univ., Tallahassee. Fluid Mechanics Research Lab.
EFFECTS OF A GROUND VORTEX ON THE AERODYNAMICS OF AN AIRFOIL
A. KROTHAPALLI and D. LEOPOLD (Stanford Univ., Calif.) *In* NASA, Ames Research Center, The 1987 Ground Vortex Workshop p 147-166 Feb. 1988
(Contract NAG2-111; NAG2-198)
Avail: NTIS HC A10/MF A01 CSCL 01A

An experimental investigation was carried out to study the aerodynamics of an airfoil with a rectangular jet exiting from its lower surface at fifty percent of the chord. The airfoil was tested with and without the influence of a ground plane. Surface static pressures were measured on the airfoil at jet to free stream velocity ratios ranging from 0 to 9. From these pressures, the variation of C sub L with velocity ratio was easily determined. The measurements indicated significant positive and negative pressure regions on the lower surface of the airfoil ahead of and after the nozzle exit respectively. The presence of a ground plane enhanced these pressure regions at low velocity ratios, but at a particular ratio for each plane location, a recirculation zone or vortex formed ahead of the jet resulting in decreased pressures and a drop in C sub L. Author

N89-10857*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NUMERICAL INVESTIGATION OF A JET IN GROUND EFFECT USING THE FORTIFIED NAVIER-STOKES SCHEME
WILLIAM R. VANDALSEM and JOSEPH L. STEGER *In its* The 1987 Ground Vortex Workshop p 191-206 Feb. 1988
Avail: NTIS HC A10/MF A01 CSCL 01A

One of the flows inherent in VSTOL operations, the jet in ground effect with a crossflow, is studied using the Fortified Navier-Stokes (FNS) scheme. Through comparison of the simulation results and the experimental data, and through the variation of the flow parameters (in the simulation) a number of interesting characteristics of the flow have been observed. For example, it appears that the forward penetration of the ground vortex is a strong inverse function of the level of mixing in the ground vortex. Also, an effort has been made to isolate issues which require additional work in order to improve the numerical simulation of the jet in ground effect flow. The FNS approach simplifies the simulation of a single jet in ground effect, but it will be even more effective in applications to more complex topologies. Author

N89-10858*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL INVESTIGATION OF THE PERFORMANCE OF A SUPERSONIC COMPRESSOR CASCADE
D. L. TWEEDT, H. A. SCHREIBER, and H. STARKEN (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne, West Germany) Jun. 1988 30 p Presented at the 33rd International Gas Turbine and Aeroengine Congress and Exposition, Amsterdam, The Netherlands, 5-9 Jun. 1988; sponsored by ASME
(NASA-TM-100879; E-4113; NAS 1.15:100879) Avail: NTIS HC A03/MF A01 CSCL 01A

Results are presented from an experimental investigation of a linear, supersonic, compressor cascade tested in the supersonic cascade wind tunnel facility at the DFVLR in Cologne, Federal Republic of Germany. The cascade design was derived from the near-tip section of a high-through-flow axial flow compressor rotor with a design relative inlet Mach number of 1.61. Test data were obtained over a range of inlet Mach numbers from 1.23 to 1.71, and a range of static pressure ratios and axial-velocity-density ratios (AVDR) at the design inlet condition. Flow velocity measurements showing the wave pattern in the cascade entrance region were obtained using a laser transit anemometer. From these

measurements, some unique-incidence conditions were determined, thus relating the supersonic inlet Mach number to the inlet flow direction. The influence of static pressure ratio and AVDR on the blade passage flow and the blade-element performance is described, and an empirical correlation is used to show the influence of these two (independent) parameters on the exit flow angle and total-pressure loss for the design inlet condition.
Author

N89-10859# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Aerothermodynamique.
INVESTIGATION ON OF THE FLOW AROUND A BACKWARD FACING STEP WITH SPANWISE BLOWING Final Report [ETUDE DE L'ECOULEMENT AUTOUR D'UNE MARCHE DESCENDANTE AVEC SOUFFLAGE TANGENTIEL]
X. DESAINT-VICTOR and W. HAJIBRAHIM Jan. 1988 71 p In FRENCH
(Contract AEROSPATIALE-21-003395)
(CERT-RF-OA-68/2259-AYD; DERAT-52/5004-23; ETN-88-93105) Avail: NTIS HC A04/MF A01

Spanwise blowing of the boundary layer to eliminate recirculation zones downstream of helicopter motor fairings/rotor heads was analyzed numerically. Flow around a backward facing step with a slit at riser level for the blowing was studied. Two slit/step height ratios were chosen and several ratios of blowing velocity to infinite upstream velocity were considered. Results show that the calculation method can predict flows with strong separation, and that spanwise blowing can eliminate recirculation downstream of an obstacle. ESA

N89-10860# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de l'Aerodynamique.
FLOW AROUND A DELTA WING WITH OR WITHOUT A CANARD (PHI BA = 60 DEG). PART 2: HYDRODYNAMIC VISUALIZATIONS IN UNSTEADY FLOW (PITCHING OSCILLATIONS) [ECOULEMENT AUTOUR D'UNE AILE DELTA SANS OU AVEC PLAN CANARD (PHI BA = 60 DEG), DEUXIEME PARTIE: VISUALISATIONS HYDRODYNAMIQUES EN INSTATIONNAIRE (OSCILLATIONS EN TANGAGE)]
H. WERLE Feb. 1988 43 p In FRENCH
(ONERA-RT-11/2891-AN-PT-2; ETN-88-93111) Avail: NTIS HC A03/MF A01

Turbulence phenomena around a thin delta wing were visualized and measured in a hydrodynamic test facility with a model in unsteady flow. The model was subjected to harmonic pitching oscillations of amplitude + or - 10 deg, around an average incidence of 15 and 20 deg. Vortices at a wing with a canard configuration were studied at Reynolds numbers between 20,000 and 100,000 and at frequency K between 0.18 and 0.46. Results show the effectiveness of the canard is greatly reducing bursting. Curves showing the alternating displacement of the vortex axis and vortex bursting point, and their evolution as a function of flow parameters are obtained. ESA

N89-10861# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Aerothermodynamique.
EXPERIMENTAL INVESTIGATION OF FLOW NEAR A CORNER, PART 2 [ETUDE EXPERIMENTALE D'UN ECOULEMENT AU VOISINAGE D'UN COIN (DEUXIEME PARTIE)]
GUY PAILHAS Jan. 1988 159 p In FRENCH
(Contract STPA-85-95-004)
(CERT-RT-OA-24/5025-AYD; DERAT-24/5025-14; ETN-88-93113) Avail: NTIS HC A08/MF A01

Flow in the angle of intersection of two walls was studied using a wind tunnel model to simulate the joint of a highly swept (arrow) wing and a fuselage, the wing being at incidence. A hot-wire anemometer was used to obtain the average flow field and turbulence field in different flow planes. Results show that the combination of sweep and incidence does not contribute to the creation of a pressure gradient strong enough to allow an important deformation of the flow lines downstream. Geometric parameters (sweep, profile incidence) appear to be essential in determining flow tropism in corners. ESA

N89-10862# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugmechanik.
INVESTIGATION OF WAKE VORTICES OF LANDING AIRCRAFT AT FRANKFURT AIRPORT (FEDERAL REPUBLIC OF GERMANY)
ROLF ULKEN May 1988 70 p In GERMAN; ENGLISH summary
(DFVLR-MITT-88-15; ISSN-0176-7739; ETN-88-93183) Avail: NTIS HC A04/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Federal Republic of Germany, 24.50 deutsche marks

Wake vortices were investigated to see whether and under which meteorological conditions landing aircraft could be endangered by wake vortices generated by leading large transport aircraft on a parallel glide path. The crosswind shows an evident influence on the horizontal motion of a vortex. But its velocity during 56 pct of the time of the main air traffic is so slow that a vortex cannot reach the parallel glide path with dangerous intensity due to its limited life-span. Within the remaining time the danger to a following aircraft depends very strongly on the meteorological conditions of the vicinity. ESA

N89-10864# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Aerothermodynamique.
THREE DIMENSIONAL SHEAR FLOW. ANALYSIS OF THE FLOW IN A DELTA ARROW WING WITH INCIDENCE ANGLE [ECOULEMENTS CISAILLES TRIDIMENSIONNELS. ANALYSE DE L'ECOULEMENT A L'INTRADOS D'UNE AILE EN FLECHE ET EN INCIDENCE]
GUY PAILHAS Mar. 1987 27 p In FRENCH
(Contract STPA-85-95-004)
(CERT-RTS-OA-25/5025-AYD; DERAT-25/5025-14; ETN-88-93319) Avail: NTIS HC A03/MF A01

Wind tunnel tests were performed on a delta wing to evaluate the average velocities and the turbulent fields. A four wire anemometer was used. The model was placed at large incidence angles and simulated a delta winged aircraft body. The analysis of the turbulence shows that the corner flow is the result of a conflict between the fluid coming out of the boundary layer below the wing, which could be receptive to the turbulence order imposed by the systems geometry, and the external fluid which forces the flow to retake the initial direction. ESA

N89-10865*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL AERODYNAMIC PERFORMANCE OF ADVANCED 40 DEG-SWEPT 10-BLADE PROPELLER MODEL AT MACH 0.6 TO 0.85
GLENN A. MITCHELL Sep. 1988 43 p
(NASA-TM-88969; E-3437; NAS 1.15:88969) Avail: NTIS HC A03/MF A01 CSCL 01A

A propeller designated as SR-6, designed with 40 deg of sweep and 10 blades to cruise at Mach 0.8 at an altitude of 10.7 km (35,000 ft), was tested in the NASA Lewis Research Center's 8- by 6-Foot Wind Tunnel. This propeller was one of a series of advanced single rotation propeller models designed and tested as part of the NASA Advanced Turboprop Project. Design-point net efficiency was almost constant to Mach 0.75 but fell above this speed more rapidly than that of any previously tested advanced propeller. Alternative spinners that further reduced the near-hub interblade Mach numbers and relieved the observed hub choking improved performance above Mach 0.75. One spinner attained estimated SR-6 Design-point net deficiencies of 80.6 percent at Mach 0.75 and 79.2 percent at Mach 0.8, higher than the measured performance of any previously tested advanced single-rotation propeller at these speeds. Author

N89-10866# Aeronautical Research Labs., Melbourne (Australia).
NON-LINEAR AERODYNAMIC CHARACTERISTICS OBTAINED FROM THE ANALYSIS OF FLIGHT-DATA
R. A. FEIK Nov. 1987 35 p
(AR-004-571; ARL-AERO-TM-390) Avail: NTIS HC A03/MF A01

A least squares regression analysis program has been documented and its advantages and shortcomings when used for analyzing flight data have been summarized. It has been shown that the shortcomings can be largely overcome by pre-processing flight measurements via compatibility checking. A particular advantage of the least squares approach is the ability to partition data into angle of attack subsets. Application to flight data from a delta wing aircraft at Mach 0.65 has been successful in extracting nonlinear features, including a sharp drop in pitch damping at around 4 degrees angle of attack, possibly associated with the development of the leading edge vortex. Comparison with previous results, internal consistency, and small scatter all confirm the effectiveness of this approach even with moderate quality instrumentation. The methodology described has considerable potential for application to highly nonlinear flight regimes. Author

N89-10867# General Dynamics/Fort Worth, Tex.
UNSTEADY LOW-SPEED WINDTUNNEL TEST OF A STRAKED DELTA WING, OSCILLATING IN PITCH. PART 1: GENERAL DESCRIPTION AND DISCUSSION OF RESULTS Final Report, Jun. 1985 - Aug. 1987
A. M. CUNNINGHAM, JR., R. G. DENBOER, C. S. DOGGER, E. G. GUERTS, and A. J. PERSOON Apr. 1988 140 p
(Contract F33615-85-C-3013)
(AD-A196456; AFWAL-TR-87-3098-PT-1) Avail: NTIS HC A07/MF A01 CSCL 01A

Results of a wind tunnel test of an oscillating straked wing indicate unsteady airloads and pressure distributions for a range of incidences (-8 to 50 deg) and amplitudes (1 to 16 deg). The wind speed was 80 meters/second, which provided reduced frequencies up to 0.50 based on root chord. The zeroth and first harmonic as well as the continuous time history of the pressure and overall loads were measured. Flow visualization was performed for flow of 30 meters/second using a pulsating laser light sheet. This part presents the description of this wind tunnel test and preliminary discussions of results obtained from the test. Details are provided on the model, instrumentation and support system as well as test program condition/run member cross-reference tables for use with the data base presented in parts 2 through 6 of this report. Model geometry and force data processing procedures are presented in the appendices. Also presented in the appendices are updated values of force data obtained from the steady tests of the model suspended by a wire balance.
GRA

N89-11067# Joint Publications Research Service, Arlington, Va.
NUMERICAL SIMULATION OF TRANSONIC FLOW AROUND ASUKA
SUSUMU TAKANASHI *In its* JPRS Report: Science and Technology: Japan p 24-25 4 Jun. 1987 Transl. into ENGLISH from Kogiken Nyusu (Toyko, Japan), Sep. 1986 p 2
Avail: NTIS HC A05/MF A01

Research is being conducted on the numerical simulation of transonic flow around a low noise short takeoff and landing (STOL) experimental aircraft, Asuka. The purposes of this research are to evaluate the high speed aerodynamic characteristics of the Asuka, to evaluate the aerodynamic interference between the elements and airframe according to the parametric study, and to construct a numeric data base. Author

N89-11069# Joint Publications Research Service, Arlington, Va.
CAD WIND TUNNEL TEST FOR HALF-CUT MODEL OF ASUKA
In its JPRS Report: Science and Technology: Japan p 29-32 4 Jun. 1987 Transl. into ENGLISH from Kogiken Nyusu (Toyko, Japan), Sep. 1986 p 5-6
Avail: NTIS HC A05/MF A01

A low noise STOL experimental aircraft, Asuka, is presently being researched and developed at a full scale flight experimental stage. The main wing itself of the C-1 transport, which is the mother aircraft of the Asuka, was not changed because the main purpose of this research was to establish a upper surface blowing which will realize a revolutionary STOL performance. Research has also been conducted on the possibility of a rise in aerodynamic performance of the optimum shape of main wings as part of the research on the practical use of future STOL aircraft. Tests were conducted in the above research by using a half-cut model with a main wing shape designed with a computer aided design system and are called low speed wind tunnel test. Author

03

AIR TRANSPORTATION AND SAFETY

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

A89-10471
QUALIFICATION AND OPERATIONAL ASPECTS OF LIGHT WEIGHT SKAD (LIGHT WEIGHT SURVIVAL KIT AIR DROPPABLE)
P. D. JOHNSON (Irvin Industries Canada, Ltd., Fort Erie) IN: SAFE Association, Annual Symposium, 25th, Las Vegas, NV, Nov. 16-19, 1987, Proceedings. Newhall, CA, SAFE Association, 1987, p. 171-175.

The light weight SKAD, a wing mounted survival kit providing reliable and accurate positioning of two interconnected six man inflatable liferafts and survival equipment, is described. The light weight SKAD operational objectives on the CP 121 Tracker aircraft were to develop and demonstrate draft loading and unloading procedures, verify compatibility with the aircraft and weapons risk under typical service conditions, and develop a system drop technique. It is noted that a liferaft positional accuracy of +/- 50 ft is estimated for systems released under typical deployment conditions. K.K.

A89-10475
ADVANCED CREW ESCAPE CAPSULE TECHNOLOGIES PROGRAM
ARUN K. TRIKHA, STEVEN M. WARREN (Boeing Military Airplane Co., Seattle, WA), and JAMES M. PETERS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: SAFE Association, Annual Symposium, 25th, Las Vegas, NV, Nov. 16-19, 1987, Proceedings. Newhall, CA, SAFE Association, 1987, p. 196-202. refs

The use of various advanced technologies such as adaptive digital control, selectable/controllable thrust, thrust vector control, and retrorockets to improve escape capsule performance is discussed. A comparison is made between various alternative escape capsule configurations, including recoverable and nonrecoverable hybrid configurations. A recoverable nose capsule configuration was found to be superior to other configurations. It is noted that the development of other technologies, such as gelled propellants, is important in significantly improving the expected weight performance without a high weight penalty.
K.K.

A89-10631* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
V/STOL AIRCRAFT CONFIGURATIONS AND OPPORTUNITIES IN THE PACIFIC BASIN
JAMES A. ALBERS and JOHN ZUK (NASA, Ames Research Center, Moffett Field, CA) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 45-72. Previously announced in STAR as N88-11644. refs
(SAE PAPER 872403)

Advanced aircraft configurations offer new transportation options for the Pacific Basin. Described is a range of vehicles from low-disk to high-disk loading aircraft, including high-speed rotorcraft, subsonic vertical and short takeoff and landing (V/STOL) aircraft, and subsonic short takeoff and landing (STOL) aircraft. The status and advantages of the various configurations are described. Some of these show promise for satisfying many of the transportation requirements of the Pacific Basin; as such, they could revolutionize short-haul transportation in that region. Author

A89-10654
INTEROPERABILITY OF MILITARY AND CIVIL AIR-CARGO SYSTEMS
PAUL D. TUCK (USAF, Office of the Assistant Chief of Staff Studies and Analyses, Washington, DC) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 331-351. refs
(SAE PAPER 821555)

This paper compares military/civil air-cargo systems in terms of in-plane hardware, materials-handling equipment (MHE), and unit-load devices (ULDs). A need exists to have available, on short notice, a U.S. airlift system for deployment of cargo/troops to remote points of operation. The DOD recently expressed a requirement for increased interoperability between military and civil air cargo systems. Interest in interoperability is also indicated by the Advanced Civil/Military Aircraft (ACMA) concept. The ACMA may be described as an aircraft for fulfilling both U.S. needs for strategic airlift and world-wide needs for civil air freight in the mid-1990s and beyond. The advances and development of cargo-capable aircrafrt and their in-plane cargo-handling systems have historically paced development of complementary ground systems. The military system relies heavily on the 88 x 108-inch pallet. The civil system relies to a greater extent on intermodal containers and the 88 or 96 x 125-inch civil pallets. Author

A89-10655
AEROSPACE TECHNOLOGY - WINDSHEAR FAA: BOEING WINDSHEAR TRAINING AID PROGRAM
CHARLES R. HIGGINS and EDGARS A. KUPCIS (Boeing Commercial Airplane Co., Seattle, WA) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 353-358.
(SAE PAPER 872441)

Severe microburst windshear has been identified as a significant cause of airline accidents during the takeoff and landing phases of flight. In 1985 the Federal Aviation Administration contracted with an industry team (manufacturers, airline training departments, meteorological experts, pilots groups, other interested parties) to develop a windshear training program for transport pilots. This paper treats the organizational structure used to develop industry consensus on the pilot training issues as well as reports on the principal elements of the training program developed by this industry team. The paper discusses the tools available to flight crews to recognize and avoid microburst windshear, and failing that, how to recover from an inadvertent encounter. Author

A89-10656
MAINTENANCE AND AIRLINE SAFETY
RAYMOND E. RAMAKIS (FAA, Aircraft Maintenance Div., Washington, DC) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 359-368. refs
(SAE PAPER 872443)

Aircraft certification is discussed, as well as airline certification and responsibilities and Federal Aviation Administration regulatory responsibilities. As a result of the continuing inspections of air carriers and repair stations since 1984, the industry and the FAA have worked to overcome various negative findings. Among other things, the air carriers have increased the number of mechanics on the payroll, increased their engineering staffs, and increased their inventory of spare parts. The FAA reinstituted national work program guidelines in October 1985, increased inspector staffing, and initiated a flight standards national aviation inspection program. K.K.

A89-10662
AEROELASTICITY PAST, PRESENT AND FUTURE
DAVIN R. SCOTT (Aerospace Technology of Australia, Australia) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 425-429.
(SAE PAPER 872449)

This paper describes a study of the oscillatory aeroelastic phenomenon, with special consideration given to the analysis of an air accident case involving an aircraft having a high wing twin turbopropeller configuration. The aeroelastic analysis was developed that made it possible to predict flutter pertinent to the flight conditions of the aircraft. Finally, a single aeroelasitc analysis system capable of dealing with any previous model was assembled. I.S.

A89-10718
FIRE SAFETY AT CIVIL AIRPORTS [OBESPECHENIE POZHARNOI BEZOPASNOSTI NA AERODROMAKH GRAZHDANSKOI AVIATSII]
MIKHAIL ABASKULIEVIC DZHAFAROV, NIKOLAI FILLIPOVICH LOZOVOI, VLADIMIR IVANOVICH LUTSENKO, and VALENTIN KONSTANTINO FEDOROV Moscow, Izdatel'stvo Transport, 1987, 264 p. In Russian. refs

The available data on the fire safety of commercial aircraft, fire fighting methods, and rescue operations are presented in a systematic manner. In particular, attention is given to the on-board fire safety systems, the use of the fire fighting equipment available at the airport, and technical characteristics of fire safety equipment. The discussion also covers the organizational and safety engineering aspects of fire fighting. V.L.

A89-10721
FUNDAMENTALS OF FLIGHT SAFETY [OSNOVY BEZOPASNOSTI POLETOV]
BORIS VASIL'EVICH ZUBKOV and EVGENII ROMANOVICH MINAEV Moscow, Izdatel'stvo Transport, 1987, 144 p. In Russian.

Various aspects of flight safety are examined on the basis of a systems approach to this complex problem. The discussion covers the principal factors determining flight safety, types of malfunctions, analysis of flight safety indices, methods of insuring the reliability of aviation equipment, and factors determining the functional efficiency of the flight crew. Attention is also given to the functions and objectives of traffic control, navigation support, classification and investigation of flight accidents, and measures designed to prevent flight accidents. V.L.

A89-12539
AIR SAFETY IN THE AGE OF DEREGULATION
LEON N. MOSES and IAN SAVAGE (Northwestern University, Evanston, IL) Issues in Science and Technology (ISSN 0748-5492), vol. 4, Spring 1988, p. 31-36. refs

The present discussion of U.S. airlines' behavior following the deregulation of this industry in 1978 notes that the development of the hub-and-spoke routing system over the past decade has increased the travel time and uncertainty of passengers while increasing the airlines' rate of overbooking. Attention is presently given to the long-term effect of deregulation on such airline safety-related matters as the upholding of maintenance and training standards under the pressure of reduced profit margins (due to more intense competition), as well as to the shortfall in FAA resources for airliner inspections and the U.S.'s low rate of such infrastructural investment as modernized ATC to cope with expanded airline operations. O.C.

A89-12548
THE ASSURANCE OF FLIGHT SAFETY - A PRIORITY TASK IN CIVIL AVIATION [DIE GEWAEHRLEISTUNG DER FLUGSICHERHEIT - EINE ERSTRANGIGE LEITUNGSAUFGABE IN DER ZIVILEN LUFTFAHRT]
ALEXANDER RIECHE (Berlin, Humboldt-Universitaet, German Democratic Republic) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 24, no. 4, 1988, p. 150, 151, 154. In German.

The development of greater flight safety in the context of a socialist society is discussed. The role of cooperation under a strong leader is stressed. The leader's main task is the development of flight safety consciousness. The selection of cadres and the formation of strong cooperative bonds among the cadres in order to advance flight safety is emphasized. C.D.

A89-12717
THE CIVIL AVIATION BIRDSTRIKE RECORD
JOHN THORPE (Civil Aviation Authority, London, England) IN: Bird hazards in aviation; Proceedings of the Symposium, London, England, Oct. 14, 1987. London, Royal Aeronautical Society, 1987, p. 1-6.

An analysis of British civil aviation records on birdstrike events has determined birdstrike rates for fixed-wing aircraft to currently lie in the 5/10,000-flight range; the helicopter rate is about 1/10,000 hours. Fully 85 percent of birdstrikes occur below 800-ft altitude, and seagulls are the birds most frequently involved. Each year, 20 engines are damaged; the approximately 5 cases in which birds are ingested by more than one engine of a multiengine aircraft are considered the most serious ones. It is anticipated that new-generation, intrinsically quieter airliner powerplants may generate a lower aural alert to birds, and thereby increase the probability of birdstrikes. O.C.

A89-12718
BIRD HAZARDS IN AVIATION - THE RAF VIEW
C. J. TURNER (RAF, London, England) IN: Bird hazards in aviation; Proceedings of the Symposium, London, England, Oct. 14, 1987. London, Royal Aeronautical Society, 1987, p. 7-11.

RAF attitudes to birdstrike problems have significantly changed since 1980, when efforts were mounted to reduce the vulnerability of military aircraft and to incorporate greater birdstrike resistance in aircraft entering the design stage. The last eight years have also witnessed the RAF's development of Bird Control Units, which actively dissuade birds of all types from the use of airfields for feeding, nesting, and other social behavior. Outside airfield boundaries, a mechanism for the dissemination of local intelligence concerning unusually heavy bird activity has been established. No aircraft have been lost to birdstrike damage in 1986-1988, as a result of these preventive measures. O.C.

A89-12721
BIRD HAZARDS IN AVIATION - SAFETY AND ECONOMIC IMPLICATIONS FOR AN AIRLINE
P. OAKE (British Airways, PLC, Houslow, England) IN: Bird hazards in aviation; Proceedings of the Symposium, London, England, Oct. 14, 1987. London, Royal Aeronautical Society, 1987, p. 49-60.

The birdstrike incident records of a major British airline presently analyzed for the period from 1980 to 1987, over UK, European, and intercontinental routes, encompass cases that resulted in the malfunction of aircraft control systems, engine or airframe damage, or the crew's precautionary termination of a flight in anticipation of potentially dangerous consequences from the strike. Attention is given to the primary and secondary aspects of costs due to birdstrike damage, in the course of brief examinations of seven case histories. O.C.

A89-12722
BIRD HAZARDS IN AVIATION - THE REGULATORY AUTHORITY'S RESPONSIBILITIES
GORDON SHARP (Civil Aviation Authority, London, England) IN: Bird hazards in aviation; Proceedings of the Symposium, London, England, Oct. 14, 1987. London, Royal Aeronautical Society, 1987, p. 61-65.

This paper presents the author's viewpoint on the requirement to 'control' birds on a licensed aerodrome in the UK and describes how the Civil Aviation Authority carries out its responsibilities; discusses the legal liability if a bird strike should occur on an aerodrome; questions whether or not we have reached a plateau in our knowledge of birds as they affect aircraft close to aerodromes and finally suggests that the bird problem, with our level of knowledge, may often be better described as a people problem. Author

N89-10035# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 10 OF 1987 ACCIDENTS
30 Mar. 1988 403 p
(PB88-916905; NTSB/AAB-88/05) Avail: NTIS HC A18/MF A01; also available on subscription, North American Continent HC $185.00/year; all others write for quote CSCL 01C

The publication contains selected aircraft accident reports in Brief Format occuring in U.S. civil and foreign aviation operations during 1987. Approximately 200 General Aviation and Air Carrier accidents presented represent a random selection. The publication is issued irregularly, normally 18 times each year. The Brief Format presents the facts, conditions, circumstances and probable causes for each accident. GRA

N89-10036# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 12 OF 1986 ACCIDENTS
25 Apr. 1988 414 p
(PB88-916903; NTSB/AAB-88/03) Avail: NTIS HC A18/MF A01; also available on subscription, North American continent HC $185.00/year; all others write for quote CSCL 01C

Selected aircraft accident reports in Brief Format occuring in the U.S. civil and foreign aviation operations during 1986 are presented. Approximately 200 General Aviation and Air Carrier accidents presented represent a random selection. The publication is issued irregularly, normally eighteen times each year. The Brief Format represents the facts, conditions, circumstances and probable causes for each accident. GRA

N89-10450# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
ANALYSIS OF RECENT IN-FLIGHT LIGHTNING MEASUREMENTS ON DIFFERENT AIRCRAFT
J. L. BOULAY, J. P. MOREAU, A. ASSELINEAU, and P. L. RUSTAN (Defense Nuclear Agency, Washington, D.C.) *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 136-144 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 01C

Two experimental programs have been conducted since 1984 in order to obtain in-situ measurements on lightning effects on aircraft. These two programs involve the CV-580 aircraft and the Transall aircraft. Researchers now have a large amount of information concerning typical parameter variations during a direct lightning stroke in flight: currents, electric and magnetic fields in several locations on the aircraft structures. One of the most important features of these measurements concerns the great similarity between parameter variations for the two experimental programs. After presentation of typical results obtained with the Transall, a comparative analysis is made of CV-580 and Transall data on I and H waveforms during the attachment phase of the lightning strike. A number of hypotheses aimed at giving physical explanations of the measurements detected in flight are discussed. Author

N89-10451*# Electro Magnetic Applications, Inc., Lakewood, Colo.
LINEAR AND NONLINEAR INTERPRETATION OF CV-580 LIGHTNING DATA
POH H. NG, TERENCE H. RUDOLPH, and RODNEY A. PERALA *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 145-151 Apr. 1988 Sponsored in part by FAA, Atlantic City, N.J.
(Contract NAS1-17748)
Avail: NTIS HC A23/MF A01 CSCL 01C

Numerical models developed for the study of lightning strike data acquired by in-flight aircraft are applied to the data measured on the CV-580. The basic technique used is the three dimensional time domain finite difference solution of Maxwell's equations. Both linear and nonlinear models are used in the analysis. In the linear model, the lightning channel and the aircraft are assumed to form a linear time invariant system. A transfer function technique can then be used to study the response of the aircraft to a given lightning strike current. Conversely, the lightning current can be inferred from the measured response. In the nonlinear model, the conductivity of air in the vicinity of the aircraft is calculated and incorporated into the solution of the Maxwell's equations. The nonlinear model thus simulates corona formation and air breakdown. Results obtained from the models are in reasonable agreement with the measured data. This study provides another validation of the models and increases confidence that the models may be used to predict aircraft response to any general lightning strike. Author

N89-10452# Boeing Advanced Systems Co., Seattle, Wash.
LIGHTNING TESTS ON AN ALL-COMPOSITE HELICOPTER
DAVID B. WALEN *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 152-159 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 01C

Lightning tests were performed on an all-composite helicopter to determine lightning-induced transient effects on the helicopter electrical and electronic systems. Results of the tests were used to assess the lightning simulation techniques. The helicopter incorporated graphite/epoxy, Kelvar, and fiberglass materials in the structure and skins. Swept continuous wave (CW) transfer function measurements and current pulse tests with drive currents ranging from 20 kA to 200 kA were used for the lightning tests. Transient voltage and current responses were measured on the helicopter avionics and wiring. The response waveform comparisons showed that the transformed transfer functions had similar shapes and amplitudes to the measured pulse responses. Within constraints of the pulse variations, scaling generally provided conservative response predictions. Author

N89-10454*# Electro Magnetic Applications, Inc., Huntsville, Ala.
ESTIMATING ELECTRIC FIELD ENHANCEMENT FACTORS ON AN AIRCRAFT UTILIZING A SMALL SCALE MODEL: A METHOD EVALUATION
CALVIN C. EASTERBROOK, TERENCE RUDOLPH, and KEVIN EASTERBROOK *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 171-174 Apr. 1988
(Contract NAS1-17748)
Avail: NTIS HC A23/MF A01 CSCL 01C

A method for obtaining field enhancement factors at specific points on an aircraft utilizing a small scale model was evaluated by measuring several canonical shapes. Comparison of the form factors obtained by analytical means with measurements indicate that the experimental method has serious flaws. Errors of 200 to 300 percent were found between analytical values and measured values. As a result of the study, the analytical method is not recommended for calibration of field meters located on aircraft, and should not be relied upon in any application where the local spatial derivatives of the electric field on the model are large over the dimensions of the sensing probe. Author

N89-10455# AIRO, Inc., Colorado Springs, Colo.
A CHRONOLOGY OF IN-CLOUD ELECTRIC FIELD AND LIGHTNING STRIKES ON AN INSTRUMENTED RESEARCH AIRCRAFT
J. WILLIAM BULLOCK and J. J. JONES (New Mexico State Bureau of Mines and Mineral Resources, Socorro.) *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 175-180 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 04B

The two lightning strikes to the aircraft in 1983 were identified. The strikes occurred when the aircraft was entering or leaving a region of strong vertical electric field. In both cases, the measured field subsequent to the strikes was greatly reduced from the pre-strike value, indicating that the strike removed the nearby charge which was the source of the pre-strike electric field. It appears that the aircraft triggered these strikes, and a possible triggering mechanism is proposed. The strikes also removed the pre-strike charge on the aircraft. Since both strikes occurred during cloud penetrations near zero degree isotherm and depleted a region of positive charge, it is believed that these were so-called Lower Position Charge Centers. Author

N89-10456*# National Severe Storms Lab., Norman, Okla.
LIGHTNING INITIATION ON AIRCRAFT IN THUNDERSTORMS
VLADISLAV MAZUR *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 181-191 Apr. 1988 Previously announced as A88-22289 Sponsored in part by NASA
Avail: NTIS HC A23/MF A01 CSCL 01C

A physical model of the initiation of lightning flashes in thunderstorms is presented. The model is based on the bi-directional charged leader concept of Kasemir, and is verified with airborne data from lightning strikes to instrumented airplanes (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

N89-10457# De Havilland Aircraft Co. of Canada Ltd., Downsview (Ontario).
LIGHTNING TESTS TO MEASURE THE BULK CURRENT LEVELS ASSOCIATED WITH THE ELECTRONIC ENGINE CONTROL OF A TURBOPROP COMMUTER TRANSPORT
PETER BOOTSMA *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 192-196 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 01C

Impulse lightning tests were carried out as part of a development program to measure the cable current levels associated with the electronic engine control (EEC) of a turboprop commuter transport. Described here are two test programs, each utilizing full scale vehicles to measure the bulk current levels associated with the engine control cable harness. In the first test program, the tests were performed with the 1200 ampere unipolar test waveform. The second test program was carried out using a 15 kiloampere damped sinusoid test waveform. The latter program was extended for a period of several weeks in order to develop a method of diverting current from the engine to the surrounding nacelle, and improve the shielding of the engine control cable harness. Author

N89-10459# Electro Magnetic Applications, Inc., Lakewood, Colo.
INTERFERENCE OF PRECIPITATION STATIC DISCHARGES WITH AIRCRAFT NAVIGATIONAL SYSTEMS
GREGORY J. RIGDEN *In* NOAA, International Aerospace and

Ground Conference on Lightning and Static Electricity p 205-212 Apr. 1988 Sponsored in part by FAA, Atlantic City, N.J.; Lightning and Transients Research Inst., St. Paul, Minn.
(Contract DTFA03-84-C-00066)
Avail: NTIS HC A23/MF A01 CSCL 01C

The objective was to address p-static problems by determining ways to reduce their effects. The Gates Learjet was used as a model for this study. The small size of the Learjet enabled an accurate numerical investigation utilizing a three dimensional finite difference approach to solving Maxwell's equations. The study included an analysis of the possible discharges, where they are likely to occur and how often, an examination of dischargers to determine the dependency of noise levels on discharger design, and a look at electromagnetic responses from different types of dischargers. Author

N89-10460# New Mexico Inst. of Mining and Technology, Socorro.
ELECTRIFICATION OF HOVERING HELICOPTERS
C. B. MOORE, MARX BROCK, and CLYDE N. RICHARDS (Atmospheric Physics, Inc., Peralta, N. Mex.) *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 213-217 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 01C

Helicopters hovering above the earth are often highly charged with electricity and this causes operational problems for ground crew personnel when contact with the aircraft is required. The source of this charge is often attributed to elastic collisions of the rotor blades with dust particles in the surrounding air, but researchers found that appreciable charge transfers also occur through the hot, conductive engine exhaust gases acted on by local electric fields. Some control of the residue charge on hovering aircraft has been achieved by shielding the exhaust gases from electric fields and then varying the voltages applied to electrodes immersed in the hot gases so as to cause an export of the unwanted charge. Author

N89-10461# Naval Research Lab., Washington, D.C. Plasma Physics Div.
MEASUREMENT OF THE ELECTROSTATIC CHARGING ON LARGE HELICOPTERS AND CONTROL OF THE SHOCK HAZARD
R. E. PECHACEK, D. P. MURPHY, and J. R. GREIG (G-T Devices, Inc., Springfield, Va.) *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 218-227 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 01C

This work was undertaken to ascertain the electrical hazard to ground personnel attaching cargo to hovering CH-53E helicopters. The hazard is severe, but a solution has been rediscovered. An approximately 10-megohm resister, replacing the stainless wire connected along the nylon cable from the helicopter to the cargo hook allows a man to discharge 200-KV, 1000-pF helicopter through his body with a barely perceptible shock. The system has been successfully field tested twice. Author

N89-10478*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IMPLICATIONS OF A RECENT LIGHTNING STRIKE TO A NASA JET TRAINER
BRUCE D. FISHER, RALPH J. TAEUBER, and KEITH E. CROUCH (Lightning Technologies, Inc., Pittsfield, Mass.) *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 360-369 Apr. 1988 Previously announced in IAA as A88-22291
Avail: NTIS HC A23/MF A01 CSCL 01C

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 of the fuselage section. The NASA investigation board concluded that the airplane was struck by lightning, which resulted in an inflight explosion with subsequent fire. The implications of this mishap to aircraft lightning protection and the avoidance of those conditions conducive to lightning strikes to aircarft are discussed. Author

N89-10483# Saab-Scania, Linkoping (Sweden).
FINITE DIFFERENCE ANALYSIS OF EXTERNAL AND INTERNAL LIGHTNING RESPONSE OF THE JAS39 CFC WING
BO I. WAHLGREN and JONAS W. ROSEN *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 396-400 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 01C

Analysis was carried out on a carbon fiber composite (CFC) wing for the JAS39 aircraft, using a 3-D finite difference technique in the time domain. The wing box was also subjected to extensive lightning testing which allowed researchers to compare test and analysis results. For both the wing and the wing box, the external configuration as well as the internal installations were modeled quite accurately. The model provided for the correct interaction between external and internal fields. The model is described in some detail and test results are given. Author

N89-10485# Societe Nationale Industrielle Aerospatiale, Toulouse (France).
MODELLING OF COMMON MODE COUPLING BETWEEN AN AIRCRAFT WING TRAVERSED BY A LIGHTNING CURRENT AND WIRING INSTALLED IN THAT WING
MICHEL CROKAERT *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 408-424 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 01C

A code for the calculation of lightning induced common mass voltage and current in wiring installed in a wing was developed on the basis of the experimental results of the tests on an Airbus A300 wing subjected to current pulses with very different shapes and amplitudes. The code uses conventional transmission line modelling by quadripole method for both internal and external fields. This model made it possible to explain how magnetic and electric coupling intervenes in time in the voltage and current in wiring. It also makes it possible to account for the loss coefficients of the two lines which make up the external and internal fields and to explain the limitation of certain overvoltages that can intervene. This enables researchers to use the similarity existing between lines and antennae to extrapolate the results to lightning striking an aircraft in flight. Author

N89-10492# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
INDIRECT EFFECTS ON ELECTRONIC AND MECHANICAL SYSTEMS INSTALLED IN CARBON FIBRE COMPOUND AIRCRAFT STRUCTURES
RAINER STRAUSS *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 470-480 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 01C

A test program for indirect strike effects on electrical and mechanical systems installed in a carbon fiber compound aircraft structure is described. The test program was carried out on the front and center of a simulated fuselage of real size, unprotected and protected with aluminum mesh. The test results showed the differences of cable shielding standards and also the shielding effect of the aluminum mesh. Author

N89-10868# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT/INCIDENT SUMMARY REPORT, COPPERHILL, TENNESSEE, FEBRUARY 22, 1986
30 Mar. 1988 9 p
(PB88-910407; NTSB/AAR-88/02-SUMM) Avail: NTIS HC A02/MF A01; also available on subscription, North American continent HC $70.00/year; all others write for quote CSCL 01C

This report is a summary of an aircraft accident investigated by the National Transportation Safety Board. The accident location and date is Copperhill, Tennessee, February 22, 1986. GRA

N89-10869# Systems Control Technology, Inc., Arlington, Va.
AERONAUTICAL DECISION MAKING FOR AIR AMBULANCE HELICOPTER PILOTS: SITUATIONAL AWARENESS EXERCISES Final Report
R. J. ADAMS and J. L. THOMPSON Jul. 1988 45 p
(Contract DTFA01-87-C-00014)
(DOT/FAA/DS-88/6) Avail: NTIS HC A03/MF A01

The following materials are based upon actual helicopter air ambulance accidents, which cover four broad accident types most recently associated with aeromedical accidents: night flying, weather, obstacle strikes, and mechanical failures. Three types of information are included for each accident type. These are: introductory/background material to provide the historical importance and frequency of each accident type; training knowledge that should be learned in order to avoid mistakes of the past; and decision making exercises. Author

N89-10871# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 2 OF 1987 ACCIDENTS
5 Feb. 1988 399 p
(PB88-916906; NTSB/AAB-88/06) Avail: NTIS HC A17/MF A01; also available on subscription, North American continent HC $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 1987. 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

N89-10872*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AVIATION TECHNOLOGY APPLICABLE TO DEVELOPING REGIONS
JOHN ZUK and LARRY R. ALTON Sep. 1988 94 p
(NASA-TM-89425; A-87093; NAS 1.15:89425) Avail: NTIS HC A05/MF A01 CSCL 01C

This paper is an analysis of aviation technologies useful for formulation of development plans to the year 2000 for emerging nations. The Caribbean Basin was used as a specific application. This development promises to be so explosive over the next 15 years as to be virtually unpredictable. Author

N89-10873# National Transportation Safety Board, Washington, D. C.
AIRCRAFT ACCIDENT REPORT: EXECUTIVE AIR CHARTER, INC., DBA AMERICAN EAGLE, FLIGHT 5452, CASA C-212, N432CA, MAYAGUEZ, PUERTO RICO, MAY 8, 1987
2 Aug. 1988 51 p
(PB88-910409; NTSB/AAR-88/07) Avail: NTIS HC A04/MF A01 CSCL 01C

On May 8, 1987, at 0650 local time, flight 5452 of Executive Air Charter, Inc., doing business as Americam Eagle, crashed short of runway 9 while on a visual approach to the airport at Mayaguez, Puerto Rico, in visual meteorological conditions. The safety issues examined in the accident investigation were pilot performance, air carrier maintenance procedures and practices, bilateral type certification of the airplane, and FAA surveillance of the air carrier. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A89-10522
AUTOMATED LANDING APPROACH USING MACHINE SEEING [AUTOMATISCHER LANDEANFLUG DURCH MASCHINELLES SEHEN]
E. D. DICKMANNS and G. EBERL (Muenchen, Universitaet der Bundeswehr, Neubiberg, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 294-300. In German. refs
(DGLR PAPER 87-131)

The automated landing approach of aircraft using autonomous, on-board evaluation of television images was evaluated by simulation using real-time processing hardware and software in the loop. The reuslting image sequence evaluation procedure, based on an integral spatiotemporal model, is described. The results, demonstrated with a business jet aircraft, demonstrate that current microprocessors using appropriate data processing are sufficient to solve this class of problems. C.D.

A89-10523
PRECONDITIONS FOR G.P.S. INSTALLATION - RECEIVERS IN DIFFERENTIAL OPERATION FOR LANDING AIRCRAFT IN GENERAL AVIATION [VORAUSSETZUNGEN ZUM EINSATZ VON G.P.S. - EMPFAENGERN IN DIFFERENTIAL-BETRIEB ZUR LANDEANFLUGFUEHRUNG VON FLUGZEUGEN DER ALLGEMEINEN LUFTFAHRT]
TH. JACOB (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 301-310. In German. refs
(Contract BMFT-LFL-8530/7)
(DGLR PAPER 87-132)

The state of the art in aircraft landing systems and quality requirements for installation of GPS in landing systems are addressed. The GPS system concept, mode of operation, and positional accuracy are discussed, and the room for improvement attainable in GPS by installing differential GPS is examined. A system concept for installing GPS in aircraft landing systems is presented, and some experimental flight results using such a system are reported. C.D.

A89-10524
RESEARCH ON SATELLITE-TO-AIRCRAFT SIGNAL COMMUNICATION [UNTERSUCHUNG DER NACHRICHTENVERBINDING SATELLIT - FLUGZEUG]
ANDREAS NEUL and JOACHIM HAGENAUER (DFVLR, Institut fuer Nachrichtentechnik, Oberpfaffenhofen, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 311-313. In German.
(DGLR PAPER 87-133)

Technology for communications between satellites and aircraft is discussed. The most important technological requirements for maintaining such a communications channel are briefly reviewed, and a study to determine the most significant physical factors affecting such a communications channel is described. The findings concerning the probability distribution of the signal power, the statistics of fade and connection, and the data transmission are reported. C.D.

A89-10580
CURRENT MILITARY/GOVERNMENT APPLICATIONS FOR SPEECH RECOGNITION

JAMES W. HICKS, JR. (SCI Technology, Inc., Huntsville, AL) IN: Aerospace Behavioral Engineering Technology Conference, 6th, Long Beach, CA, Oct. 5-8, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 37-39.
(SAE PAPER 871750)

This paper presents an overview of several military/government programs in which SCI Technology has implemented and tested its speech recognition technology. Included are the Speckled Trout (U.S. Air Force), LHX (Light Helicopter Experimental, U.S. Army), Space Shuttle (NASA), Space Station, AFTI F-16, and ATF (Advanced Tactical Fighter) programs. Some of the programs consist of technology demonstrations, while others involve flight testing, and one, Speckled Trout, operationally installing and utilizing a system on a continual basis. In some cases, the hardware consists of an SCI Voice Control Unit (VCU-5137) and in others, a Voice Development System (VDS-7001). Author

A89-10581
AFTI/F-16 VOICE INTERACTIVE AVIONICS EVALUATION
F. ALLAN ROSENHOOVER (General Dynamics Corp., Fort Worth, TX) IN: Aerospace Behavioral Engineering Technology Conference, 6th, Long Beach, CA, Oct. 5-8, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 41-48.
(SAE PAPER 871751)

This paper describes the structure of the Voice Interactive Avionics (VIA) system and the results of the AFTI/F-16 flight testing of this system. The areas of evaluation during various mission profiles, needed for establishing the interactive voice needs for mission success are discussed together with problems encountered during the tests and the lessons learned from incorporating the VIA technology into the tactical fighter aircraft. The comparison of the data obtained during the voice task scenarios with the same scenarios flown strictly by manual operation showed an overall reduction in pilot workload when voice tasking was employed. I.S.

A89-10642
THE AUSTRALIAN AVIATION SATELLITE SYSTEM
DON KNOX (Department of Transport and Communications, Airways Div., Australia) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 197-201.
(SAE PAPER 872420)

The Aviation Satellite System carries a significant portion of aeronautical safety communications throughout Australia. One of the benefits of this system is the provision of direct high-quality aircraft-ground VHF communications to overcome the inherent limitations of the high-frequency system. Another benefit is the optimization of air-route structures to allow for direct routing and optimum flight paths for aircraft. B.J.

A89-10722
LASER NAVIGATION EQUIPMENT [LAZERNYE NAVIGATSIONNYE USTROISTVA]
VLADIMIR EVSEEVICH ZUEV and VITALII IAKOVLEVICH FADEEV Moscow, Izdatel'stvo Radio i Sviaz', 1987, 161 p. In Russian. refs

The physical principles of operation and the general design of laser navigational aids used in the landing and piloting of aircraft are examined. Particular attention is given to methods for calculating and optimizing the performance characteristics of laser navigation equipment with allowance for the effect of the atmosphere on the propagation of laser radiation. Based on the results obtained from the operation of experimental laser navigation equipment, recommendations concerning the use of such equipment are made. V.L.

A89-12152#
AIR-TRAFFIC FLOW MANAGEMENT TODAY [VERKEHRSFLUSSSTEUERUNG HEUTE]
OLAF RIECKE (Bundesanstalt fuer Flugsicherung, Luftraumnutzungzentrale, Frankfurt am Main, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), vol. 29, no. 2, 1988, p. 284-288. In German.

The role of air-traffic flow management (ATFM) in preventing overloads of the European air-safety and ATC systems during peak traffic periods is reviewed, with a focus on the organizational structure and procedures in the FRG. Statistical data on recent increases in traffic flow are summarized; the overloads encountered in summer 1987 are described (up to 55 flights/h in sectors with a maximum ATC capacity of 35-40 flights/h); and the primary tasks of ATFM are identified as (1) strategic planning before peak seasons and (2) tactical measures (including early recognition of congestion, channeling of major flows, devising alternate routes, and temporarily increasing ATC capacities). Details of tactical ATFM are discussed, and preliminary predictions for 1988 are presented. T.K.

A89-12404*# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
SPEECH RECOGNITION IN ADVANCED ROTORCRAFT - USING SPEECH CONTROLS TO REDUCE MANUAL CONTROL OVERLOAD
MICHAEL A. VIDULICH (USAF, Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH) and MICHAEL R. BORTOLUSSI (Western Aerospace Laboratories, Inc., Moffett Field, CA) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 10 p. refs
(Contract NCC2-486)

An experiment has been conducted to ascertain the usefulness of helicopter pilot speech controls and their effect on time-sharing performance, under the impetus of multiple-resource theories of attention which predict that time-sharing should be more efficient with mixed manual and speech controls than with all-manual ones. The test simulation involved an advanced, single-pilot scout/attack helicopter. Performance and subjective workload levels obtained supported the claimed utility of speech recognition-based controls; specifically, time-sharing performance was improved while preparing a data-burst transmission of information during helicopter hover. O.C.

A89-12414#
TACTICAL ROUTE PLANNING
JOHN GILMORE, DAN LONG, TOM FRIEDEL, and STEVE TYNOR (Georgia Institute of Technology, Atlanta) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988. refs

The dynamic tactical route-planning subsystem designated 'Trek' consists of preprocessing, points-of-interest extraction, postprocessing, graph construction, and heuristic search phases. An account is presently given of Trek's application to high-level route planning for a military Autonomous Helicopter System in which potential threats that are to be avoided by evasive maneuvering are modeled in terms of threat-exposure time. The model assumes that direct or indirect masking is the only way to escape detection by a given radar, so that evasive maneuvering within that radar's envelope has no positive effect. O.C.

A89-12449
AIR NAVIGATION SYSTEMS. I - ASTRONOMICAL NAVIGATION IN THE AIR 1919-1969
J. E. D. WILLIAMS Journal of Navigation (ISSN 0373-4633), vol. 41, Sept. 1988, p. 375-406. refs

The history of astronomical navigation in the air is discussed from the first transatlantic flight in 1919 to 1969 when the development of other systems made astronomical fixing obsolescent. Methods of sight reduction are emphasized. The astronomical position line and the intercept method, methods for solving the PZX triangle, inspection methods, the use of slide rules and almanacs, astrographic methods, and celestial analogs are discussed. R.B.

N89-10038# Federal Aviation Administration, Washington, D.C. Advanced System Design Service.
TERMINAL CONTROL AREA DESIGN AND AIR TRAFFIC LOADINGS Final Report
THOMAS H. HIGGINS Aug. 1988 34 p
(DOT/FAA/DS-88/11) Avail: NTIS HC A03/MF A01

The response probability density function (pdf) technique adapted here uses the pdf's of the variables governing both the air traffic loadings of stress and the terminal airspace design configurations sensitivty or strengths. This technique is proposed as a method which may be used to predict the relative level of safety and collision risk for TCA design configurations and air traffic loadings. For the first time, a strong relationship was found between near midair collision reports and midair collisions for annual operations within the fifty states. Operations, airports, and airspace area were found to relate to these criteria of safety and provide useful interactive predictor equations. Author

N89-10885# Arinc Research Corp., Annapolis, Md.
IN-SERVICE EVALUATION OF THE TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) INDUSTRY PROTOTYPE
DANIEL H. TILLOTSON, LOREN D. BOLSTRIDGE, and GARY P. GAMBARANI May 1988 306 p
(Contract DTFA01-80-C-10093)
(DOT/FAA/SA-88/2; REPT-3011-01-03-4675) Avail: NTIS HC A14/MF A01

An operational evaluation of the Traffic Alert and Collision Avoidance System (TCAS 2) Industry Prototype was conducted to assess the utility of the TCAS to flight crews, to assess the impacts of TCAS on flight crew workload, to assess the impacts of TCAS on the air traffic control (ATC) system, and to obtain flight crew comments on TCAS design parameters and cockpit displays. The evaluation was conducted on one Boeing 727 aircraft operating in airline revenue service with Piedmont Airlines. Quantitative data on TCAS performance were collected to characterize the location and frequency of TCAS advisories. Quantitative data were collected from flight crews and cockpit observers to assess the utility of TCAS and to assess the impacts of TCAS on ATC and the flight crews. Minor operational anomalies were identified and changes to operational procedures or TCAS logic were recommended. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A89-10101*# Air Force Academy, Colo.
FLIGHT-TEST DETERMINATION OF AIRCRAFT CRUISE CHARACTERISTICS USING ACCELERATION AND DECELERATION TECHNIQUES
T. R. YECHOUT (U.S. Air Force Academy, Colorado Springs, CO) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 577-582.
(Contract NSG-4028)

A flight-test technique has been developed under NASA Dryden sponsorship NSG 4028 to predict aircraft cruise performance characteristics. The technique used acceleration and deceleration maneuvers to define baseline aerodynamic and propulsion system characteristics, which were then input to a performance modeling prediction program. Conventional stabilized 'speed power' tests, which are normally used for cruise performance definition, can comprise a large portion of the flight time in a program. A significant reduction in flight time was estimated using the performance modeling approach with associated savings in cost and schedule. A 20-h verification flight-test program was accomplished. Author

A89-10107#
OPTIMIZATION OF THE CONCEPTUAL DESIGN AND MISSION PROFILES OF SHORT-HAUL AIRCRAFT
DIMITRI SIMOS and LLOYD R. JENKINSON (Loughborough University of Technology, England) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 618-624. Previously cited in issue 05, p. 591, Accession no. A87-17933. refs

A89-10109*# PRC Kentron, Inc., Hampton, Va.
MULTILEVEL DECOMPOSITION APPROACH TO THE PRELIMINARY SIZING OF A TRANSPORT AIRCRAFT WING
GREGORY A. WRENN and AUGUSTINE R. DOVI (PRC Kentron, Inc., Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1, p. 856-866) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 632-638. Previously cited in issue 14, p. 2105, Accession no. A87-33651. refs
(Contract NAS1-16794)

A89-10111#
CORRELATION AND ANALYSIS FOR SH-2F 101 ROTOR
FU-SHANG WEI and ROBERT JONES (Kaman Aerospace Corp., Bloomfield, CT) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B, p. 743-752) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 647-652. Previously cited in issue 14, p. 2106, Accession no. A87-33726. refs

A89-10113#
SIMULATION OF A BIRDSTRIKE IMPACT ON AIRCRAFT CANOPY MATERIAL
T. V. BAUGHN (Southern Methodist University, Dallas, TX) and L. W. GRAHAM (General Dynamics Corp., Fort Worth, TX) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 659-664. refs

The simulation of a birdstrike on a material used in aircraft canopies is performed using the ABAQUS finite-element code. The results of the simulation are compared to the response of a test coupon struck by a rubber ball with properties that provide a load on the coupon comparable to a bird. The displacement-time history of the test coupon is recorded using a high-speed camera. The results of the impact test are compared to the finite-element results. One of the major tasks in developing the simulation was obtaining a load history to apply to the model. The impact load associated with a birdstrike is hydrodynamic, time dependent, and decreases exponentially from the centerline of the impact region. The velocity of impact indicates that material properties at high-strain rates would be required for the simulation. Published material properties at lower strain rates provided adequate information to demonstrate good correlation for the loads examined. Good correlation was achieved in comparing the centerline deflection time histories recorded in the impact test and obtained from the finite-element simulation. Author

A89-10463
AERODYNAMIC CHARACTERISTICS OF THE ACES-II EJECTION SEAT AT TRANSONIC MACH NUMBERS
DAVID E. A. REICHENAU (Calspan Corp., Arnold AFB, TN) and B. J. WHITE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: SAFE Association, Annual Symposium, 25th, Las Vegas, NV, Nov. 16-19, 1987, Proceedings. Newhall, CA, SAFE Association, 1987, p. 113-120.

An investigation was carried out in a 16-ft transonic wind tunnel to determine the full-scale aerodynamic characteristics of the Advanced Concept Ejection Seat (ACES-II). It is noted that the ACES design is the standard ejection seat used in the USAF F-15, F-16, A-10, B-1B, and T-46 aircraft. Particular attention is given to the effects of Mach Number, dynamic pressure, crew member size, clothing/flight gear, and seat configuration. The aerodynamic characteristics of the ACES II configuration are in good agreement with other typical ejection seat configurations.

Adding clothing and flight gear to the manikins had little effect on the model's static stability or performance characteristics. K.K.

A89-10466
MULTI-AXIS SEAT EJECTION (MASE) SLED
HOWARD G. CLARK (USAF, Test Track Div., Holloman AFB, NM) IN: SAFE Association, Annual Symposium, 25th, Las Vegas, NV, Nov. 16-19, 1987, Proceedings. Newhall, CA, SAFE Association, 1987, p. 136-140. refs

The MASE sled allows ejection over a range of fixed pitch, roll, and yaw angles and dynamic rolling conditions. This sled has a pitch range of + or - 30 deg, a yaw range of + or -20 deg, and a roll range of + or - 90 deg, in addition to the ability to roll at high rates during the seat ejection. Consideration is given to the sled fabrication status and the test program planned for FY88. It is noted that the MASE sled will be used as the test bed for the CREST advanced seat development program in conjunction with the advanced dynamic anthropomorphic manikin which will measure seat-man dynamic interactions. K.K.

A89-10478
PASSIVE THERMAL PROTECTION SYSTEM
KEVIN T. BETZ (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: SAFE Association, Annual Symposium, 25th, Las Vegas, NV, Nov. 16-19, 1987, Proceedings. Newhall, CA, SAFE Association, 1987, p. 220-223. refs

The passive thermal protection system (PTPS), which provides cockpit thermal protection from a nuclear firefall, consists of laminated flat glass panels with integral perimeter frames mounted inboard of the aircraft transparencies. The objective of a joint B-1B System Program Office/Defense Nuclear Agency effort was to develop and qualify PTPS for possible retrofit to the B-1B bomber. It was found that the thermal performance of PTPS required refinement to eliminate increased transmissivity with increases in temperature above 120 F. It is noted that a redesigned PLZT helmet-mounted goggle is required to fully realize the advantages of PTPS. K.K.

A89-10482
AN INVESTIGATION OF THE PRESSURE IN AN EJECTION SEAT BAY DUE TO ROCKET JET
PING QIU (China Flight Test Research Center, Xian, People's Republic of China) IN: SAFE Association, Annual Symposium, 25th, Las Vegas, NV, Nov. 16-19, 1987, Proceedings. Newhall, CA, SAFE Association, 1987, p. 249-254.

The distribution of pressure in an ejection seat bay due to rocket jet obtained by simulation test is briefly described in this paper. And also the regions likely to experience high pressure and level of high pressure to be expected are given, with the variation of pressure inside seat bay under different seat position and other test conditions. These provide the basis for analyzing and assessing the effect of rocket jet on seat bay structure. Author

A89-10516
APPLICATION OF WINGLETS WITH INTEGRATED, ADJUSTED TRAILING-EDGE FLAPS IN A GENERAL AVIATION AIRCRAFT [ANWENDUNG VON WINGLETS MIT INTEGRIERTER, GEREGELTER HINTERKANTENKLAPPE AN EINEM FLUGZEUG DER GENERAL AVIATION]
A. DIEKMANN (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 235-244. In German.
(DGLR PAPER 87-080)

The use of winglets with adjusted trailing-edge flaps is proposed as a remedy for the flight-mechanical problems caused by rigid winglets. The design and functioning of the flaps and of a simple, linear control is discussed. The concept is illustrated using a general aviation aircraft. C.D.

A89-10517
CONFIGURATION OPTIMIZATION OF COMMERCIAL AIRCRAFT [KONFIGURATIONSOPTIMIERUNG VON VERKEHRSFLUGZEUGEN]
CH. HABERLAND, W. FENSKE, and M. GRABERT (Berlin, Technische Universitaet, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 245-253. In German. refs
(DGLR PAPER 87-081)

The Computer-Augmented Preliminary Design of Aircraft (CAPDA) system for aircraft configuration development and optimization in the design phase is presented. The basic division into a model-oriented program structure with modular analytical method part and a separate monitor is described, and the principle of dynamic variant programming for full computer-based imaging of the geometry and performance using fewer configuration parameters is explained. A preprocessor is used to obtain the empirical-statistical determination of the complete geometries preliminary to design. The use of efficient convergence acceleration methods for the design consolidation is described, and the aims, methods, and limits of the configuration optimization are shown using examples. The broad application possibilities offered by the graphic postprocessors implemented in this system are demonstrated. C.D.

A89-10518
FS 32 - A SPLIT-FOWLER GLIDER PROBLEM PRESENTATION AND SOLUTIONS [FS 32 - EIN SPALT-FOWLER-SEGELFLUGZEUG PROBLEMSTELLUNGEN UND LOESUNGEN]
JOACHIM FLEINER IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 254-263. In German.
(DGLR PAPER 87-082)

The fs 32 project to develop a glider with novel, variable-geometry wings is examined. The relevant technical data and the potential for achieving a significant increase in performance with fs 32 are discussed, and the related constructional and technological problems are addressed. The choice of materials and design of the various glider components are discussed in detail. C.D.

A89-10520
DEVELOPMENT OF A HELICOPTER SIMULATION PROGRAM [ENTWICKLUNG EINES HUBSCHRAUBERSIMULATIONSPROGRAMMES]
UWE ARNOLD (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 275-286. In German. refs
(DGLR PAPER 87-123)

The theoretical bases and structure of a Fortran program for simmulating the rigid body motion of helicopters are presented. The rotor calculation is quasi-stationarily bound to the numerical integration of the differential equations of motion. The steering is governed by a regulator which simulates pilot behavior or a corresponding practical stabilization system. The initial flight state provides a trimming calculation. The discussion is illustrated by examples involving maneuvers. C.D.

A89-10526
SHEAR WIND MEASUREMENTS ABOARD A PIPER PA 18 AND THE DESIGN OF A MODEL GLIDER AIRCRAFT FOR DYNAMIC GLIDING FLIGHT [SCHERWINDMESSUNGEN AN BORD EINER PIPER PA 18 UND AUSLEGUNG EINES MODELLSEGELFLUGZEUGES FUER DEN DYNAMISCHEN SEGELFLUG]
O. GOEBEL (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany,

Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 322-328. In German. refs
(DGLR PAPER 87-135/1)

An aircraft on-board method for measuring shear wind gradients is presented. The physical principles of the method are explained, and the installation of the requisite equipment on a Piper PA 18 is described. Comparisons with other measurements are reported. The optimization of the measurements using a simulative computer program is discussed. C.D.

A89-10527
COMPUTER PROGRAM FOR SIMULATING DYNAMIC GLIDING FLIGHT [EIN RECHNERPROGRAMM ZUR SIMULATION DES DYNAMISCHEN SEGELFLUGS]
THORSTEN NOTTEBAUM (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 329-338. In German. refs
(DGLR PAPER 87-135/2)

A simple computer program for simulating flight maneuvers with any gliding aircraft under measured shear wind conditions is described. The program can be used to evaluate the possibility of conducting dynamic gliding flight with modern glider aircraft. The simulated flight maneuvers are described and the equations of motion are presented. The determination of the resistance force is addressed. The shear wind field and specific total energy are discussed briefly. The program is described and its flight testing is reported. The determination of the minimal requisite wind shear for three glider aircraft is given, and a sample calculation is described. C.D.

A89-10632
THE BOEING 7J7 - THE EVOLUTION OF TECHNOLOGY AND DESIGN
PETER L. SUTCLIFFE (Boeing Commercial Airplane Co., Seattle, WA) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 73-84.
(SAE PAPER 872405)

The paper describes some of the technologies that are being considered for the 7J7 and shows how those that benefit the ultimate bottom line of operating costs are being incorporated. Some of the developments considered are lightweight structural components constructed of advanced composites and aluminum-lithium alloys; advanced aerodynamics allowing thicker, lower sweep, higher aspect ratio wings; flat-panel flight deck displays to reduce weight, cost, and power requirements; fly-by-wire controls; and dramatic improvements in propulsive efficiency from new engine designs such as the advanced propfan. B.J.

A89-10639
EVOLUTION OF THE STOL AND MANEUVER TECHNOLOGY DEMONSTRATOR
J. A. LAUGHREY (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 167-180. refs
(SAE PAPER 872417)

The STOL and Maneuver Technology Demonstrator Program is designing and developing, through tests, simulations and analyses, a new aircraft and propulsion control system that not only better utilizes aerodynamic controls, but also incorporates the propulsive forces of vectoring and reversing, plus braking and steering on landing roll out. The new concepts being developed, which include an integrated flight and nozzle control with a two-dimensional nozzle, will be validated through a series of flights exploring takeoff and landing techniques along with cruise and maneuvering flight. Results of this program are being used to transition these concepts into future fighter systems. Author

A89-10640*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, Calif.
X-29A FORWARD-SWEPT-WING FLIGHT RESEARCH PROGRAM STATUS
GARY A. TRIPPENSEE and DAVID P. LUX (NASA, Flight Research Center, Edwards, CA) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 181-188. Previously announced in STAR as N88-17644.
(SAE PAPER 872418)

The X-29A aircraft is a fascinating combination of integrated technologies incorporated into a unique research aircraft. The X-29A program is a multiple agency program with management and other responsibilities divided among NASA, DARPA, the U.S. Air Force, and the Grumman Corporation. An overview of the recently completed X-29A flight research program, objectives achieved, and a discussion of its future is presented. Also discussed are the flight test approach expanding the envelope, typical flight maneuvers performed, X-29A program accomplishments, lessons learned for the Number One aircraft, and future plans with the Number Two aircraft. A schedule for both aircraft is presented. A description of the unique technologies incorporated into the X-29A aircraft is given, along with descriptions of the onboard instrumentation system. The X-29A aircraft research program has proven highly successful. Using high fly rates from a very reliable experimental aircraft, the program has consistently met or exceeded its design and research goals. Author

A89-10641
MISSION-ADAPTIVE WING
RONALD W. DECAMP, RICHARD HARDY, and DOUGLAS K. GOULD (Boeing Commercial Airplane Co., Seattle, WA) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 189-195.
(SAE PAPER 872419)

The Mission-Adaptive Wing (MAW) employs composite materials and uses a digital fly-by-wire flight control system to change wing contour to maintain peak aerodynamic efficiency over a large flight envelope. Future aircraft will require large subsonic and supersonic lift-to-drag ratios for maximum cruise ranges at high and low altitudes. At the same time, they will require the ability to pull high lift coefficients for maneuvers. The Mission-Adaptive Wing provides these features by deflecting flexible wing surfaces to achieve the wing camber and smooth continuous upper surface contour required for peak aerodynamic performance. The MAW program completed manual control flight testing in November 1986 and started automatic control flight testing in the summer of 1987. During the manual phase of flight testing, surfaces were set in discrete positions. Resulting data confirmed the aerodynamic potential to achieve all program goals. The automatic control phases will test four modes designed to increase range, maneuverability, and operational flexibility without affecting pilot workload. Author

A89-10653
INTRODUCTION OF THE HORNET - A SUCCESS STORY
H. E. COVERT (McDonnell Douglas-Australia, Ltd., Australia), E. H. BORGMEYER, J. M. MARTIN, J. S. MORRISON, and J. M. FLYNN (McDonnell Aircraft Co., Saint Louis, MO) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 319-323.
(SAE PAPER 872436)

The F/A-18 Hornet is the U.S. Navy's newest combat aircraft. It is also in service with the U.S. Marine Corps, the Canadian Armed Forces, the Royal Australian Air Force and the Spanish Navy. All of these different users have been very successful in integrating the Hornet into their operations with a minimum of effort and disruption. This is due to the Hornet's design, in which a strong emphasis was placed on reliability and maintainability. The result is a weapon system which is easily learned by the

personnel who must operate it. Other benefits include a high readiness rate and a much reduced requirement for support personnel and equipment. Author

A89-10663
A STUDY ON EFFECTS OF AIRCRAFT NOISE ENVIRONMENT ON ITS STRUCTURE
FU SHIJIAN (Nanchang Aircraft Manufacturing Co., Jiangxi, People's Republic of China) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings (A89-10627 01-01). Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 431-436. Translation. Previously cited in issue 08, p. 1144, Accession no. A88-23189. (SAE PAPER 872450)

A89-11447
FATIGUE CRACK GROWTH IN AIRCRAFT MAIN LANDING GEAR WHEELS
ARVIND NAGAR (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Fracture mechanics; Proceedings of the Nineteenth National Symposium, San Antonio, TX, June 30-July 2, 1986. Philadelphia, PA, American Society for Testing and Materials, 1988, p. 868-882. refs

The fracture behavior of aircraft landing gear wheels of 2014-T6 aluminum is analyzed under service-simulated conditions using a variety of fatigue crack growth characterization techniques. Stress intensity factor solutions and material data are applied to perform crack growth predictions using a crack growth program, CRKGRO. With new stress intensity factor subroutines added to the program library, the analytic predictions of crack growth show good agreement with the measured crack lengths in a full-scale structural test on a cracked wheel. A damage characteristic curve for the wheel flange is proposed. V.L.

A89-11486
APPLICATION OF AN ADVANCED PANEL METHOD TO AERODYNAMIC PROBLEMS OF AIRCRAFT DESIGN
JOHN L. HESS and WALTER O. VALAREZO (Douglas Aircraft Co., Long Beach, CA) IN: Panel methods in fluid mechanics with emphasis on aerodynamics; Proceedings of the Third GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 16-18, 1987. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 79-90. refs

A surface-source panel method for computing general geometries and complicated flow situations in aerodynamics is described. The present higher-order formulation includes an improved iterative solver and a propeller capability that predicts not only blade performance but also the mutual interference between a propeller and the airframe on which it is mounted. An interactive boundary-layer method is also considered. Results are presented for various propeller flowfields. R.R.

A89-11491
A SUBSONIC PANEL METHOD FOR DESIGN OF 3-DIMENSIONAL COMPLEX CONFIGURATIONS WITH SPECIFIED PRESSURE DISTRIBUTION
KRZYSZTOF KUBRYNSKI (Instytut Lotnictwa, Warsaw, Poland) IN: Panel methods in fluid mechanics with emphasis on aerodynamics; Proceedings of the Third GAMM-Seminar, Kiel, Federal Republic of Germany, Jan. 16-18, 1987. Brunswick, Federal Republic of Germany, Friedr. Vieweg und Sohn, 1988, p. 137-146. refs

A cheap, iterative method for aerodynamic design of complex 3-dimensional configurations (such as wing-body combination) with prescribed surface pressure distribution is presented. The method is based on the panel method with numerical optimization. In each iteration cycle the geometry modifications are modelled by surface transpiration. Some examples of application of this method for wing-body combinations are presented. Author

A89-11559
MIG-29 DESIGN MERGES OLD, NEW TECHNOLOGIES
JEFFREY M. LENOROVITZ Aviation Week and Space Technology (ISSN 0005-2175), vol. 129, Sept. 26, 1988, p. 40, 41, 43 (3 ff.).

The Soviet Union's Mikoyan MiG-29, a rugged combat aircraft designed primarily for offensive air-to-air missions, is described. The single-seat aircraft has a glass-fiber-wrap nose radome which houses a coherent pulse-Doppler radar; this radar can supposedly detect a fighter-sized target out to a range of 100 km. Soviet-supplied data indicate that the aircraft has a maximum Mach number above Mach 2.3, and a service ceiling of 17,000 m. K.K.

A89-12416#
'THE POINTER', A NEW CONCEPT FOR RPV AIR VEHICLES
RODNEY TAYLOR (Bell Helicopter Textron, Fort Worth, TX) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 11 p.

The tilt-rotor VTOL concept thus far demonstrated by the XV-15 and V-22 aircraft is being used by a small RPV of about 600 lb gross weight, designated 'Pointer'. Pointer employs a single, fuselage-mounted engine whose power is taken by gearbox and two driveshafts to the tiltable wingtip nacelles. The VTOL capability of this propulsion system obviates all launch and recovery equipment without forfeiture of high forward speeds during critical mission segments; in particular, shipboard operations can be readily conducted from small deck areas. O.C.

A89-12558#
METHOD TO OPTIMIZE NACELLE SHAPE IN A SUPERSONIC CRUISE AIRCRAFT
REINER SUIKAT and SAEED FAROKHI (Kansas, University, Lawrence) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 717-723. Previously cited in issue 03, p. 286, Accession no. A88-14254. refs

A89-12562*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFICIENT VIBRATION MODE ANALYSIS OF AIRCRAFT WITH MULTIPLE EXTERNAL STORE CONFIGURATIONS
M. KARPEL (NASA, Langley Research Center, Hampton, VA; Israel Aircraft Industries, Ltd., Lod) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 747-751. refs

A coupling method for efficient vibration mode analysis of aircraft with multiple external store configurations is presented. A set of low-frequency vibration modes, including rigid-body modes, represent the aircraft. Each external store is represented by its vibration modes with clamped boundary conditions, and by its rigid-body inertial properties. The aircraft modes are obtained from a finite-element model loaded by dummy rigid external stores with fictitious masses. The coupling procedure unloads the dummy stores and loads the actual stores instead. The analytical development is presented, the effects of the fictitious mass magnitudes are discussed, and a numerical example is given for a combat aircraft with external wing stores. Comparison with vibration modes obtained by a direct (full-size) eigensolution shows very accurate coupling results. Once the aircraft and stores data bases are constructed, the computer time for analyzing any external store configuration is two to three orders of magnitude less than that of a direct solution. Author

A89-12564#
PREDICTION OF AIRCRAFT-PROPELLER-INDUCED, STRUCTURE-BORNE INTERIOR NOISE
JAMES F. UNRUH (Southwest Research Institute, San Antonio, TX) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 758-764. Research supported by Southwest Research Institute. Previously cited in issue 07, p. 946, Accession no. A88-22196. refs

A89-12565#
SEAPLANE TAKEOFF PERFORMANCE - USING DELTA RATIO AS A METHOD OF CORRELATION
DALE DE REMER (North Dakota, University, Grand Forks) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 765, 766.

The 'delta ratio', defined as a seaplane's takeoff water-run distance/total distance over a 50-ft obstacle, allows a pilot to determine whether a given takeoff can be made irrespective of lake size, density altitude, engine and propeller condition, or aircraft weight. Attention is presently given to the effect of aircraft weight and takeoff technique variations on the assumption of constant delta ratio. A flap-change technique is identified as effective in reducing a heavily loaded seaplane's distance over an obstacle. O.C.

A89-12719
DESIGN AND TESTING FOR AIRFRAMES
J. C. GEERING (British Aerospace, PLC, London, England) IN: Bird hazards in aviation; Proceedings of the Symposium, London, England, Oct. 14, 1987. London, Royal Aeronautical Society, 1987, p. 24-27.

An account is given of the criteria that must be satisfied in civil transport aircraft design to reduce vulnerability to birdstrike damage, in a manner consistent with weight and cost penalty minimization. Attention is given to the compromises among strength, function, weight, and cost, that must be achieved in the design of nose radomes, cockpit transparencies, wing leading edges, engine installations, and empennages. Aircraft bird impact tests must be conducted on full-size aircraft components, in order to correctly distribute total impact energy. A compressed air gun propels the birdstrike missile at the test specimen, which is usually the fresh carcass of a chicken. O.C.

A89-12720
WINDSCREEN DESIGN AND TESTING
E. S. HINKLEY (Triplex Aircraft and Special Products, Ltd., Birmingham, England) IN: Bird hazards in aviation; Proceedings of the Symposium, London, England, Oct. 14, 1987. London, Royal Aeronautical Society, 1987, p. 28-48.

The paper reviews the problem of bird strikes on windscreens predominantly from the civil aerospace applications, and gives details of the various designs of windscreens used to combat this specific threat and the materials that are used. The materials include glass strengthened to various levels, as cast and stretched acrylic, polyvinyl butyral and polyurethane interlayers and polycarbonates. The types of design that have emerged over approximately 30 years are reviewed, ranging from earlier designs relying upon the PVB interlayer to the more complex results of recent developments using composite plastic/glass constructions, for instance the EH101 windscreen and Boeing 7J7. Author

N89-10040# Materials Research Labs., Melbourne (Australia).
CONTAMINATION OF ENVIRONMENTAL CONTROL SYSTEMS IN HERCULES AIRCRAFT
A. G. KELSO, J. M. CHARLESWORTH, and G. G. MCVEA Apr. 1988 27 p
(MRL-R-1116; AR-005-230) Avail: NTIS HC A03/MF A01

The assistance of MRL was requested by RAAF in determining the origins of contamination of trrboprop bleed air used for environmental control in Hercules C-130 transport aircraft. Air sampling in the interior of affected planes was performed in-flight and on the ground, together with laboratory sampling of vapor from all suspect contaminating fluids. Gas chromatographic (GC) and GC/mass spectrometric (MS) analysis of collected samples confirmed that aviation turbine fuel leakage produces a continuous background of hydrocarbon vapor around 0.1 to 0.5 ppm in affected aircraft. Positive indications of turbine oil vapors were found in filter bags taken from the air-duct system of suspect aircraft. Some traces of organophosphorus compounds, particularly the tricresyl phosphate additive in the oil, were found in the air filter bags. However, at present there is no evidence to support a hypothesis that neurotoxic bicyclophosphorous compounds derived from the oil additive are present. It is strongly recommended that in addition to normal maintenance of turbine oil seals and fuel nozzles, the use of charcoal cloth filters in the air ducting system be investigated as a means of absorbing the noxious odors. Author

N89-10041# Lockheed Aeronautical Systems Co., Burbank, Calif.
WHEEL PERFORMANCE EVALUATION. PHASE 1: ANALYSIS Final Report
P. C. DURUP, T. R. BRUSSAT, and L. BAKOW Sep. 1988 107 p
(DOT/FAA/CT-88/16) Avail: NTIS HC A06/MF A01

The procedures of analysis and dynamometer testing that may be used to develop data and supporting technology for improving aircraft wheel performance are described. As related to current wheel standards and in-service inspection procedures, load/test spectra which characterize wheel operating environments (associated with long, medium, and short haul aircraft) are defined. These spectra may be applied as a basis for effective dynamometer testing and to the verification of wheel service limits taking into account stress corrosion and crack growth conditions. Author

N89-10042# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
DESIGN AND EVALUATION OF DYNAMIC FLIGHT TEST MANOEUVERES
J. A. MULDER Oct. 1986 305 p
(PB88-210760; LR-497) Avail: NTIS HC A14/MF A01 CSCL 01C

Analysis of dynamic flight test data, in the sense of estimating stability and control derivaties from measurements of the dynamic response of the aircraft to control input signals, can be formulated in the theoretical frame work of maximum likelihood estimation theory. It is shown that, if certain conditions concerning accuracy and type of the variables measured in flight are met, the original maximum likelihood estimation problem can be decomposed into two separate estimation problems which are much easier to solve than the original estimation problem. A new technique for the calculation of optimal input signals was developed. The technique is based on the description of input singals by linear combinations of elements of finite sets of orthonormal functions. A flight test program was carried out with a DeHaviland DHC-2 Beaver experimental aircraft, equiped with an automatic control system. The system allowed precise implementation in real time of quite arbitrary elevator, aileron and rudder control input signals. Also a high accuracy flight test measurement system was installed in the aircraft. Author

N89-10887 California Univ., Los Angeles.
AEROELASTICITY AND STRUCTURAL OPTIMIZATION OF HELICOPTER ROTOR BLADES WITH SWEPT TIPS Ph.D. Thesis
ROBERTO CELI 1987 507 p
Avail: Univ. Microfilms Order No. DA8800601

Structural optimization techniques are used to minimize the oscillatory vertical hub shears for a helicopter in forward flight, subject to aeroelastic stability constraints, blade natural frequency placement constraints, and autorotation constraints. A special technique is used to build a sequence of approximate, inexpensive to solve approximate optimization problems, the solutions of which converge to the solution of the exact, expensive to solve optimization problem. Blade configurations with both straight and swept tips, and single- and double-cell cross sections are analyzed. The results show that the approach used is very efficient, and produces improved designs with a very small number of blade aeroelastic analyses. A special finite element for the modeling of a swept tip rotor blade is derived. A methodology for the formulation of the aeroelastic stability and response for helicopter rotor blades is proposed, which reduces considerably the implementation effort, and is applicable to both straight and swept tip blades. The methodology is combined with a finite element model of the blade, and a quasilinear solution technique. As a preliminary to the analysis of swept tip blades, a study was conducted of the aeroelastic behavior of rotor blades with noncoincident elastic axis, aerodynamic centers, and centers of mass. Dissert. Abstr.

N89-10889 Southampton Univ. (England).
THE USE OF THE COMPLEX SUMMATION METHOD FOR FORMULATING ALGORITHMS FOR DECOUPLING VERTICAL/HORIZONTAL MOTIONS OF ROLLING AIRCRAFT
Ph.D. Thesis
E. M. BELO 1987 249 p
Avail: Univ. Microfilms Order No. BRD-80844

Algorithms produced for rolling Aircraft Flight Control Systems to decouple vertical from horizontal motions are assessed. The aim is to study the use of the Complex Summation Method as a technique to assist the designer in the selection of algorithms choosen to achieve this objective. The benefit of this method for decoupling objective is that the presence of coupling is easily seen by the existence of imaginery coefficients in the complex system equations. A numerical example is presented and results in terms of time responses are obtained from the application of an algorithms which transforms it into a Similar and Antisymmetrically Coupled (SAC) system with outputs being the acceleration decoupled in Inertial Axes. Dissert. Abstr.

N89-10890*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
FLIGHT TEST RESULTS FOR THE DAEDALUS AND LIGHT EAGLE HUMAN POWERED AIRCRAFT
R. BRYAN SULLIVAN and SIEGFRIED H. ZERWECKH 7 Jun. 1988 138 p
(Contract NAG1-836)
(NASA-CR-183305; NAS 1.26:183305) Avail: NTIS HC A07/MF A01 CSCL 01C

The results of the flight test program of the Daedalus and Light Eagle human powered aircraft in the winter of 1987/88 are given. The results from experiments exploring the Light Eagle's rigid body and structural dynamics are presented. The interactions of these dynamics with the autopilot design are investigated. Estimates of the power required to fly the Daedalus aircraft are detailed. The system of sensors, signal conditioning boards, and data acquisition equipment used to record the flight data is also described. In order to investigate the dynamics of the aircraft, flight test maneuvers were developed to yield maximum data quality from the point of view of estimating lateral and longitudinal stability derivatives. From this data, structural flexibility and unsteady aerodynamics have been modeled in an ad hoc manner and are used to augment the equations of motion with flexibility effects. Results of maneuvers that were flown are compared with the predictions from the flexibility model. To extend the ad hoc flexibility model, a fully flexible aeroelastic model has been developed. The model is unusual in the approximate equality of many structural natural frequencies and the importance of unsteady aerodynamic effects. the Gossamer Albatross. It is hypothesized that this inverse ground effect is caused by turbulence in the Earth's boundary layer. The diameters of the largest boundary layer eddies (which represent most of the turbulent kinetic energy) are proportional to altitude; thus, closer to the ground, the energy in the boundary layer becomes concentrated in eddies of smaller and smaller diameter. Eventually the eddies become sufficiently small (approximately 0.5 cm) that they trip the laminar boundary layer on the wing. As a result, a greater percentage of the wing area is covered with turbulent flow. Consequently the aircraft's drag and the pow er required both increase as the aircraft flies closer to the ground. The results of the flight test program are examined critically, especially with respect to future applications. Maneuvers that allow the observation of stability derivatives for flexible aircraft are detailed. Considerations for the design of autopilots for future human power aircraft and high-altitude RPV's are discussed. Techniques useful in estimating the power required to fly aircraft of very high lift to drag ratio are described.

N89-10891# Department of Defence, Canberra (Australia). Central Studies Branch.
SOME STATISTICAL ASPECTS OF ATTRITION STUDIES
B. K. MCMILLAN May 1988 27 p
(AD-A196665; CSB-MEMO-3; DODA-AR-005-257) Avail: NTIS HC A03/MF A01 CSCL 12C

A methodology for analysing aircraft attrition data and establishing the reliability of the results is given. Underlying assumptions include exponentially distributed times between attritions, and a mean that increases with operating experience. Principal techniques used are Maximum Likelihood Estimation and Jackknifing. An example is given drawn from F/A-18 data. GRA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A89-10128#
COST-EFFECTIVE STRAPDOWN I.N.S. DESIGN AND THE NEED FOR STANDARD FLIGHT PROFILES
N. F. WATSON and E. A. F. CAMPBELL (Ferranti Defence Systems, Ltd., Edinburgh, Scotland) IN: Symposium Gyro Technology 1987; Proceedings of the Symposium, Stuttgart, Federal Republic of Germany, Sept. 22, 23, 1987. Stuttgart/Duesseldorf, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1987, p. 14.0-14.49. refs

A method is proposed for minimizing INS costs for a given performance level. A mathematical error model is first developed which can be used to predict the statistical properties of INS position and velocity errors for a given flight profile from the variance of each significant error source. The model can then be used to derive a set of limits for the variance of each parameter which are consistent with the performance requirements of the specification. Such an 'error budget' can be used to predict the statistical performance of the strapdown INS for any given flight profile. The introduction of a standard set of flight profiles will make it possible to establish an error budget which meets the specified performance requirements for specified flight profiles without imposing unrealistic requirements on the components of the system. Cost-effective design is achieved partly by deriving component specifications which are just sufficient to enable the INS to perform adequately (taking into account worst case conditions). V.L.

A89-10129#
INTEGRATED REDUNDANT REFERENCE SYSTEMS FOR FLIGHT CONTROL AND NAVIGATION WITH SKEWED SENSOR ARRANGEMENT
U. KROGMANN (Bodenseewerk Geraetetechnik GmbH, Ueberlingen, Federal Republic of Germany) IN: Symposium Gyro Technology 1987; Proceedings of the Symposium, Stuttgart, Federal Republic of Germany, Sept. 22, 23, 1987. Stuttgart/Duesseldorf, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1987, p. 15.0-15.20.

The concept of an integrated redundant reference system for flight control and navigation is examined, and a prototype of such a system is briefly described. In the system proposed here, the required performance and flight safety are obtained in the sense of a synergistic complement of flight control/stabilization and navigation by utilizing a minimum number of redundant sensors with sufficient reliability and accuracy and by means of an effective redundance management technique for failure detection and identification. Skewed sensor orientations are employed in order to minimize the number of sensors. The sensor layout and the signal processing structure of the prototype system are shown. V.L.

A89-10131#
STATE OF THE ART INERTIAL NAVIGATION - FLIGHT TESTING OF THE HONEYWELL LINS STANDARD NAVIGATOR H-423
D. W. WAGNER (Honeywell Regelsysteme GmbH, Maintal, Federal Republic of Germany) IN: Symposium Gyro Technology 1987; Proceedings of the Symposium, Stuttgart, Federal Republic of

Germany, Sept. 22, 23, 1987. Stuttgart/Duesseldorf, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1987, p. 17.0-17.26.

The hardware and software of the Honeywell Laser Inertial Navigation System (LINS) H-423 are described, and results of the flight testing of the H-423 system conducted on a TORNADO aircraft are reported. An evaluation of the flight test data shows the accuracy of the LINS to be better than 0.3 nm/h, as compared to the specified value of 0.8 mn/h. Horizontal velocity errors, which are critical to weapon delivery functions, are less than 2.2 ft/s rms compared to the specified 2.5 ft/s limit. The results have been achieved with alignment times of 6 min versus the specified time of 8 min. V.L.

A89-10364
APPLICATIONS OF TIME AND WAVELENGTH DIVISION MULTIPLEXING TO DIGITAL OPTICAL CODE PLATES
D. VARSHNEYA (Teledyne Ryan Electronics, San Diego, CA) and W. L. GLOMB, JR. (United Technologies Research Center, East Hartford, CT) IN: Fiber optic and laser sensors V; Proceedings of the Meeting, San Diego, CA, Aug. 17-19, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 210-213. refs

The application of pulse time division multiplexing and wavelength division multiplexing to reflective digital optical code plates for sensing position on aircraft is discussed, with particular attention given to temperature drifts and component tolerances in the optical power budgets. Both approaches are found to be constrained by environmental effects and small power budgets. In addition, the performance of the reflective WDM system is strongly dependent on the number of connectors used in the interconnect fiber. It is emphasized that the development of either of these sensor concepts requires careful design and evaluation to resolve these problems. V.L.

A89-10521
NAVIGATION OF AIRCRAFT WITH RIGID IMAGE-FORMING SENSORS [NAVIGATION VON FLUGGERAETEN MIT STARREN ABBILDENDEN SENSOREN]
K.-H. KEIL, U. MACKENROTH, R. SCHMIDT, and H. ZINNER (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 287-293. In German. BMVg-supported research. refs
(DGLR PAPER 87-130)

A system is described which permits an aircraft to be navigated based only on information fed by an image-forming sensor built rigidly into the aircraft. The necessary flight parameters are derived by evaluating the spatial and temporal intensity variations in the image plane, and image processing is accomplished using model assumptions and a Kalman filter. Simulations are used to show that the values resulting from this image processing are complete and accurate enough to permit adequate steering and control of the aircraft. C.D.

A89-10525
THE 'PNEUMATIC WIND SHEAR SENSOR' (PWSS) - AN AID TO FLIGHT PATH REGULATION AND TO DISTURBANCE MAGNITUDE IDENTIFICATION IN SHEAR WIND SITUATIONS [DER 'PNEUMATIC WIND SHEAR SENSOR' (PWSS) - EIN HILFSMITTEL ZUR FLUGBAHNREGELUNG UND ZUR STOERGROESSENIDENTIFIKATION BEI SCHERWINDSITUATIONEN]
S. ZHU, H. NELLES, and R. STAUFENBIEL (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 314-321. In German. refs
(DGLR PAPER 87-134)

Test results on a newly developed, simple Pneumatic Wind Shear Sensor (PWSS) are reported. The test aircraft is described and the PWSS principles are analytically presented. Flight results under inversion weather conditions are given, including wind and temperature profiles and vertical shear features. C.D.

A89-10536
THE HISTORY OF AIRCRAFT ONBOARD EQUIPMENT [ZUR GESCHICHTE DER FLUGZEUG-BORDAUSRUESTUNG]
G. W. A. KLEIN IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 436-442. In German. refs
(DGLR PAPER 87-054)

The development history of onboard electrical equipment for aircraft is traced, with a focus on flight-control and navigation devices developed in Germany during the 1930s and 1940s. Topics addressed include generators, gyroscopes, compasses, and inertial navigation. Extensive drawings and diagrams are provided. T.K.

A89-10582
THE DESIGN EYE REFERENCE POINT
GERALD STONE (Douglas Aircraft Co., Long Beach, CA) IN: Aerospace Behavioral Engineering Technology Conference, 6th, Long Beach, CA, Oct. 5-8, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 51-57. refs
(SAE PAPER 871763)

This paper discusses the meaning of the pilot's 'design eye reference point' (DERP) concept and examines the difference between operational experience and current cockpit design procedures relative to the DERP. It is emphasized that, while the DERP is an effective concept for defining flight deck architecture in relation to the pilot interface, it does not adequately express operational practice. It is shown that, in practice, failure to place the pilot's eye in the proper position will result in a decreased visual segment of the ground during approach or the obscuration of vital flight displays, affecting flight safety. A potential design solution that employs a modified automotive 'eyellipse' concept is proposed as a possible alternative to DERP. The effect of this new design methodology on existing cockpit geometry is demonstrated. I.S.

A89-10585
AVIONIC COLOR LIQUID CRYSTAL DISPLAYS - RECENT TRENDS
THOMAS L. CREDELLE (GE Corporate Research and Development Center, Schenectady, NY) IN: Aerospace Behavioral Engineering Technology Conference, 6th, Long Beach, CA, Oct. 5-8, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 77-82. refs
(SAE PAPER 871790)

Flat panel technology, specifically liquid crystal flat panel technology, has made tremendous progress in the past few years and is now poised to challenge the CRTs in avionic applications. The operating principles and electrooptic characteristics of active-matrix-addressed liquid crystal displays are discussed in this paper. Issues related to performance in the demanding cockpit environment are also presented. Operating characteristics of a 1024 x 1024 color LCD is shown. Author

A89-10617
THE V-22 VIBRATION, STRUCTURAL LIFE, AND ENGINE DIAGNOSTIC SYSTEM, VSLED
MICHAEL J. AUGUSTIN (Bell Helicopter Textron, Inc., Fort Worth, TX) and JOHN D. PHILLIPS (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 67-78.
(SAE 871732)

The development of the vibration, structural life, and engine diagnostic (VSLED) system for the V-22 tiltrotor aircraft is discussed. The V-22, its avionic interfaces to VSLED, the VSLED hardware, and the concepts used to monitor the V-22 engines are examined. The program schedule for building the VSLED airborne unit is presented. The functional requirements of the

VSLED system are discussed, including the detection of operating limit exceedances, performance degradation trending, fault detection and isolation, power assurance checks, post-flight maintenance data, and parts life usage monitoring. R.B.

A89-10647
SURVEILLANCE - HIGH-TECHNOLOGY FIT-OUT FOR THE NOMAD AIRCRAFT
RICHARD PAGE and BILL BROWN (Government Aircraft Factories, Port Melbourne, Australia) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 235-242.
(SAE PAPER 872428)

Nomad, a proven low-level marine surveillance aircraft, has been upgraded to counter illegal drug smuggling. A conceptual design was formed after providing the latest applicable sensor equipment in a prototype fit-out to the Nomad aircraft. Issues discussed are the proof of concept, the FLIR installation, the radar installation, the sensor operator work station, avionic systems integration, the navigation system, and the communications and audio system. The final design was firmed after evaluation of the prototype results and in consultation with the future operators. B.J.

A89-10658
HEALTH AND USAGE MONITORING - THE INTEGRATED APPROACH
IAIN ROBERTSON and CLIVE PAGET (Smiths Industries Aerospace and Defence Co., Hampshire, England) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 375-384.
(SAE PAPER 872445)

The state-of-the-art health and usage monitoring systems applied to the propulsion and structural elements of fixed and rotary wing civil aircraft are described. A typical system including an airborne processor and recorder, a data transfer unit, and a ground-based analysis computer is presented. Current work sponsored by the British Civil Aviation Authority is discussed as well as future possibilities. K.K.

A89-10692
CIRCUIT PROTECTION FOR ADVANCED AIRCRAFT - A FUNCTIONAL AND HISTORICAL PERSPECTIVE
FRANCIS A. CANNAVO, JR., ROBERT W. PETERSON, and CARLTON M. COBB (Texas Instruments, Inc., Dallas) IN: Aerospace avionics equipment and integration; Proceedings of the Second Conference, Dallas, TX, Nov. 2-4, 1987. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 167-172.
(SAE PAPER 872502)

Aircraft power distribution systems traditionally have been controlled by the use of electromechanical devices. Advances in solid state and computer technology now offer the potential for fully automatic control. Solid state power controllers (SSPC) are now emerging to meet this need. By prudent SSPC design, it is possible to gain the control advantages offered by solid state technology while at the same time retaining the protection advantages of traditional circuit breakers. This paper describes the key features of circuit breakers in use today that should be considered critical and incorporated into the SSPC specifications for future aircraft as well as describing the special features possible with SSPCs. Author

A89-12321
OPERATIONAL FINDINGS FROM A TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) EVALUATION
DAN TILLOTSON (Arinc Research Corp., Annapolis, MD) SAE, Aerospace Vehicle Conference, Annapolis, MD, Apr. 18-20, 1988. 16 p.
(SAE PAPER 880943)

This paper provides a summary of the data and findings from a ten-month evaluation of the Traffic Alert and Collision Avoidance System (TCAS) II Industry Prototype installed on a Piedmont Airlines' Boeing 727 aircraft. The data presented represents quantitative and qualitative information on the performance of TCAS II in the National Airspace System (NAS) and identifies the impacts of TCAS on Air Traffic Control and the flight crew. The information provided concentrates on the characteristics of the TCAS encounters and the operational use of the system. Author

A89-12403*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SIMULATION AND ANALYSIS OF IMAGE-BASED NAVIGATION SYSTEM FOR ROTORCRAFT LOW-ALTITUDE FLIGHT
BANAVAR SRIDHAR (NASA, Ames Research Center, Moffett Field, CA) and ANIL V. PHATAK (Analytical Mechanics Associates, Mountain View, CA) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 11 p. refs

The automation of helicopter NOE flight entails the modification of nominal trajectories on the basis of the detection and location of obstacles by means of onboard sensors. This process is presently studied using a sequence of images from a passive sensor mounted at the helicopter's center of gravity and oriented with the viewing axis along the rotorcraft's longitudinal body-axis. Three different Kalman filters are used to estimate the location of an object on the ground during the course of various simulated helicopter maneuvers; two of the three filters are found to yield good object location estimates. O.C.

A89-12411#
APPLICATION OF CONSTRAINT SUSPENSION TECHNIQUES TO DIAGNOSIS IN HELICOPTER CAUTION/WARNING SYSTEMS
GREG GLENN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 8 p. Army-supported research. refs

The U.S. Army's Apache Enhanced Diagnostic System program has accomplished the development of a demonstrator system capable of simulating the multiplex bus traffic of caution/warning-related data, and then invoking a diagnostic module upon detection of an abnormal condition. Problem indicators are prioritized on the basis of severity, and displayed on a simulated cockpit display and multifunction display. Severe problems are announced aurally by means of digitally-sampled stored messages. The diagnostic module employs a candidate-generation technique, via 'constraint-suspension', to prune the list of suspected components during failure diagnosis; constraint-suspension is a form of model-based reasoning that allows the diagnosis of faults through a modeling of correct system behavior and a comparison of actual and modeled outputs. O.C.

A89-12415#
DEVELOPMENT OF A RULE-BASED DEMONSTRATION PROTOTYPE EXPERT SYSTEM FOR INFLIGHT EMERGENCIES FOR THE UH1H HELICOPTER
JOHNNIE A. HAM (U.S. Army; Georgia Institute of Technology, Atlanta) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 8 p. refs

An expert system was developed for the UH1H helicopter to identify emergencies using a rule-based control strategy. Once the emergency is correctly identified, the expert then considers altitude and airspeed and presents the pilot with the procedure to follow. Judgments can be processed despite incomplete sensor information, utilizing the 'expert' to determine the most probable failure that had occurred. The engine category of failures was used for test cases. Software developed was accomplished in LISP using GEST (Generic Expert System Tool). Hardware and implementation issues, as well as automatic response and pilot interaction are also addressed. Four areas need further exploration:

the need for configurable software; the susceptibility of components to EMI/EMP interference; and the potentials of parallel processing and optical computers. Author

N89-10834# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Avionics Lab.
ADVANCED AVIONICS ARCHITECTURE PAVE PILLAR
JOHN C. OSTGAARD *In* AGARD, Computing Systems Configuration for Highly Integrated Guidance and Control Systems 8 p Jun. 1988
Avail: NTIS HC A08/MF A01

The increased use of advanced electronics has given modern combat aircraft phenomenal levels of performance, but at a stiff price in initial cost, maintenance workload and aircraft availability. Hence, aircraft design is shifting to give equal emphasis on performance, affordability, maintainability, and reliability in the development of avionic systems. The paper discusses the challenges and benefits of an avionics architecture concept which integrates avionic functions at the system level thereby improving the system's accuracy, increasing its immunity to failure, and decreasing its reliance on multiple redundant sensors. This design philosophy, which permits resources to be shared across subsystems, requires a highly coupled system-wide management and control program (operating system) supported by a wide-band distribution network, high-speed data and signal processors, and extensive mass memory. The implementation strategy for this avionics architecture is the system-wide utilization of common modular building blocks using advanced microelectronics such as VHSIC, standard 3/4 ATR modules and integrated racks, all interconnected by fiber optic networks. The generic integration approach and architecture produced by the PAVE PILLAR program is the foundation for avionics development in the next generation aircraft for the U.S. DOD and include such aircraft as the USAF Advanced Tactical Fighter (ATF). Author

N89-10835# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Data and Signal Processing Group.
DATA AND SIGNAL PROCESSING ARCHITECTURES FOR FUTURE AVIONICS
MARK T. MICHAEL *In* AGARD, Computing Systems Configuration for Highly Integrated Guidance and Control Systems 12 p Jun. 1988
Avail: NTIS HC A08/MF A01

Pave Pillar architecture incorporates a Common Signal Processor (CSP) concept as a key building block of a USAF advanced avionics suite. This concept embodies the use of standard internal interfaces, a family of modules, use of the programming language Ada to express application program for the data processors within CSP, and the use of a Graph Notation to represent signal processing functions for the signal processing components of the CSP. The modularity permits upgrading any hardware or software component with minimal disruption to the rest of the design. CSP is an open architecture in that the interfaces and module specifications are non-proprietary and can be built by other vendors. The paper will address the system concept, hardware architecture, and software philosophy comprising the CSP system. It will describe in general terms how the CSP hardware works and its expandability. Existing modules will be listed and potential future modules identified. A brief description of the Graph Notation and its advantages will be provided. The CSP Local Operating System capabilities and use will be summarized. Application studies to determine the suitability of the CSP concept for different avionic applications such as radar, electronic warfare, communications, and electro-optical sensors will be briefly summarized. The role of the MIL-STD-1750A processors in CSP and their limitations will be touched on, and future upgrades to 32-bit machines discussed. Author

N89-10836# Harris Corp., Melbourne, Fla. Government Aerospace Systems Div.
FIBER OPTIC BUSES AND NETWORKS FOR ADVANCED AVIONICS ARCHITECTURES
R. W. UHLHORN *In* AGARD, Computing Systems Configuration for Highly Integrated Guidance and Control Systems 15 p Jun. 1988
Avail: NTIS HC A08/MF A01

An avionics architecture exploiting high-speed, high density VLSI and VHSIC technology by repartitioning the traditional avionics suite requires subsystem interconnection via backbone and backplane buses and networks operating at data rates far exceeding those used for avionics in the past. In fact, the rates are high enough that fiber optics is the only interconnect technology that does not impose substantial size, weight, and life cycle cost penalties on the overall system. In the Pave Pillar architecture the fiber optic multiplex bus for command and control, block transfer, and flight control functions, based on a variation of the IEEE 802.4 and 802.2 token-passing bus protocol for the physical and data link layers, operates at 50 Mbps. A number of specific implementations have emerged. The parallel internal bus protocol ties users (data processors) together in the backplane and through a bus interface unit to the multiplex bus. Other kinds of networks are used to serve subsystems connecting video terminals, sensors, signal processors, etc. An overview of the multiplexed high-speed data bus and parallel backplane bus designs and their interface is presented. The implementation details and options for the fiber optic network which supports the interconnection of avionics bus interface modules in different physical locations are discussed. Passive and active star-coupled networks are compared and conclusions drawn. The state of the art in packaging of the avionics bus interface and related line replaceable modules is illustrated. Author

07

AIRCRAFT PROPULSION AND POWER

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

A89-10528
ASPECTS OF INCREASING ECONOMY USING FUTURE LOW-POWER AIRCRAFT PROPULSION SYSTEMS [ASPEKTE ZUR WIRTSCHAFTLICHKEITSSTEIGERUNG BEI ZUKUENFTIGEN LUFTFAHRTANTRIEBEN KLEINER LEISTUNG]
U. DAMMEL and H. RICHTER (KHD Luftfahrttechnik GmbH, Oberursel, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 344-349. In German.
(DGLR PAPER 87-100)

Examples are used here to show what steps need to be taken to increase the economy of future low-power aircraft propulsion systems. Technologies involving thermodynamics, flow mechanics, materials science, construction, mechanical components, and control are considered. A leading concept for the 1990s is described. C.D.

A89-10613
AIRCRAFT GAS TURBINE ENGINE MONITORING SYSTEMS: AN UPDATE
Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-728), 1988, 330 p. For individual items see A89-10614 to A89-10626.
(SAE SP-728)

Papers concerning aircraft gas turbine engine monitoring systems are presented, including pocket calculator trend monitoring for gas turbine engines, the development and testing of inflight engine performance monitoring technique for the U.S. Navy P-3C airplane, a guide to temperature monitoring in gas turbine engines, and an overview of airborne vibration monitoring systems. Other aspects include the V-22 vibration, structural life, and engine

diagnostic system, an operational engine monitoring system, a ground based engine monitoring program for general application, engine monitoring systems for helicopters, and quantitative debris monitoring. Oil system monitoring, vibration monitoring systems, life usage monitoring and parts management for aircraft gas monitoring systems are also discussed. R.B.

A89-10614
POCKET CALCULATOR TREND MONITORING FOR GAS TURBINE ENGINES
R. HALLIDAY and R. D. JACKSON (Pratt and Whitney Canada, Longueil, Canada) IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 1-4.
(SAE 841461)

The possibility of using a programmable pocket calculator to predict the need for engine maintenance by monitoring basic engine parameters at known environmental conditions is discussed. The calculator normalizes the gas generator speed, interturbine temperature, and fuel flow, and corrects for the baseline altitude and speed. The change between the actual and baseline parameters at the normalized output power are plotted against engine running time to give a trend plot. Deviations can be interpreted to determine when engine maintenance is required. Thus, hot section inspections scheduling can be based on trend plots, providing a maintenance cost savings. R.B.

A89-10615
DEVELOPMENT AND TESTING OF AN INFLIGHT ENGINE PERFORMANCE MONITORING TECHNIQUE FOR THE U.S. NAVY P-3C AIRPLANE
JOSEPH D. DUPCAK (Lockheed-California Co., Burbank), PAUL DEPPE, and RICH PREVATT (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 5-14. refs
(SAE 841462)

The development of a low-cost procedure for monitoring engine performance for the U.S. Navy P-3C airplane is discussed. The development program consists of three phases: (1) a flight test program to obtain engine performance data to determine standards or baselines, (2) the establishment of algorithms and procedures for implementing inflight engine performance trending, and (3) a fleet trial. The proposed engine monitoring system is described and preliminary results of the fleet trials are presented. R.B.

A89-10616
AIR 1900 - GUIDE TO TEMPERATURE MONITORING IN AIRCRAFT GAS TURBINE ENGINES
JERRY L. EDWARDS (Rosemount, Inc., Burnsville, MN) IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 15-55.
(SAE 871730)

This Aerospace Information Report (AIR) is being prepared by the E-32 Committee in recognition of the need to provide the most up-to-date information on temperature measurement for production gas turbine engines. Information on various functions for which sensors are used is provided, and the most widely used sensor types are identified. Considerations are made for the entire measurement system and not just the sensor itself. Selection criteria are discussed and the problem of identifying and quantifying error sources is discussed for the purpose of achieving accurate measurements. The AIR concludes with a discussion of special problems encountered in temperature measurement. Author

A89-10618
LESSONS LEARNED FROM AN OPERATIONAL ENGINE MONITORING SYSTEM AND THEIR CORRELATION WITH FUTURE DEVELOPMENTS
GARY J. WEBB (South African Airways, Johannesburg, Republic of South Africa) IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 79-84. refs
(SAE 871733)

Engine monitoring systems have been in use on civil airliners since the late sixties and have developed continuously. This paper reviews major problems encountered by a typical user and examines current and future developments to determine the extent to which lessons learned in the past have been applied to development efforts. The view gained is that future systems will indeed resolve most of the problems encountered. The paper provides existing and potential engine monitoring users with insight into the main pitfalls of these systems and provides guidelines on what to look for in an engine monitoring system. Author

A89-10619
GAS TURBINE ENGINE MONITORING SYSTEMS - HELICOPTER EXPERIENCE
JAMES L. PETTIGREW (Howell Instruments, Inc., Fort Worth, TX) IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 97-111. refs
(SAE 871735)

A monitoring system for military and civilian helicopters is discussed, stressing the use of digital technology engine hardware to improve the quantity and quality of data available for propulsion system management. The Engine Performance Assurance Monitoring System (EPAMS), which is used in the U.S. Navy's CH-53E, is evaluated and the possible commercial application of EPAMS is examined. Information provided by the system includes a record of operating time, data for engine trending, maximum temperatures and RPMs for each engine, data for power changes, hot section factor count, times above selected values, and the coast-down time at shutdown. R.B.

A89-10620
FIELD EXPERIENCE WITH QUANTITATIVE DEBRIS MONITORING
FRANK DIPASQUALE (Aeroquip Corp., Tedeco Div., Glenolden, PA) IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 113-120. refs
(SAE 871736)

Sensor technology for the monitoring of failing engine components has been developed for on-board fluid condition monitoring and to reduce false alarms. The technology, called quantitative debris monitoring (QDM), is described and illustrated, and results are presented from flight and ground based tests. Tests include the use of the QDM system to monitor debris from a turbine engine bearing in a load and operational environment simulating flight conditions, the application of QDM to helicopter gearbox monitoring to detect fretting bearing and bearing race, bearing wear detection, and detection of labyrinth seal wear and spalled inner race. R.B.

A89-10621
TEXMAS - AN EXPERT SYSTEM FOR GAS TURBINE ENGINE DIAGNOSIS AND MORE
KENNETH COLLINGE and KENNETH SCHOFF (Textron, Inc., Avco Lycoming Textron, Stratford, CT) IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 121-127.
(SAE 871737)

The Turbine Engine Expert Maintenance Advisor System (Texmas) is being developed for use with the T53 engine. Texmas allows for engine performance measurements, the monitoring of trends in measured parameters, event monitoring, low cycle fatigue, creep rupture, cyclic fatigue life estimation, and fault isolations. The expert systems and the system's computer programs are described, and the research projects involved in the development of Texmas are discussed. Also, the implementation and maintenance of Texmas are examined. R.B.

A89-10622
GUIDE TO OIL SYSTEM MONITORING IN AIRCRAFT GAS TURBINE ENGINES
IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 129-171. refs
(SAE AIR 1828)

A technical guide for the selection and use of oil system monitoring devices is presented. The benefits of oil system monitoring devices are discussed, including reliabiltiy, availability, cost savings, product assurance and verification, and safety. The monitoring of oil pressure, temperature, quantity, and filter bypass indicator is considered. Established techniques and experimental devices for oil debris monitoring and techniques for oil condition monitoring are discussed. The general requirements for an oil system monitoring system are given and considerations for debris monitoring are presented, including sensor integration into the oil system and oil system layout for optimum prognostic and cost effectiveness. R.B.

A89-10623
A GUIDE TO AIRCRAFT TURBINE ENGINE VIBRATION MONITORING SYSTEMS
IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 173-196. refs
(SAE AIR 1839)

A technical guide for the selection, installation, and use of airborne engine vibration monitoring systems and their elements is presented, with emphasis on system hardware design considerations. Aspects of system design which are evaluated include signal source, mounting surface, interfaces, mounting point, displacement and velocity transducers, accelerometers, signal transmission, cable, shielding, grounding, circuit type, connectors, filtering, output formats, and warning functions. Also, tracking filter based systems are examined. The determination of system and performance requirements and the process of system design approval and integration are discussed. R.B.

A89-10624
LESSONS LEARNED FROM DEVELOPMENTAL AND OPERATIONAL TURBINE ENGINE MONITORING SYSTEMS
IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 197-257.
(SAE AIR 1871B)

The development and operation of several engine monitoring systems is discussed, pointing out problems in engine operational maintenance which can be addressed in the development of future systems. The systems examined include the Condition Monitoring Program for T700-GE-700, the Inflight Engine Condition Monitoring System, the Advanced Diagnostic Engine Monitoring System, F/A Inflight Engine Condition Monitoring System, UK Military Engine Usage, Condition, and Maintenance Systems, and an operational engine monitoring system applied to an international airline. Recommendations for future developments include the transmission of data from out-stations or inflight to allow effective trouble-shooting away from base, a data base system where data is dumped into the airline engineering computer allowing users to develop their own application programs, and the presentation of engine monitoring data on display screens, minimizing paper output. R.B.

A89-10625
GUIDE TO LIFE USAGE MONITORING AND PARTS MANAGEMENT FOR AIRCRAFT GAS TURBINE ENGINES
IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 259-301.
(SAE AIR 1872)

Approaches to engine life usage monitoring and parts management are reviewed. Control requirements for these systems are summarized and failure causes of life-limited parts are discussed, including low and high cycle fatigue, thermal fatigue and creep. Engine life prediction and usage measurement, method validation, and parts life usage data management are examined. The advantages of engine life usage monitoring and parts management systems are presented, and several of these systems are described and evaluated. R.B.

A89-10626
GUIDE TO LIMITED ENGINE MONITORING SYSTEMS FOR AIRCRAFT GAS TURBINE ENGINES
IN: Aircraft gas turbine engine monitoring systems: An update. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 303-323. refs
(SAE AIR 1873)

A limited engine monitoring system which can be used by a flight crew or maintenance staff to monitor the health of gas turbine engines in aircraft is discussed. The monitoring of gas path performance and mechanical parameters, low cycle fatigue counters, and engine history recorders are considered. The benefits, parameters, and architecture of limited engine monitoring systems are examined. Recommendations for the development of these systems include unambiguous readings for cockpit displays, manufacturer input into design specification, minimizing the effects of manual and automated data acquisition on the trend deltas, algorithms for the reduction of measured data which reflect engine configuration, and supplying complete comprehensive documentation for system use to manufacturers. R.B.

A89-10635
RB211 DEVELOPMENTS
D. J. PICKEREL (Rolls-Royce, PLC, London, England) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 105-118.
(SAE PAPER 872409)

This paper examines briefly the growth prospects of long haul civil air transportation in the Pacific Basin and the contribution made by the RB211-524 in the Boeing 747. The development of the latest committed version of this engine giving over 60,000 lb static thrust is described as well as the design of the proposed 65,000 lb static thrust RB211-524L powerplant. Finally, the prospects for new Ultra High Bypass Ratio cowled turbofans for long haul operation in the next century are reviewed. Author

A89-10636
GAS TURBINE ENGINE DEVELOPMENT PARTNERSHIPS
JIM KORN (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 119-132.
(SAE PAPER 872410)

The structure and progress of the followig major aircraft gas turbine development programs are examined: (1) the T406-AD-400 turboshaft for the V-22 Osprey; (2) the T800-LHT-800 turboshaft engine for LHX; and (3) the Model 578 propfan propulsion system for transport aircraft. All of these programs contain partnership agreements that allow extensive development participation and all rely on a blend of developed hardware with infusion of modern technology. It is concluded that the development of gas turbine engines can benefit from the synergistic aspects gained by partnership agreements. B.J.

A89-10637* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PROPULSION-AIRFRAME INTEGRATION FOR COMMERCIAL AND MILITARY AIRCRAFT
WILLIAM P. HENDERSON (NASA, Langley Research Center, Hampton, VA) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 133-144. refs
(SAE PAPER 872411)

A significant level of research is ongoing at NASA's Langley Research Center on integrating the propulsion system with the aircraft. This program has included nacelle/pylon/wing integration for turbofan transports, propeller/nacelle/wing integration for turboprop transports, and nozzle/afterbody/empennage integration for high performance aircraft. The studies included in this paper focus more specifically on pylon shaping and nacelle location studies for turbofan transports, nacelle and wing contouring and propeller location effects for turboprop transports, and nozzle shaping and empennage effects for high performance aircraft. The studies were primarily conducted in NASA Langley's 16-Foot Transonic Tunnel at Mach numbers up to 1.20. Some higher Mach number data obtained at NASA's Lewis Research Center is also included. Author

A89-11026#
A DYNAMIC CHARACTERISTIC ANALYSIS OF A BLADED DISK ASSEMBLY
DEPING GAO, YISONG ZHANG, and LIYAN YI (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, April 1988, p. 97-100, 183. In Chinese, with abstract in English. refs

The dynamic characteristics of a bladed disk assembly are calculated by means of sector elements of thick plates and wave propagation technique of periodical structure. The method saves greatly the computing time and the storage of computer. The vibration characteristics between the bladed disk assembly and the single blade or disk are compared and the influences of the variation of geometric parameters of the bladed disk assembly on its vibration characteristics are considered. Some conclusions are drawn which will play an important part in further research on the vibration control of an aeroengine. A bladed disk assembly of an actual compressor is analyzed in this paper, and the results obtained coincide with the experimental data. Therefore, the presented method is applicable to practical engineering. Author

A89-11034#
REDUCTION OF EJECTOR NOISE WITH MULTIHOLE NOZZLE
RENSONG FANG and RONGXUE ZHANG (Nanjing Aeronautics Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, April 1988, p. 145-148, 188. In Chinese, with abstract in English.

In order to reduce the noise, an ejector with a multihole nozzle is proposed as the primary nozzle, and its design method is presented. For comparison of the aerodynamic performance and the noise characteristics with those of conventional ones in subsonic and supersonic ejector systems, the sound power levels and the primary and secondary mass flow rates of the ejectors were measured, and the static thrusts of the ejectors were estimated, based on the measured mass flow rates. The shroud length of the ejector system tested was altered in the experiments so as to study the effect of this parameter on noise and thrust. The experimental results show that the multihole nozzle ejector system not only reduces noise considerably but also gains better aerodynamic performance due to a shorter shroud. The shorter the shroud, the more noise reduction and the greater the static thrust increment that can be achieved. Author

A89-11040#
A JET THRUST MEASUREMENT METHOD WITH GAS COMPOSITION ANALYSIS
SHIYI PENG (Nanhua Power Plant Research Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, April 1988, p. 167, 168, 191. In Chinese, with abstract in English.

A new method is proposed which uses composition analysis of gas from engine for determining jet thrust at a given fuel consumption. This method has been verified in JT15D engine testing, and the thrust error is about 6.9 percent. Author

A89-11044#
ESTABLISHMENT OF VARIABLE VANE REGULATION LAW
ZHENGMU WANG (Shenyang Aeroengine Co., People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, April 1988, p. 178-180, 192. In Chinese, with abstract in English.

An approach to establishing the optimum regulation law of the variable vane for a turbojet engine is presented. The stable operating boundary of the engine can be determined according to matching with effective flight conditions. Author

A89-11051#
APPLICATION OF END-BEND BLADE FOR ENHANCING SURGE MARGIN
YUNJIN CAI, YULING ZHONG, and LUHONG QIAN (Shenyang Aeroengine Co., People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, July 1988, p. 215-218, 281. In Chinese, with abstract in English.

The blade end-bend technique is applied to the first and second stators of the HP compressor of a twin-spool engine to ameliorate the flow on the second and third rotors. The tests of the modified engine show that its surge margin and efficiency are enhanced by 7.3 and 4.1 percent, respectively, but the flow and pressure ratio vary only a little. The flight tests prove that the shutdown of the engine which occurred in flight has been eliminated, so that the engine can operate reliably and stably within the overall flight envelope. The performance of the engine and the aircraft has been improved significantly. Author

A89-11052#
APPROACH TO BLADE END-BEND MECHANISM
LIXI HUANG, XINGLU WEI, and ZEYAN PENG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, July 1988, p. 219-222, 281, 282. In Chinese, with abstract in English.

Blade end-bend is a new technique to improve the performance of compressors. A comprehensive study of two multistage compressors has been completed with numerical calculation, theoretical analysis, and experimental investigation. It is shown that the end-bend causes redistribution of the whole flowfield, and that the changes of characteristics in the main flow region may be a factor to improving the engine performance. A comparative study of several end-bend patterns shows that the character of redistribution differs among them. It is important to choose the end-bend pattern suitable for the specific compressor. Author

A89-11054#
UNSTEADY LOADING NOISE OF COUNTER-ROTATING PROPELLER
XIOAFENG SUN, ZONGAN HU, and SHENG ZHOU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, July 1988, p. 227-230, 283. In Chinese, with abstract in English. refs

The unsteady loading noise generated by interaction of a front rotor wake with an aft rotor in a counterrotating (CR) propeller is analyzed, and the noise radiation formulas are derived. Numerical predictions of noise for a real CR propeller are completed and compared with experimental data. It is concluded that the sound pressure level (SPL) in the axial direction of the rotor is fully determined by the component of unsteady loading noise, but in rotor plane the main contribution to SPL is the component of steady loading noise, and the effect of the unsteady noise is limited to the range of higher harmonics in this case. Author

A89-11055#
PROPFAN DESIGN BY PROPELLER-NACELLE INTERACTION ANALYSIS
NIANGUO ZHU, MAOZHANG CHEN, and DAOZHI LIU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, July 1988, p. 231-234, 282. In Chinese, with abstract in English. refs

A propeller-nacelle interaction analysis has been developed in this paper as a kind of lifting-line analysis. It represents the blades

by curved lifting lines, taking into consideration the blade sweep and the effect of the nacelle on the propfan flowfield. The wake model assumes that the vortex filaments occur along stream surfaces. Some corrections have been made to the transonic portion of the blade and the large solid cascade portion at hub. Comparison of the results of the design and analysis with those obtained previously show that the method is feasible and effective. Aspects of its improvement are also discussed. Author

A89-11074
EXPERIENCE WITH THE DEVELOPMENT OF TURBOPROP ENGINES [PERSPEKTIVY DALSIHO VYVOJE TURBOVRTULOVYCH MOTORU]
OLDRICH BUNATA Zpravodaj VZLU (ISSN 0044-5355), no. 3, 1988, p. 121-129. In Czech. refs

Data on the performance and operational characteristics of various turboprop engines are presented. The pros and cons of various concepts are examined, and data on the improvement of the main parameters of the working cycle and on engine costs are presented. Particular consideration is given to the advantages and disadvantages of two-stage radial and axial-radial compressors. B.J.

A89-11075
CONTROL OF THE LOW-CYCLE SERVICE LIFE OF THE PRIMARY COMPONENTS OF AIRCRAFT TURBINE ENGINES ACCORDING TO THE DAMAGE-TOLERANCE CONCEPT [RIZENI NIZKOCYKLOVE ZIVOTNOSTI PRIMARNICH CASTI LETECKYCH TURBINOVYCH MOTORU PODLE KONCEPCE DT]
JIRI STATECNY Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1988, p. 225-234. In Czech. refs

The application of the damage-tolerance concept presupposes the close cooperation between the R&D base, the manufacturer, the user, and the overhaul shops. This paper examines the establishment of purposeful coordinated activities within this area. A strategy is proposed for the Aircraft Research and Test Institute to ensure the appropriate methodological provisions necessary for the application of the damage-tolerance concept. B.J.

A89-12307* Florida Univ., Gainesville.
CALCULATIONS OF THE UNSTEADY, THREE-DIMENSIONAL FLOW FIELD INSIDE A MOTORED WANKEL ENGINE
ERLENDUR STEINTHORSSON, TOM I.-P. SHIH (Florida, University, Gainesville), HAROLD J. SCHOCK, JR. (Michigan State University, East Lansing), and JAMES STEGEMAN (NASA, Lewis Research Center, Cleveland, OH) SAE, International Congress and Exposition, Detroit, MI, Feb. 29-Mar. 4, 1988. 31 p. refs
(Contract NAG3-363)
(SAE PAPER 880625)

A computer program (referred to as UF-LRC-3D) was developed for studying the unsteady, three-dimensional flow field inside the combustion chambers of motored Wankel engines as a function of engine design and operating parameters. This paper presents the details of the governing equations and the numerical method used by UF-LRC-3D. Also presented are numerical solutions generated by UF-LRC-3D showing the velocity field inside a motored Wankel engine, the mixing of nonhomogeneous fuel-air mixtures that enter through the intake port, and the mixing that takes place when a gaseous fuel is injected into the combustion chamber during compression. Author

N89-10012# United Technologies Research Center, East Hartford, Conn.
AEROELASTIC COUPLING: AN ELEMENTARY APPROACH
FRANKLIN O. CARTA *In* AGARD, AGARD Manual on Aeroelasticity in Axial-Flow Turbo Machines. Volume 2: Structural Dynamics and Aeroelasticity 16 p Jun. 1988
Avail: NTIS HC A12/MF A01

It was shown in the original 1967 paper that the energy method, using unsteady isolated airfoil theory, and applied to actual multiblade rotors, yielded results that were remarkably accurate. This fortuitous agreement was sufficiently encouraging to foster a continuing development of the technique and its constituent aerodynamic and structural dynamic components. As shown in these two volumes and in the several citations to advanced analyses, current practice has gone well beyond the relatively simplistic view of the early paper. The aerodynamic input now encompasses multiblade systems subjected to compressible flows, and structures are modeled to include nonlinearities and mistuning. Nevertheless, the paper has served its purpose well. In its original form it set the stage for the continual improvement of engine flutter prediction methods, and in this manual it provides the reader with a vehicle for coordinating the separate disciplines which, together, represent the modern approach to flutter prediction of turbomachinery blade rows. Author

N89-10013# Massachusetts Inst. of Tech., Cambridge. Gas Turbine Lab.
AEROELASTIC FORMULATION FOR TUNED AND MISTUNED ROTORS
EDWARD F. CRAWLEY *In* AGARD, AGARD Manual on Aeroelasticity in Axial-Flow Turbo Machines. Volume 2: Structural Dynamics and Aeroelasticity 24 p Jun. 1988
Avail: NTIS HC A12/MF A01

The topics to be addressed are: the formulation of the aeroelastic problem, including a summary of the relations necessary to transform various diverse structural and aerodynamic models to a consistent notation; a brief review of the solution techniques applicable; the trends in aeroelastic stability for tuned rotors; and the effects of mistuning on stability. Author

N89-10014# Pratt and Whitney Aircraft, East Hartford, Conn.
FAN FLUTTER TEST
HANS STARGARDTER *In* AGARD, AGARD Manual on Aeroelasticity in Axial-Flow Turbo Machines. Volume 2: Structural Dynamics and Aeroelasticity 35 p Jun. 1988
Avail: NTIS HC A12/MF A01

The objective is to describe an aeroelastic investigation of fan flutter. Discussion includes test procedures for flutter evaluation, data acquisition and reduction, safety, and instrumentation. Some data contents are included, but are not the primary concern. Initially, a complete sequence of preparation, testing, and analysis of an ideal fan flutter test is presented. This is followed by identification of dangerous blade vibrations, a case history of a NASA/Pratt and Whitney Subsonic/Transonic Flutter Study, and a discussion and analysis of the program results. Lastly, a summary relating this test to the overall discussion of fan flutter testing is presented. It will be noted that many of the steps in the ideal test situation were omitted in the actual case history. Most of these differences are in the test preparation area because the case history used a previously tested design in which much of the preliminary work and safety screening was already accomplished. Author

N89-10015# Jeffers (James D., III), Tampa, Fla.
AEROELASTIC THERMAL EFFECTS
JAMES D. JEFFERS, III *In* AGARD, AGARD Manual on Aeroelasticity in Axial-Flow Turbo Machines. Volume 2: Structural Dynamics and Aeroelasticity 6 p Jun. 1988
Avail: NTIS HC A12/MF A01

The adverse effect of increasing temperature on the stability of turbomachinery airfoils was long recognized but remains today one that is not fully understood. The quantitative effect on the reduced frequency parameter, k = omega c/V, which was experimentally and analytically shown to be one of the most influential stability parameters, is readily calculated. The effects of increasing temperature on the parameters that comprise reduced frequency are well known. Unfortunately, the resulting effect on aeroelastic stability, particularly for stall flutter, is not. This inability to completely assess thermal effects, among others, was dramatically underscored by an occurrence of subsonic stall flutter in the first stage fan rotor of the F100 turbofan engine early in the development program. The severity of the problem prompted an intensive experimental test program and analysis to first determine a solution and, further, to assess the design techniques used to avoid the problem. As a result, a decade of extensive

analytical and experimental research was conducted at the Government Products Division of Pratt and Whitney Aircraft, the United Technologies Research Center, and the NASA Lewis Research Center. The following is a summary of some of the findings of these investigations. Author

N89-10043*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VIBRATION, PERFORMANCE, FLUTTER AND FORCED RESPONSE CHARACTERISTICS OF A LARGE-SCALE PROPFAN AND ITS AEROELASTIC MODEL
RICHARD AUGUST (Sverdrup Technology, Inc., Cleveland, Ohio.) and KRISHNA RAO V. KAZA 1988 28 p Presented at the 24th Joint Propulsion Conference, Boston, Mass., 11-13 Jul. 1988; sponsored by AIAA, ASME, SAE and ASEE
(NASA-TM-101322; E-4260; NAS 1.15:101322; AIAA-88-3155) Avail: NTIS HC A03/MF A01 CSCL 21E

An investigation of the vibration, performance, flutter, and forced response of the large-scale propfan, SR7L, and its aeroelastic model, SR7A, has been performed by applying available structural and aeroelastic analytical codes and then correlating measured and calculated results. Finite element models of the blades were used to obtain modal frequencies, displacements, stresses and strains. These values were then used in conjunction with a 3-D, unsteady, lifting surface aerodynamic theory for the subsequent aeroelastic analyses of the blades. The agreement between measured and calculated frequencies and mode shapes for both models is very good. Calculated power coefficients correlate well with those measured for low advance ratios. Flutter results show that both propfans are stable at their respective design points. There is also good agreement between calculated and measured blade vibratory strains due to excitation resulting from yawed flow for the SR7A propfan. The similarity of structural and aeroelastic results show that the SR7A propfan simulates the SR7L characteristics. Author

N89-10044# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
A COMPARATIVE EVALUATION OF RPD (ROTARY PARTICLE DEPOSITOR) AND FERROGRAPHIC DIAGNOSTIC METHODS FOR TURBINE ENGINE LUBRICANT SAMPLES Final Report, 12 May - 30 Sep. 1987
ROBERT L. WRIGHT Mar. 1988 28 p
(AD-A196207; AFWAL-TR-88-2020) Avail: NTIS HC A03/MF A01 CSCL 11H

A Rotary Particle Depositor (RPD) was evaluated and compared to analytical (AF) and direct reading (DR) ferrographs to ascertain if the RPD is better suited for analysis of wear debris in turbine engine lubricant samples than the AF and DR. Experimentally, sieved iron particles were added to synthetic turbine engine lubricants at various concentrations and analyzed by RPD and ferrographic methods and compared. Also, lubricant samples containing a fine test dust were analyzed by RPD and AF to determine the effectiveness of the RPD's centripetal acceleration and the AF's gravity flow in eliminating non-ferrous contamination from the sample. Finally, actual lubricant samples from a turbine engine simulator were analyzed by RPD and ferrographic methods and compared. For lubricant samples with relatively small amounts of non-ferrous contamination or samples where non-ferrous particles are important in machine health condition assessment, the AF and DR ferrographs are equal or superior to RPD for lubricant analyses. GRA

N89-10045*# Queensland Univ., St. Lucia (Australia). Dept. of M. E.
SHOCK TUNNEL STUDIES OF SCRAMJET PHENOMENA Final Report
R. G. MORGAN, A. PAULL, R. J. STALKER, P. JACOBS, N. MORRIS, I. STRINGER, and C. BRESCIANINI Sep. 1988 16 p
(Contract NAGW-674)
(NASA-CR-181721; NAS 1.26:181721) Avail: NTIS HC A03/MF A01 CSCL 21E

Commissioning of the new T4 shock tunnel at the University of Queensland implied that it was no longer necessary to focus the work of the research group about an annual test series conducted in the T3 shock tunnel in Canberra. Therefore, it has been possible to organize a group for work to proceed along lines such that particular personnel are associated with particular project areas. The format of this report consists of a series of reports on specific project areas, with a brief general introduction commenting on each report. The introduction is structured by project areas, with the title of the relevant report stated under the project area heading. The reports themselves follow in the order of the project area headings. Author

N89-10892# Naval Air Propulsion Test Center, Trenton, N.J.
STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN US COMMERCIAL AVIATION DURING 1982 Final Report
R. A. DELUCIA and J. T. SALVINO Jul. 1988 24 p
(Contract DOT-FA71NA-AP-98)
(DOT/FAA/CT-88/23) Avail: NTIS HC A03/MF A01

Statistics are presented relating to gas turbine engine rotor failures which occurred during 1982 in U.S. commercial aviation service use. One-hundred and sixty-one rotor failures occurred in 1982. Rotor fragments were generated in 88 of the failures and, of these, 16 were uncontained. The predominant failure involved blade fragments. Seven disk failures occurred and all were uncontained. Seventy percent of the 161 failures occurred during the takeoff and climb stages of flight. This service data analysis is prepared on a calendar year basis and published yearly. The data support flight safety analysis, proposed regulatory actions, certification standards, and cost benefit analyses. Author

N89-10894# Rohr Industries, Inc., Chula Vista, Calif.
DE-ICING OF AIRCRAFT TURBINE ENGINE INLETS Final Report
H. A. ROSENTHAL, D. O. NELEPOVITZ, and H. M. ROCKHOLT Jun. 1988 68 p
(Contract DTFA03-86-C-0050)
(DOT/FAA/CT-87/37) Avail: NTIS HC A04/MF A01

The results of an FAA investigation to determine the effects of using de-icing, as opposed to anti-icing, in aircraft turbine engine inlets are given. A literature search was conducted. Ice protection equipment technology was assessed. The icing/de-icing process, de-ice system operation and performance, ice detector characteristics, and a method for determining the effects of the de-icing process on the turbine engine and its associated induction system are discussed. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A89-10103*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIMENTAL STUDY OF EFFECTS OF FOREBODY GEOMETRY ON HIGH ANGLE-OF-ATTACK STABILITY
JAY M. BRANDON and LUAT T. NGUYEN (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 591-597. Previously cited in issue 07, p. 849, Accession no. A86-19818. refs

A89-10515
COMPARISON OF LONGITUDINALLY STABILIZED BEHAVIOR IN VERTICAL TURBULENCE BETWEEN A MODERN CANARD CONFIGURATION AND A CONVENTIONAL AIRCRAFT [VERGLEICH DES LAENGSSTABILITAETSVERHALTENS IN VERTIKALER TURBULENZ ZWISCHEN EINEM MODERNEN ENTENENTWURF UND EINEM KONVENTIONELLEN FLUGZEUG]
J. FECHER (Gyroflug Ingenieurgesellschaft mbH, Baden-Baden, Federal Republic of Germany) and O. BARTSCH (Messerschmitt-Boelkow-Blohm, Munich, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 229-234. In German.
(DGLR PAPER 87-078)

The longitudinal stability behavior in vertical turbulence for aircraft with conventional and canard configurations is compared. A mathematical model of the canard characteristics is developed. The phygoid and angle of attack of the two aircraft types are studied, and the frequency curves, power density spectra, and effective values are obtained. C.D.

A89-10519
ASPECTS OF THE CONTROL AND STABILIZATION OF SUPERSONIC COMMERCIAL AIRCRAFT [ASPEKTE DER STEUERUNG UND STABILISIERUNG VON UEBERSCHALLVERKEHRSFLUGZEUGEN]
P. MANGOLD and W. ALLES (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 264-274. In German.
(DGLR PAPER 87-122)

Recent technological advances have revived the notion of supersonic and hypersonic aircraft in commerical aviation. For aircraft with slender delta wings, questions of control and stabilization are highly significant. In this paper, the demands placed on the stabilization system of such an aircraft are considered, and related issues regarding automated flight are examined. The relevant design and realization considerations are addressed. C.D.

A89-10668
THE STUDY OF THE GLOBAL STABILITY OF HIGH PERFORMANCE AIRCRAFT AT HIGH ANGLES-OF-ATTACK
HAO GAO and ZHI-QIANG ZHOU (Northwestern Polytechnical University, Xian, People's Republic of China) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 473-485. refs
(SAE PAPER 872456)

A new approach based on the qualitative theory of ordinary differential equations, bifurcation analysis, and catastrophe theory is proposed to study the global stability of high-performance aircraft at high angles of attack. The relationship between the stability criteria commonly used in aircraft designs and the eigenvalues of linearized matrices at the equilibrium points is studied. Important high angle-of-attack flight phenomena such as jump hysteresis, wing rock, and spin are analyzed using the present approach. K.K.

A89-10669
MODERN TECHNIQUES FOR THE CONTROL OF RPV'S
CHARLES MULHAUSER and JOHN WHITE (Aerospace Technologies of Australia, Australia) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 487-497.
(SAE PAPER 872457)

This paper discusses the techniques used in the control of remotely piloted mid-scale target aircrafts (TAs), with particular attention given to the control features of the Jindivik TA, which is a high-speed high-altitude jet-powered pilotless TA which is also capable of low-altitude flight. The development of the control of the level of automation, flight controller skills, the apportionment of control, and tracking/navigation is described. Testing confirmed that with the introduction of automatic control techniques fewer operators with lesser skill levels can be used for the TA control. Digital autopilot systems are enabling TA to operate autonomously, with providing a diminishing role for the GCS. I.S.

A89-12402#
THE NOE PILOT'S ASSOCIATE - A JOB DESCRIPTION
NICK LAPPOS (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 8 p.

The increasing demands of NOE military helicopter operations entail reduced margins-of-error, reduced knowledge of the overall situation, reduced visual and electrooptical event horizons, and reduced capability for tactical communication and control. Attention is presently given to emerging possibilities for the automation of helicopter crew burdens in NOE operations, and the consequent expansion of capabilities expected. AI techniques are applied to communications and monitoring tasks, subsystem diagnostics and healing, the integration of system controls, and tactical planning and orientation. O.C.

A89-12417#
DIGITAL AUTOPILOTS FOR ROTARY WINGED UNMANNED AERIAL VEHICLES
ROBERT C. MICHELSON (Georgia Institute of Technology, Atlanta) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 6 p.

Future rotary-wing RPVs will require high-to-total-authority stability augmentation systems, which will require digital implementations capable of supplanting both the piloting (inner loop control) and navigator (outer loop control) functions. Such digital autopilots are presently noted to yield greater performance flexibility under a range of anticipated flight regimes, and will be capable of accommodating more complex tasks, as well as of exhibiting tolerance to high-EMI environments. It is also projected that digital autopilots will be able to sustain substantial physical damage and to perform 'self-healing' to regain full operational effectiveness. O.C.

A89-12555#
CONTROL OF AUTOROTATIONAL CHARACTERISTICS OF LIGHT-AIRPLANE FUSELAGES
B. N. PAMADI (Indian Institute of Technology, Bombay, India), V. JAMBUNATHAN, and A. RAHMAN Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 695-701. Previously cited in issue 08, p. 1052, Accession no. A87-22574. refs

A89-12556*# California Univ., Davis.
BOUNDARY-LAYER TRANSITION EFFECTS ON AIRPLANE STABILITY AND CONTROL
C. P. VAN DAM (California, University, Davis) and B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 702-709. Previously cited in issue 23, p. 3415, Accession no. A86-47708. refs

N89-10046*# Manudyne Systems, Inc., Los Altos, Calif.
HELICOPTER ROLL CONTROL EFFECTIVENESS CRITERIA PROGRAM SUMMARY Final Contractor Report, Jul. 1983 - Jul. 1987
ROBERT K. HEFFLEY, SIMON M. BOURNE, and MARC A. MNICH Apr. 1988 103 p Prepared for Army Research and Technology Labs., Moffett Field, Calif.
(Contract NAS2-11665)
(NASA-CR-177477; NAS 1.26:177477; USAAVSCOM-TR-87-A-13)
Avail: NTIS HC A06/MF A01 CSCL 01C

A study of helicopter roll control effectiveness is summarized for the purpose of defining military helicopter handling qualities requirements. The study is based on an analysis of pilot-in-the-loop task performance of several basic maneuvers. This is extended by a series of piloted simulations using the NASA Ames Vertical Motion Simulator and selected flight data. The main results cover roll control power and short-term response characteristics. In general the handling qualities requirements recommended are set in conjunction with desired levels of flight task and maneuver response which can be directly observed in actual flight. An important aspect of this, however, is that vehicle handling qualities need to be set with regard to some quantitative aspect of mission performance. Specific examples of how this can be accomplished include a lateral unmask/remask maneuver in the presence of a threat and an air tracking maneuver which recognizes the kill probability enhancement connected with decreasing the range to the target. Conclusions and recommendations address not only the handling qualities recommendations, but also the general use of flight simulators and the dependence of mission performance on handling qualities. Author

N89-10047# National Aerospace Lab., Tokyo (Japan).
FUNCTIONAL MOCK-UP TESTS OF THE FLIGHT CONTROL SYSTEM OF THE NAL QSTOL RESEARCH AIRCRAFT: PLANNING AND MECHANICAL SYSTEM TEST
Sep. 1987 56 p In JAPANESE; ENGLISH summary
(NAL-TR-944; ISSN-0389-4010) Avail: NTIS HC A04/MF A01

The control system of the National Aerospace Laboratory Quiet-STOL Research Aircraft has a mechanical control system and a triplex digital Stability and Control Augmentation System (SCAS). The mechanical system is responsible for the safety control system, while the digital SCAS system was to be evaluated through experiments. Functional mock-up tests were carried out to check safety and performance of the total control system using actual system component hardware and simulating aerodynamic and mechanical environmental conditions. The mechanical system dynamics test and the total plan for the functional mock-up test are described as the fundamental process to ensure minimum safety requirements of the system component matching. The static and dynamic characteristics of the mechanical control system showed good agreement with the specifications of Japanese Airworthiness Standards (equivalent to FAR25) and MIL. Author

N89-10058*# Lockheed-Georgia Co., Marietta.
QUADRUPLEX DIGITAL FLIGHT CONTROL SYSTEM ASSESSMENT Final Report
D. B. MULCARE, L. E. DOWNING, and M. K. SMITH Jul. 1988 68 p
(Contract NAS2-11853)
(NASA-CR-182741; NAS 1.26:182741; DOT/FAA/CT-86/30-REV) Avail: NTIS HC A04/MF A01 CSCL 01C

Described are the development and validation of a double fail-operational digital flight control system architecture for critical pitch axis functions. Architectural tradeoffs are assessed, system simulator modifications are described, and demonstration testing results are critiqued. Assessment tools and their application are also illustrated. Ultimately, the vital role of system simulation, tailored to digital mechanization attributes, is shown to be essential to validating the airworthiness of full-time critical functions such as augmented fly-by-wire systems for relaxed static stability airplanes. Author

N89-10059*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DEVELOPMENT IN HELICOPTER TAIL BOOM STRAKE APPLICATIONS IN THE US
JOHN C. WILSON, HENRY L. KELLEY, CYNTHIA C. DONAHUE, and KENNETH R. YENNI Oct. 1988 19 p Prepared for presentation at the International Conference on Helicopter Handling Qualities and Control, London, England, 15-17 Nov. 1988
(NASA-TM-101496; NAS 1.15:101496; AVSCOM-TM-88-B-014) Avail: NTIS HC A03/MF A01 CSCL 01C

The use of a strake or spoiler on a helicopter tail boom to beneficially change helicopter tail boom air loads was suggested in the United States in 1975. The anticipated benefits were a change of tail boom loads to reduce required tail rotor thrust and power and improve directional control. High tail boom air loads experienced by the YAH-64 and described in 1978 led to a wind tunnel investigation of the usefullness of strakes in altering such loads on the AH-64, UH-60, and UH-1 helicopters. The wind tunnel tests of 2-D cross sections of the tail boom of each demonstrated that a strake or strakes would be effective. Several limited test programs with the U.S. Army's OH-58A, AH-64, and UH-60A were conducted which showed the effects of strakes were modest for those helicopters. The most recent flight test program, with a Bell 204B, disclosed that for the 204B the tail boom strake or strakes would provide more than a modest improvement in directional control and reduction in tail rotor power. Author

N89-10832# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Aircraft Div.
COMPUTING SYSTEM CONFIGURATION FOR FIGHTER AIRCRAFT FLIGHT CONTROL SYSTEMS
H. J. KAUL, H. LUEERS, and J. RAUCH *In* AGARD, Computing Systems Configuration for Highly Integrated Guidance Control Systems 32 p Jun. 1988
Avail: NTIS HC A08/MF A01

Flight Control Systems (FCS) for present and future Fighter Aircraft developments are based on three basic technologies, CCV-ACT-digital signal processing. These technologies have opened a new degree of freedom for optimizing overall weapon system performance by extending the requirements to be implemented by the FCS. The computing subsystem of the FCS is the key element of the FCS by which this performance optimization can be achieved. Digital FCS for fighter aircraft in service or under development exhibit a basically common architecture (static parallel redundancy, centralized heavily burdened computing subsystem) which has continuously evolved since the early days of CCV and ACT activities. The objectives of the paper are to relate this classical architecture to the advancing requirements and the new emerging technologies and to analyze its potentials for future developments. Author

N89-10895*# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
A STUDY OF HELICOPTER STABILITY AND CONTROL INCLUDING BLADE DYNAMICS Final Report, Jul. 1983 - Sep. 1987
XIN ZHAO and H. C. CURTISS, JR. Oct. 1988 169 p
(Contract NAG2-244)
(NASA-CR-183245; NAS 1.26:183245) Avail: NTIS HC A08/MF A01 CSCL 01C

A linearized model of rotorcraft dynamics has been developed through the use of symbolic automatic equation generating techniques. The dynamic model has been formulated in a unique way such that it can be used to analyze a variety of rotor/body coupling problems including a rotor mounted on a flexible shaft with a number of modes as well as free-flight stability and control characteristics. Direct comparison of the time response to longitudinal, lateral and directional control inputs at various trim conditions shows that the linear model yields good to very good correlation with flight test. In particular it is shown that a dynamic inflow model is essential to obtain good time response correlation, especially for the hover trim condition. It also is shown that the main rotor wake interaction with the tail rotor and fixed tail surfaces is a significant contributor to the response at translational flight trim conditions. A relatively simple model for the downwash and sidewash at the tail surfaces based on flat vortex wake theory is shown to produce good agreement. Then, the influence of rotor flap and lag dynamics on automatic control systems feedback gain limitations is investigated with the model. It is shown that the blade dynamics, especially lagging dynamics, can severly limit the useable values of the feedback gain for simple feedback control and that multivariable optimal control theory is a powerful tool to design high gain augmentation control system. The

frequency-shaped optimal control design can offer much better flight dynamic characteristics and a stable margin for the feedback system without need to model the lagging dynamics. Author

N89-10896# George Washington Univ., Washington, D.C. Graduate School of Engineering and Applied Science.
INVESTIGATION OF THE TUMBLING PHENOMENON USING COMPUTER SIMULATION M.S. Thesis
SCOTT POWELL FEARS Sep. 1985 138 p
Avail: NTIS HC A07/MF A01

A single degree-of-freedom free-to-pitch simulation of the X-29A was developed and used to investigate the tumble susceptibility of the X-29A with its controls fixed. Validation of the ability of the aerodynamic models used in this simulation to accurately describe tumbling was accomplished by comparing the simulation results to dynamic wind-tunnel test results. The wind-tunnel and simulation results showed a strong tendency to tumble in the nose-down direction for the controls-fixed X-29A. A three degree-of-freedom piloted simulation of the X-29A using similar aerodynamic models was developed and used to test the tumble susceptibility of the X-29A with its controls active. These tests showed that high initial pitch rates are required for tumble entry from trimmed flight. Finally, a parametric study of the aerodynamic characteristics that affect tumble susceptibility was conducted using the single degree-of-freedom simulation and generic aerodynamic data representing the X-29A configuration and a conventional configuration at various static margins. It was shown that an ordinate direction shift in the static pitching-moment data, differences in the pitching-moment magnitudes or alpha ranges of the positive and negative regions of the static pitching-moment data, reduced static margins, reduced stable pitch damping magnitudes, and regions of unstable pitch damping will contribute to the tumble susceptibility of a given configuration. Author

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RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A89-10115#
LASER SHEET TECHNIQUE FOR VISUALIZING A PERIODIC ROTOR WAKE
A. G. BRAND, N. M. KOMERATH, and H. M. MCMAHON (Georgia Institute of Technology, Atlanta) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 667-669. Previously cited in issue 07, p. 955, Accession no. A88-22140. refs

A89-11037#
A DATA ACQUISITION SYSTEM FOR BLADE VIBRATION TEST
CHENGSHENG ZHANG and ZHAOHONG SONG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, April 1988, p. 158-160, 190. In Chinese, with abstract in English. refs

A real-time data acquisition system based on IBM-PC for vibration test is provided. The highest sampling frequency of each channel is 100 kc/s. There are 16 A/D channels and 2 D/A channels in this system. The tests of frequency spectrum analysis and vibration stress distribution of blade have been completed with this system. Author

A89-12550*# Kansas Univ. Center for Research, Inc., Lawrence.
INLET DEVELOPMENT FOR THE NFAC 80- BY 120-FOOT INDRAFT WIND TUNNEL
JOHANNES M. VAN AKEN (University of Kansas Center for Research, Inc., Lawrence), JAMES C. ROSS, and PETER T. ZELL (NASA, Ames Research Center, Moffett Field, CA) AIAA, Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988. 10 p. refs
(AIAA PAPER 88-2528)

This paper describes the inlet design requirements of the National Full-Scale Aerodynamic Complex (NFAC), a closed-loop 4-by-80 foot wind tunnel and indraft 80-by-120 foot wind tunnel. The requirements are based upon desired test section flow quality, atmospheric wind isolation, and noise attenuation. An aerodynamic design study of the inlet treatment is described along with the analysis method and the small-scale testing program used. Measurements taken in the full-scale facility are presented, and the flow quality is summarized. The results are compared with theoretical predictions and small-scale model results. C.D.

A89-12560*# Stanford Univ., Calif.
CONVERGENCE SCHEMES FOR AN ADAPTIVE-WALL WIND TUNNEL
Z. Z. CELIK (Stanford University, CA) and S. BODAPATI (U.S. Naval Postgraduate School, Monterey, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 733-739. Previously cited in issue 18, p. 2818, Accession no. A87-42454. refs
(Contract NCC2-225)

N89-10060*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HIGHLIGHTS OF EXPERIENCE WITH A FLEXIBLE WALLED TEST SECTION IN THE NASA LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
STEPHEN W. D. WOLF (Vigyan Research Associates, Inc., Hampton, Va.) and EDWARD J. RAY Sep. 1988 12 p Previously announced in IAA as A88-37938
(NASA-TM-101491; NAS 1.15:101491) Avail: NTIS HC A03/MF A01 CSCL 14B

The unique combination of adaptive wall technology with a contonuous flow cryogenic wind tunnel is described. This powerful combination allows wind tunnel users to carry out 2-D tests at flight Reynolds numbers with wall interference essentially eliminated. Validation testing was conducted to support this claim using well tested symmetrical and cambered airfoils at transonic speeds and high Reynolds numbers. The test section hardware has four solid walls, with the floor and ceiling flexible. The method of adapting/shaping the floor and ceiling to eliminate top and bottom wall interference at its source is outlined. Data comparisons for different size models tested and others in several sophisticated 2-D wind tunnels are made. In addition, the effects of Reynolds number, testing at high lift with associated large flexible wall movements, the uniqueness of the adapted wall shapes, and the effects of sidewall boundary layer control are examined. The 0.3-m TCT is now the most advanced 2-D research facility anywhere. Author

N89-10897*# National Academy of Sciences - National Research Council, Washington, D. C.
REVIEW OF AERONAUTICAL WIND TUNNEL FACILITIES
27 Jul. 1988 64 p
(Contract NASW-4003)
(NASA-CR-183057; NAS 1.26:183057) Avail: NTIS HC A04/MF A01 CSCL 14B

The nation's aeronautical wind tunnel facilities constitute a valuable technological resource and make a significant contribution to the global supremacy of U.S. aircraft, both civil and military. At the request of NASA, the National Research Council's Aeronautics and Space Engineering Board organized a commitee to review the state of repair, adequacy, and future needs of major aeronautical wind tunnel facilities in meeting national goals. The comittee identified three main areas where actions are needed to sustain the capability of NASA's aeronautical wind tunnel facilities to support the national aeronautical research and development activities: tunnel maintenance and upgrading, productivity enhancement, and accommodation of new requirements (particularly in hypersonics). Each of these areas are addressed

and the committee recommendations for appropriate actions presented. Author

N89-10898# Sandia National Labs., Albuquerque, N. Mex.
SANDIA NATIONAL LABORATORIES FLIGHT SIMULATION FACILITIES
T. M. CRIEL and F. V. WYATT May 1988 14 p
(Contract DE-AC04-76DP-00789)
(DE88-012108; SAND-87-2034) Avail: NTIS HC A03/MF A01

Flight simulation computer facilities and motion simulator facilities at Sandia National Laboratories include an AD-100 (both real-time digital simulation computers), two AD-5s (analog computers), a VAX 11/780 (a digital mainframe), a PDP 11/60 (a digital computer), and a Carco S-450R-3/R three-axis motion simulator. This report describes the current equipment. DOE

N89-10899# Sandia National Labs., Albuquerque, N. Mex. Photometrics and Optical Development Div.
SCHLIEREN MEASUREMENTS AT THE 10,000-FOOT SLED TRACK
R. A. HILL, R. L. HUGHES, and A. A. SEHMER Jul. 1988 19 p.
(Contract DE-AC04-76DP-00789)
(DE88-012748; SAND-88-0497) Avail: NTIS HC A03/MF A01

A schlieren technique has been used at the 10,000-foot sled track to record the interaction of the horizontal bow shock produced by a supersonic sled with the track structure. Under the conditions of these tests, the bow shock reflected from the west retaining wall is observed to interact with the aft portion of the sled; the bow shock reflected from the east rail passes to the rear of the sled. DOE

N89-10900*# California Univ., Davis. Dept. of Mechanical Engineering.
DESIGN AND EVALUATION OF A COCKPIT DISPLAY FOR HOVERING FLIGHT
RONALD A. HESS and PETER JAMES GORDER 2 Oct. 1988 39 p
(Contract NCC2-383)
(NASA-CR-183247; NAS 1.26:183247) Avail: NTIS HC A03/MF A01 CSCL 14B

A simulator evaluation of a cockpit display format for hovering flight is described. The display format is based on the position-velocity-acceleration representation (PVA) similar to that used in the Pilot Night Vision System in the Army AH-64 helicopter. By only varying the nature of the display law driving the primary indicator in the PVA format, i.e., the acceleration symbol, three candidate displays are created and evaluated. These range from a Status display in which the primary indicator provides true acceleration information to a Command display, in which the primary indicator provides flight director information. Simulation results indicate that two of the three displays offer performance and handling qualities which make them excellent candidates for future helicopter cockpit display systems. Author

N89-10901# Oak Ridge National Lab., Tenn.
PROTOTYPE DATA ACQUISITION AND ANALYSIS SYSTEM FOR NAVY OPERATIONAL FLIGHT SIMULATORS
R. C. MULLER, G. O. ALLGOOD, and B. VANHOY 1988 6 p Presented at the American Institute of Aeronautics and Astronautics Simulation Technology Conference, Atlanta, Ga., 7 Sep. 1988
(Contract DE-AC05-84OR-21400)
(DE88-014557; CONF-8809108-1) Avail: NTIS HC A02

A problem of flight simulators has been the discomfort experienced by some pilots to the point of nausea. Likely explanations are a significant lack of synchronization between sight and movement as well as motion in the critical frequency magnitude region. A program to examine this problem has been undertaken at Oak Ridge National Laboratory, and the selection of appropriate computer hardware and software for analyzing motion and visual systems in real time is described. While requirements such as high data acquisition rate and high rates of arithmetic operations have driven the sections, rapid advances in computer technology have guided system development toward easy upgrade at modest cost. Results from use and demonstration have been positive, especially in the areas of reliability and ease of use. DOE

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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.

A89-10691
GLOBAL POSITIONING SYSTEM (GPS) RECEIVER INITIALIZATION METHODS FOR MIL-STD-1760A
ROBERT M. KANE (General Dynamics Corp., Convair Div., San Diego, CA) IN: Aerospace avionics equipment and integration; Proceedings of the Second Conference, Dallas, TX, Nov. 2-4, 1987. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 155-162. refs
(SAE PAPER 872501)

The needs of a store that includes GPS are discussed as well as methods appropriate for a long-term solution to initialization. Alternatives that will reveal the inherent flexibility of GPS and thus permit better short-term compatibilty with existing aircraft are described. Of particular interest are digital initialization, time synchronization, and RF signal delivery. K.K.

A89-11119#
AERODYNAMIC DESIGN AND PERFORMANCE OF A BENT-AXIS GEOMETRY VEHICLE
W. H. RUTLEDGE, G. F. POLANSKY, and E. L. CLARK (Sandia National Laboratories, Albuquerque, NM) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, July-Aug. 1988, p. 257-262. refs
(AIAA PAPER 87-2491)

Variable bent-axis maneuvering vehicles provide a unique type of control for a variety of supersonic and hypersonic missions. Unfortunately, the large hinge moments often associated with these vehicles have prevented their application. This study examines the application of both experimental data and computational aerodynamics techniques in the design of such vehicles. A procedure is presented for the efficient design of a bent-axis geometry given a set of system constraints. In particular, the selection of vehicle parameters to produce minimum hinge moments for trimmed flight is examined in detail. Finally, the overall performance of the bent-axis geometry is reviewed in terms of static stability, lift-to-drag ratio, and control effectiveness. Author

A89-12317
HOTOL COMMAND AND CONTROL SYSTEMS
J. D. ROWLEY (British Aerospace, PLC, London, England) SAE, Aerospace Vehicle Conference, Annapolis, MD, Apr. 18-20, 1988. 15 p.
(SAE PAPER 880929)

HOTOL is intended to provide a low cost means of delivering payloads to low earth orbit. The vehicle is thus designed for unmanned and largely autonomous operations with very limited contact with a ground station. This paper outlines the Command and Control Systems studies undertaken to date and proposed for future phases. Author

N89-10111*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FIRE BEHAVIOR AND RISK ANALYSIS IN SPACECRAFT
ROBERT FRIEDMAN and KURT R. SACKSTEDER 1988 14 p Prepared for presentation at the Winter Annual Meeting of the American Society of Mechanical Engineers, Chicago, Ill., 28 Nov.

- 3 Dec. 1988
(NASA-TM-100944; E-4232; NAS 1.15:100944) Avail: NTIS HC A03/MF A01 CSCL 22B

Practical risk management for present and future spacecraft, including space stations, involves the optimization of residual risks balanced by the spacecraft operational, technological, and economic limitations. Spacecraft fire safety is approached through three strategies, in order of risk: (1) control of fire-causing elements, through exclusion of flammable materials for example; (2) response to incipient fires through detection and alarm; and (3) recovery of normal conditions through extinguishment and cleanup. Present understanding of combustion in low gravity is that, compared to normal gravity behavior, fire hazards may be reduced by the absence of buoyant gas flows yet at the same time increased by ventilation flows and hot particle expulsion. This paper discusses the application of low-gravity combustion knowledge and appropriate aircraft analogies to fire detection, fire fighting, and fire-safety decisions for eventual fire-risk management and optimization in spacecraft. Author

N89-10123*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TECHNOLOGY ISSUES ASSOCIATED WITH FUELING THE NATIONAL AEROSPACE PLANE WITH SLUSH HYDROGEN
NED P. HANNUM 1988 9 p Prepared for presentation at the 7th Joint Intersociety Cryogenic Conference Symposium, Houston, Tex., 22-26 Jan. 1989; sponsored in part by ASME, AIChE and IIR
(NASA-TM-101386; E-4445; NAS 1.15:101386) Avail: NTIS HC A02/MF A01 CSCL 21H

The National Aerospace Plane is a horizontal takeoff and landing, single stage-to-orbit vehicle using hydrogen fuel. The first flights are planned for the mid 1990's. The success of this important national program requires advances in virtually every discipline associated with both airbreathing and space flight. The high heating value, cooling capacity, and combustion properties make hydrogen the fuel of choice, but low density results in a large vehicle. Both fuel cooling capacity and density are increased with the use of slush hydrogen and result in significant reductions in vehicle size. A national program to advance this technology and to find engineering solutions to the many design issues is now under way. The program uses the expertise of the cryogenics production and services industry, the instrumentation industry, universities and governments. The program will be discussed to highlight the major issues and display progress to date. Author

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A89-10069
MICROSTRUCTURAL OPTIMISATION OF TITANIUM ALLOYS FOR DEFECT TOLERANCE IN GAS TURBINE ENGINE COMPONENTS
M. T. COPE, P. J. POSTANS, and M. A. HICKS (Rolls-Royce, PLC, London, England) IN: Microstructure fracture toughness and fatigue crack growth rate in titanium alloys; Proceedings of the 1987 TMS-AIME Annual Symposium, Denver, CO, Feb. 24, 25, 1987. Warrendale, PA, Metallurgical Society, Inc., 1987, p. 137-145.

The paper is concerned with titanium alloy development for high-temperature compressor disc applications, where resistance to low cycle fatigue and creep is of primary importance. Particular attention is given to the problem of reducing the microstructural unit size while maintaining the tortuous nature of the crack path in transformed beta microstructures. Results are presented for aligned and basketweave microstructures in near-alpha alloys used in gas turbine engines, with some observations on crack growth behavior in IMI834, a new high-temperature titanium alloy. V.L.

A89-11103#
ACTIVE CONTROL OF REHEAT BUZZ
A. P. DOWLING, N. HOOPER, P. J. LANGHORNE (Cambridge University, England), and G. J. BLOXSIDGE AIAA Journal (ISSN 0001-1452), vol. 26, July 1988, p. 783-790. Research supported by Rolls-Royce, PLC. Previously cited in issue 08, p. 1152, Accession no. A87-22628. refs

A89-11214
INFLUENCE OF REGENERATION TREATMENTS ON CREEP RUPTURE LIVES OF TURBINE BLADES
W.-B. BUSCH (Fraunhofer-Institut fuer angewandte Materialforschung, Bermen, Federal Republic of Germany) and J. WORTMANN (MTU Motoren- und Turbinen- Union Muenchen GmbH, Munich, Federal Republic of Germany) IN: High temperature alloys: Their exploitable potential. London and New York, Elsevier Applied Science, 1988, p. 337-346.

Experimental data are presented on the regeneration treatment of turbine blades of forged Nimonic 108 alloy to show that hot isostatic pressing offers the possibility of the complete healing of creep voids. Process time and temperatures can be kept sufficiently low to suppress undesirable diffusion processes. After the regeneration treatment described here, the life of test specimens, all of which reached the tertiary creep stage, was at least 75 percent of that of virgin specimens. V.L.

A89-11216
THE HIGH TEMPERATURE OXIDATION BEHAVIOR OF THE SINGLE CRYSTAL NI-BASE ALLOY M002 MOD. WITH AND WITHOUT PROTECTIVE COATINGS
L. PEICHL, J. WORTMANN (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany), and H. -J. RAETZER-SCHEIBE (DFVLR, Cologne, Federal Republic of Germany) IN: High temperature alloys: Their exploitable potential. London and New York, Elsevier Applied Science, 1988, p. 363-373. refs

Cyclic high-temperature oxidation tests were carried out on cylindrical bar (100x8 mm) specimens of the single-crystal Ni-base alloy M002 mod. with an Al coating, a PtAl coating, an MCrAlY coating, and in the uncoated condition. It is found that the oxidation of the specimens increases in the following order: uncoated - Al - PtAl - MCrAlY. With all three coatings, cubic and plate-type W-rich phases are found in the base material. Subsurface porosity forms in the uncoated specimens and in specimens with Al and PtAl coatings after the coating has disintegrated. The MCrAlY coating shows extensive porosity at the coating-substrate interface. V.L.

A89-12330* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DEPOSITION OF NA2SO4 FROM SALT-SEEDED COMBUSTION GASES OF A HIGH VELOCITY BURNER RIG
G. J. SANTORO, F. J. KOHL, C. A. STEARNS (NASA, Lewis Research Center, Cleveland, OH), S. A. GOKOGLU (Analex Corp., Cleveland, OH), and D. A. ROSNER (Yale University, New Haven, CT) IN: High temperature corrosion in energy systems. Warrendale, PA, Metallurgical Society of AIME, 1985, p. 417-434. refs

With a view to developing simulation criteria for the laboratory testing of high-temperature materials for gas turbine engines, the deposition rates of sodium sulfate from sodium salt-seeded combustion gases were determined experimentally using a well instrumented high-velocity burner. In the experiments, Na2SO4, NaCl, NaNO3, and simulated sea salt solutions were injected into the combustor of the Mach 0.3 burner rig operating at constant fuel/air ratios. The deposits formed on an inert rotating collector were then weighed and analyzed. The experimental results are compared to Rosner's vapor diffusion theory. Some additional test results, including droplet size distribution of an atomized salt spray, are used in interpreting the deposition rate data. V.L.

A89-12759* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE EFFECTS OF FLUIDS IN THE AIRCRAFT ENVIRONMENT ON A POLYETHERIMIDE
EDWARD R. LONG, JR. (NASA, Langley Research Center, Cleveland, OH) and WILLIAM D. COLLINS (Old Dominion University, Norfolk, VA) Polymer Engineering and Science (ISSN 0032-3888), vol. 28, no. 12, June 1988, p. 823-828. refs
(Contract NCC1-90)

Fluid absorption studies have been made for a polyetherimide thermoplastic film and a unidirectional composite of the thermoplastic with graphite fibers immersed in water. JP4 jet fuel, ethylene glycol, and hydraulic fluid. The changes in the weight, thickness, and tensile properties were measured for the film. The changes in the flexural properties of the composite were measured for specimens whose fiber orientation was transverse to their length. Only the hydraulic fluid, which caused an erosion or dissolving of the resin at the specimen surface, affected the film's properties. Both the water and the hydraulic fluid affected the flexural properties of the composite, due to capillary absorption along the fiber-resin interface. Author

N89-10125*# Clemson Univ., S.C. Dept. of Mechanical Engineering.
FRACTURE CRITERIA FOR DISCONTINUOUSLY REINFORCED METAL MATRIX COMPOSITES Semiannual Report, 16 Feb. - 15 Aug. 1988
H. J. RACK, J. G. GOREE, J. ALBRITTON, and P. RATNAPARKHI 21 Oct. 1988 152 p
(Contract NAG1-724)
(NASA-CR-181175; NAS 1.26:181175) Avail: NTIS HC A08/MF A01 CSCL 11D

Summarized is the progress achieved during the period September 16, 1987 to August 15, 1988 on NASA Grant NAG1-724, Fracture Criteria for Discontinuously Reinforced Metal Matrix Composites. Appended are copies of three manuscripts prepared under NASA funding during the performance period. Author

N89-10156*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
T55-L-712 TURBINE ENGINE COMPRESSOR HOUSING REFURBISHMENT-PLASMA SPRAY PROJECT
GEORGE W. LEISSLER and JOHN S. YUHAS (Army Aviation Systems Command, Cleveland, Ohio.) Oct. 1988 44 p
(Contract DA PROJ. 1L1-62209-AH-76)
(NASA-TM-101310; E-4301; NAS 1.15:101310) Avail: NTIS HC A03/MF A01 CSCL 11F

A study was conducted to assess the feasibility of reclaiming T55-L-712 turbine engine compressor housings with an 88 wt percent aluminum to 12 wt percent silicon alloy applied by a plasma spray process. Tensile strength testing was conducted on as-sprayed and thermally cycled test specimens which were plasma sprayed with 0.020 to 0.100 in. coating thicknesses. Satisfactory tensile strength values were observed in the as-sprayed tensile specimens. There was essentially no decrease in tensile strength after thermally cycling the tensile specimens. Furthermore, compressor housings were plasma sprayed and thermally cycled in a 150-hr engine test and a 200-hr actual flight test during which the turbine engine was operated at a variety of loads, speeds and torques. The plasma sprayed coating system showed no evidence of degradation or delamination from the compressor housings. As a result of these tests, a procedure was designed and developed for the application of an aluminum-silicon alloy in order to reclaim T55-L-712 turbine engine compressor housings. Author

N89-10161# Massachusetts Inst. of Tech., Cambridge. Dept. of Materials Science and Engineering.
A STUDY OF THE FATIGUE BEHAVIOR OF SMALL CRACKS IN NICKEL-BASE SUPERALLOYS Final Report, 1 Jan. 1984 - 1 Aug. 1987
REGIS M. PELLOUX, JUN FENG, and GLENN ROMANOSKI 24 Feb. 1988 153 p
(Contract AF AFOSR-0075-84; AF PROJ. 2306)
(AD-A195489; AFOSR-88-0457TR) Avail: NTIS HC A08/MF A01 CSCL 11F

The fatigue of behavior of short cracks was investigated in five wrought nickel-base superalloys currently used for aircraft turbine disks. Cracks were initiated at artificial defects and at persistent slip bands. Test frequencies ranged from 20Hz to 10cpm. Fatigue crack growth rates were measured over crack lengths ranging from 10 um to 1mm. Most of the testing was performed in load control with stress ranges approaching the cyclic yield strengths of alloys. Strain controlled tests were performed on IN100 under elastic-plastic cycling conditions. GRA

N89-10167# Lawrence Livermore National Lab., Calif.
DIRECTIONAL SPECTRAL EMISSIVITY MEASUREMENTS ON A CERAMIC MOLD MATERIAL
MARK A. HAVSTAD and WILLIAM MCLEAN Apr. 1988 17 p
(Contract W-7405-ENG-48)
(DE88-015407; UCID-21385) Avail: NTIS HC A03/MF A01

This document describes directional spectral emittance measurements made on a ceramic mold material that is to be used to cast high- temperature turbine rotors. The work was performed at approximately 700 K and 5 x 10 to the -9 Torr in an emissivity measurement apparatus. The results, which show low scatter and conform to expectations derived from both theoretical relations and published ceramic data, give a total hemispherical emissivity of 0.42 + or - 0.04 when integrated over wavelength and direction at 1000 K. DOE

N89-10175# Federal Aviation Agency, Atlantic City, N.J.
THE PERFORMANCE OF ALTERNATE FUELS IN GENERAL AVIATION AIRCRAFT Final Report
AUGUSTO M. FERRARA and RICHARD WARES (IIT Research Inst., Bartlesville, Okla.) Jul. 1988 47 p
(DOT/FAA/CT-88/13) Avail: NTIS HC A03/MF A01

The results of a study which measured the effects of pressure altitude on fuel weathering are described. Samples of unleaded automobile gasoline were exposed to varying pressure altitudes, and the effects of this exposure on aircraft performance and volatility were measured. The composition of the fuel, aircraft configuration, and the initial temperature of the fuel when transferred to the tank were varied to determine the extent these variables affected the aircraft performance. Experiments were conducted which demonstrated that the use of 100 F fuel during aircraft certification will provide the greatest margin of safety. In addition, the suitability of methyl-tertiary-butyl ether as an acceptable fuel for use in general aviation aircraft was demonstrated. Several different oxygenated fuels (including gasolines containing alcohols) were aged in ground-based tests. The results are presented. Author

N89-10179# Federal Aviation Agency, Atlantic City, N.J.
ALTERNATE FUELS FOR GENERAL AVIATION AIRCRAFT WITH SPARK IGNITION ENGINES Final Report
AUGUSTO M. FERRARA Jun. 1988 81 p
(DOT/FAA/CT-88/05) Avail: NTIS HC A05/MF A01

Described are the results of a study into the behavior of several alternate fuels under consideration for use in general aviation aircraft engines. The study consists of a literature search and engine tests using a dynamometer. The literature search identifies material compatibility problems and possible solutions. For the engine tests, a number of gasoline/alcohol blends were prepared using both ethanol and methanol in varying concentrations and the vapor lock behavior was identified. The engine oil was analyzed during the study with the intent of detecting accelerated wear. Based on the results of the study, a number of considerations pertaining to the use of these alternate fuels in general aviation aircraft are identified. Author

N89-10951*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TENSION FATIGUE ANALYSIS AND LIFE PREDICTION FOR COMPOSITE LAMINATES

T. K. OBRIEN, M. RIGAMONTI, and C. ZANOTTI (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy) Oct. 1988 55 p
(NASA-TM-100549; NAS 1.15:100549; AVSCOM-TM-88-B-015)
Avail: NTIS HC A04/MF A01 CSCL 11D

A tension fatigue life prediction methodology for composite laminates is presented. Tension fatigue tests were conducted on quasi-isotropic and orthotropic glass epoxy, graphite epoxy, and glass/graphite epoxy hybrid laminates. Edge delamination onset data were used to generate plots of strain energy release rate as a function of cycles to delamination onset. These plots were then used along with strain energy release rate analyses of delaminations initiating at matrix cracks to predict local delamination onset. Stiffness loss was measured experimentally to account for the accumulation of matrix cracks and for delamination growth. Fatigue failure was predicted by comparing the increase in global strain resulting from stiffness loss to the decrease in laminate failure strain resulting from delaminations forming at matrix cracks through the laminate thickness. Good agreement between measured and predicted lives indicated that the through-thickness damage accumulation model can accurately describe fatigue failure for laminates where the delamination onset behavior in fatigue is well characterized, and stiffness loss can be monitored in real time to account for damage growth. Author

N89-11005# Joint Publications Research Service, Arlington, Va.
EFFECT OF PROTECTIVE COATINGS ON LIFE OF HEAT-RESISTANT NICKEL STEEL UNDER CYCLIC HEAT LOAD Abstract Only
G. N. TRETYACHENKO, G. R. SEMANOV, K. YU. YAKOVCHUK, R. I. KURIAT, I. S. MALASHENKO, A. A. RABINOVICH, and N. P. VASHCHILO *In its* JPRS Report: Science and Technology. USSR: Materials Science p 15 4 Apr. 1988 Transl. into ENGLISH from Problemy Prochnosti (Kiev, USSR), no. 12, Dec. 1987 p 3-7
Avail: NTIS HC A03/MF A01

An experimental study of fireproof coatings on heat-resistant high-chromium nickel steel for gas-turbine blades was made, its purpose being to evaluate their effect on the fatigue resistance of this steel under cyclic heat load in an atmosphere containing products of diesel fuel combustion with up to 0.25 percent sulfur. Two multimetal coating materials Co-Cr-Al-Y and Ni-Co-Cr-Al-Y as well as a double-layer composite material Co-Cr-Al-Y-ZrO sub 2 Y sub 2 O sub 3 (25 to 70 micrometers thick layer of tetragonal + monoclinic Zr sub 2 stabilized by addition of Y sub 2 O sub 3) were tested, having been deposited on prismatic wedges of that steel by the electron-beam vaporization and vacuum condensation process. For comparison, bare wedges were also tested in the same manner. Thermal cycling was done in three separate tests, with the maximum temperature 980 C, 1000 C, 1020 C (pressure 500 MPa) respectively. The life wedges were found to be extended by the coatings in tests with lower maximum temperature. Microstructural examination under MIM-7 and Neophot-2 optical microscopes, X-ray spectral phase analysis in a Cameca microanalyzer, and microhardness measurements with a PMT-3 tester under a 50 g load have revealed that the ceramic layer provides high erosion resistance only, while the metal layer provides the fatigue resistance and is where cracks originate at high temperature. Author

N89-11020# Centre d'Essais Aeronautique Toulouse (France). Section des Essais Mecaniques.
CREEP TESTS FOR SLOW AND FAST FATIGUE CONDITIONS ON ALUMINUM ALLOY SPECIMENS [ESSAIS DE FLUAGE DE FATIGUE LENTE ET RAPIDE SUR DES EPROUVETTES EN ALLIAGES D'ALUMINIUM]
27 Feb. 1987 69 p In FRENCH
(Contract STPA-437103/79)
(REPT-M0-535200; ETN-88-93321; REPT-437103/79) Avail: NTIS HC A04/MF A01

Tests were performed to evaluate the performance of aluminum alloys used in supersonic aircraft construction, as well as riveted joints assemblied with titanium alloy rivets. The creep tests were carried out at temperatures from 80 to 120 C. Results show acceptable values in the case of fatigue and fast fatigue tests, while the behavior of creep normal specimens is anomalous. The test conditions are discussed. ESA

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ENGINEERING

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

A89-10076* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ADHESIVELY BONDED JOINTS: TESTING, ANALYSIS, AND DESIGN; PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM, BALTIMORE, MD, SEPT. 10-12, 1986
W. S. JOHNSON, ED. (NASA, Langley Research Center, Hampton, VA) Symposium supported by ASTM. Philadelphia, PA, American Society for Testing and Materials, 1988, 324 p. For individual items see A89-10077 to A89-10095.

The papers contained in this volume provide an overview of the state of the art of testing, analysis, and design of adhesively bonded joints. The papers are grouped in the following sections: mechanical testing, stress analysis, failure mechanisms, and design and durability. Specific topics discussed include determination and verification of elastic parameters for adhesives; factors influencing elastic stresses in double cantilever beam specimens; special mixed finite elements for interfacial stress analysis of ahesively bonded joints; debonding characteristics of adhesively bonded woven Kevlar composites; and environmental durability of adhesively bonded joints. V.L.

A89-10091* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECT OF ADHESIVE DEBOND ON STRESS-INTENSITY FACTORS IN BONDED COMPOSITE PANELS
C. A. BIGELOW (NASA, Langley Research Center, Hampton, VA) IN: Adhesively bonded joints: Testing, analysis, and design; Proceedings of the International Symposium, Baltimore, MD, Sept. 10-12, 1986. Philadelphia, PA, American Society for Testing and Materials, 1988, p. 209-228. refs

Stress-intensity factors are calculated for a cracked infinite sheet adhesively bonded to a stringer, and debonding of the adhesive layer is predicted. The stringer is modeled as a semiinfinite sheet. Adhesive nonlinearity is also included. Both the sheet and stringer are treated as homogeneous, orthotropic materials, a set of integral equations is formulated and solved to obtain the adhesive shear stresses and crack-tip stress-intensity factors. Adhesive debonding is predicted using a rupture criterion based on the combined adhesive stresses. A through-the-thickness crack is located in the infinite sheet perpendicular to the edge of the stringer. When the crack is not under the stringer, the debond extends along the edge of the stringer. When the crack tip is beneath the stringer, the debond extends to the crack tip, then along the edge of the stringer. Stress levels required for debond initiation decrease as the crack tip is moved beneath the stringer. With a nonlinear adhesive, the debond initiates at higher applied stress levels than in linear adhesive cases. Compared with the linear adhesive solution, modeling a nonlinear adhesive causes the stress-intensity factor to decrease when debonding is included. Author

A89-10093
STRESS ANALYSIS CONCEPTS FOR ADHESIVE BONDING OF AIRCRAFT PRIMARY STRUCTURE
RAYMOND B. KRIEGER, JR. (American Cyanamid Co., Havre de Grace, MD) IN: Adhesively bonded joints: Testing, analysis, and

design; Proceedings of the International Symposium, Baltimore, MD, Sept. 10-12, 1986. Philadelphia, PA, American Society for Testing and Materials, 1988, p. 264-275. refs

This paper is a summation of the author's work toward creating valid stress analysis of adhesively bonded structure. The context is airframe construction, specifically metal to metal bonds, and excluding sandwich structure. A model joint is presented as being a basic representation of the problem. A linear formula is given to calculate the maximum stress on the joint. This is seen to be stiffness driven, hence the adhesive shear stiffness is indispensable. Two extensometers are described as follows: KGR-1 for adhesive shear stress versus strain, and KGR-2 for maximum adhesive strain on the model joint. An actual design is discussed, including adhesive selection by strain properties and adhesive quality controlboy adhesive stress versus strain data. Author

A89-10095
ENVIRONMENTAL DURABILITY OF ADHESIVELY BONDED JOINTS

LARRY R. PITRONE and STANLEY R. BROWN (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: Adhesively bonded joints: Testing, analysis, and design; Proceedings of the International Symposium, Baltimore, MD, Sept. 10-12, 1986. Philadelphia, PA, American Society for Testing and Materials, 1988, p. 289-303. refs

Effective determination of adhesively bonded joint durability is crucial for reliable component design and realization of advanced performance. In order to model bond endurance in a manner more consistent with severe service environments, a cyclic stress durability apparatus that achieved constant shear stress without loss due to creep relaxation was designed and implemented for accelerated joint durability analysis of two modified epoxy based structural adhesives. Results were compared with those achieved by sustained stress durability. Thermal analysis of the bulk adhesives, both before and after hygrothermal exposure, was compared with bonded joint mechanical and durability performance to explore the potential utility of thermal analytical methods in describing adhesive joint properties. Two cure histories for each adhesive were investigated to establish bonded joint performance and environmental resistance for conventional joint fabrication and potential adhesive/adherend co-curing capabilities. Author

A89-10096
SWEDISH SYMPOSIUM ON RESIDUAL STRESSES, SUNNE, SWEDEN, MAR. 30-APR. 2, 1987, PROCEEDINGS

TORSTEN ERICSSON, ED. (Linkoping Institute of Technology, Sweden) and JENS BERGSTROM, ED. (Uddeholms AB, Hagfors, Sweden) Symposium organized by Linkoping Institute of Technology; Supported by the Uddeholm Research Foundation. Hagfors, Sweden, Uddeholms AB, 1987, 296 p. For individual items see A89-10097 to A89-10099.

The papers presented in this volume focus on recent theoretical and experimental research in residual stresses, with the areas covered including the mechanisms of residual stress buildup, stress introduction through different processes, residual stress measurements, and possible design applications. Papers are presented on residual stresses due to machining and their influence on the fatigue properties of steel, residual stresses in coatings, residual stresses and distortion due to welding, and influence of residual stress fields on fatigue crack propagation. V.L.

A89-10099#
FATIGUE LIFE INFLUENCE OF RESIDUAL STRESSES FROM COLD WORKING AND HIGH SPECTRUM LOADS IN AIRCRAFT STRUCTURAL DESIGN

THOMAS JOHANSSON and SVEN-ERIK LARSSON (Saab-Scania AB, Linkoping, Sweden) IN: Swedish Symposium on Residual Stresses, Sunne, Sweden, Mar. 30-Apr. 2, 1987, Proceedings. Hagfors, Sweden, Uddeholms AB, 1987, p. 246-265. refs

Experimental data are presented on the residual stresses and fatigue lives of cold worked attachment lugs of AA7010-T73651 aluminum alloy with expanded holes. It is shown that the expansion methods used (split sleeve cold expansion and roller burnishing) improve the fatigue life of the lugs by creating compressive stresses around the hole. The improvement is a factor of 2-2.5 in comparison with nonexpanded reference lugs. The relaxation of residual stresses due to external loads is investigated by nonlinear finite element analysis, and a method is proposed for calculating cumulative fatigue damage with allowance for residual stresses. V.L.

A89-10121#
PACKAGED FIBER OPTIC GYROS WITH HIGH BIAS STABILITY

P. GROELLMANN, J. HERTH, M. KEMMLER, K. KEMPF, G. NEUMANN (LITEF GmbH, Litton Technische Werke, Freiburg im Breisgau, Federal Republic of Germany) et al. IN: Symposium Gyro Technology 1987; Proceedings of the Symposium, Stuttgart, Federal Republic of Germany, Sept. 22, 23, 1987. Stuttgart/Duesseldorf, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1987, p. 4.0-4.17. BMFT-supported research. refs

LITEF is developing a fiber optic gyro of the 0.1 deg/h class for strapdown system applications. At the same time, modifications are being performed on the LTR-81 attitude and heading reference system to allow its use as a fiber gyro testbed. Flight tests are scheduled for the end of 1988. This paper gives an overview of the gyro design, its components, and test results achieved. Author

A89-10154
TURBULENCE MANAGEMENT AND RELAMINARISATION; PROCEEDINGS OF THE IUTAM SYMPOSIUM, BANGALORE, INDIA, JAN. 19-23, 1987

H. W. LIEPMANN, ED. (California Institute of Technology, Pasadena) and R. NARASIMHA, ED. (National Aeronautical Laboratory; Indian Institute of Science, Bangalore, India) Symposium sponsored by IUTAM, Indian National Science Academy, CSIR, et al. Berlin and New York, Springer-Verlag, 1988, 530 p. For individual items see A89-10555 to A89-10181.

Theoretical, experimental, and applications aspects of turbulence control are examined in reviews and reports of recent investigations. Topics addressed include structures, outer-layer devices, and surface manipulation for wall-bounded flows; dynamics and control of the transition to turbulence; relaminarization; natural laminar flows; free shear flows; and separated flows. Consideration is given to measurements in a synthetic turbulent boundary layer (TBL), TBL modeling and manipulation for zero and adverse pressure gradients, high-Reynolds-number LEBU devices, turbulence management by groove roughness, numerical simulations of transition in a decelerating boundary layer, xanthan-gum turbulent-drag reduction, the pairing process in an excited plane TBL, turbulent mixing in accelerating jets, and the structure and control of a turbulent reattaching flow. T.K.

A89-10159
TURBULENT BOUNDARY LAYER MANIPULATION AND MODELLING IN ZERO AND ADVERSE PRESSURE GRADIENTS

A. M. SAVILL (Cambridge University, England) IN: Turbulence management and relaminarisation; Proceedings of the IUTAM Symposium, Bangalore, India, Jan. 13-23, 1987. Berlin and New York, Springer-Verlag, 1988, p. 69-83. Research supported by Rolls-Royce, PLC. refs

Results are reported from experimental investigations of (1) the zero-pressure-gradient boundary layer behind a single flat-plate manipulator and (2) a tandem manipulated layer subjected to a strong adverse pressure gradient. Data obtained using hot-wire anemometry, sublayer-scale fence skin-friction measurements, and Preston tubes are presented in extensive graphs and discussed in detail, with particular attention to problems of empirical turbulence modeling. It is found that the reductions in skin friction produced by the manipulator plates result from a combination of direct action on the boundary layer, interactions between manipulator wake vortices and the modified eddy structure, and a shielding action

of the wake as a new internal layer grows. Good predictive accuracy is achieved using the modified ASM model of Leschziner (1986).
T.K.

A89-10163
THE WALL-PRESSURE FLUCTUATIONS OF MODIFIED TURBULENT BOUNDARY LAYER WITH RIBLETS
KWING-SO CHOI (British Maritime Technology, Ltd., Teddington, England) IN: Turbulence management and relaminarisation; Proceedings of the IUTAM Symposium, Bangalore, India, Jan. 13-23, 1987. Berlin and New York, Springer-Verlag, 1988, p. 149-160. Research supported by the Department of Trade and Technology of England. refs

An experiment was carried out in a wind tunnel, where the wall pressure fluctuations were measured in a modified turbulent boundary layer with riblets, and the results were compared with those without riblets. It was found that the rms intensity was reduced by 4 percent by the surface modification, most of which was the low-frequency component in the energy spectrum. This moderate reduction seemed to be a result of the reduced turbulence intensity confined within a small volume close to the riblet surface.
Author

A89-10173
ON THE PAIRING PROCESS IN AN EXCITED, PLANE, TURBULENT MIXING LAYER
I. WYGNANSKI and I. WEISBROT (Tel Aviv University, Israel) IN: Turbulence management and relaminarisation; Proceedings of the IUTAM Symposium, Bangalore, India, Jan. 13-23, 1987. Berlin and New York, Springer-Verlag, 1988, p. 409-422. refs
(Contract AF-AFOSR-86-0323; N00014-85-K-0412)

The flow field in a plane turbulent mixing layer which was disturbed by a small oscillating flap was investigated. Three experiments were carried out: one in which the flap oscillated sinusoidally at a single frequency; a second in which the flap oscillated at two frequencies, a fundamental and a subharmonic, but the ensuing motion was dominated by the fundamental perturbation; and a third in which the amplitude of the subharmonic perturbation was increased until a distortion in the mean flow was noticeable. Two velocity components were measured at all phase angles relative to the subharmonic oscillation of the flap at densely spaced intervals. The data were used to map the vorticity fields and streak-line patterns, for the purpose of assessing the relevance of the latter to the understanding of the dynamical process.
Author

A89-10181
CONTROL OF SEPARATED FLOW ON A SYMMETRIC AIRFOIL
CHIANG SHIH, MARIO LEE, and CHIN-MING HO (Southern California, University, Los Angeles, CA) IN: Turbulence management and relaminarisation; Proceedings of the IUTAM Symposium, Bangalore, India, Jan. 13-23, 1987. Berlin and New York, Springer-Verlag, 1988, p. 515-524. refs
(Contract F49620-85-C-0080)

On a stationary NACA 0012 airfoil, the separated flow and its control were examined in an unsteady free stream. The experiment was carried out in an unsteady water channel. Desired acceleration histories were obtained by controlling the free stream velocity of the channel. The initial separation process and the downstream development were studied in detail. Based upon this information, control devices were placed on the airfoil and significant modifications on the flow were observed.
Author

A89-10182
ADVANCED BOUNDARY ELEMENT METHODS; PROCEEDINGS OF THE IUTAM SYMPOSIUM, SAN ANTONIO, TX, APR. 13-16, 1987
T. A. CRUSE, ED. (Southwest Research Institute, San Antonio, TX) Symposium sponsored by IUTAM, Southwest Research Institute, Daimler-Benz AG, and NSF. Berlin and New York, Springer-Verlag, 1988, 506 p. For individual items see A89-10183 to A89-10201.

The fundamental principles of the BEM and specific algorithms, numerical modeling approaches, and engineering applications are discussed in reviews and reports. Topics addressed include a hybrid formulation for the Green function in stratified media, advanced BEMs and coupled methods in geomechanics, a dual-reciprocity boundary element for parabolic problems, BEMs for three-dimensional optimum design, nonlinear analysis of elastic plates using the BEM, and single-integral equations for scattering by a penetrable obstacle. Consideration is given to a polar coordinate integration scheme with a hierarchical correction procedure, cubic interpolation and special elements in two-dimensional potential problems with the BEM, integral-equation analysis of elastic shells, and a boundary-integral-equation method with higher computational accuracy.
T.K.

A89-10261
AUTOMATED OPTICAL INSTRUMENT FOR EXTRACTING WATER DROPLET IMPINGEMENT DATA FROM WIND TUNNEL EXPERIMENTS
G. A. FREUND, JR., F. M. DICKEY, R. ELANGOVAN, M. D. BREER (Boeing Military Airplane Co., Wichita, KS), and M. PAPADAKIS (Wichita State University, KS) IN: Current developments in optical engineering II; Proceedings of the Meeting, San Diego, CA, Aug. 18-21, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 148-156. Research supported by Boeing Co. refs

Extraction of empirical water droplet impingement characteristics from records of wind tunnel dye-tracer experiments has been an extremely time consuming process in the past. Described are a method for extracting impingement data by measuring optical reflectance and a computer controlled laser reflectometer which was designed and built for making these measurements. The instrument increases the efficiency of the data extraction process by at least an order of magnitude. The accuracy of the reflectometer is discussed and some results obtained with the reflectometer are presented. The results are used to verify three-dimensional particle trajectory computer codes, which may then be used for design analysis and certification of aircraft antiicing/deicing systems.
Author

A89-10359
FIBER-OPTIC SENSOR SYSTEMS FOR AEROSPACE APPLICATIONS
E. UDD, R. J. MICHAL, S. E. HIGLEY, J. P. THERIAULT, P. LECONG (McDonnell Douglas Astronautics Co., Huntington Beach, CA) et al. IN: Fiber optic and laser sensors V; Proceedings of the Meeting, San Diego, CA, Aug. 17-19, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 162-168.

Advanced aircraft and spacecraft will require fiber-optic sensor systems to monitor the environment around the platform as well as the structural integrity of the vehicle itself. These sensors when embedded in composite or metal matrix material can also be used to monitor the manufacturing process. Thus, this technology provides a means to sense key environmental parameters from the creation of parts, through assembly, test and flight for the life of the platform.
Author

A89-10512
TRANSITION RECOGNITION IN AIRCRAFT WING PROFILES WITH THE AID OF PIEZOELECTRIC SHEETINGS [TRANSITIONSERKENNUNG AN TRAGFLUEGELPROFILEN MIT HILFE PIEZO-ELECTRISCHER FOLIEN]
P. MIROW (Berlin, Technische Universitaet, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 190-198. In German. refs
(DGLR PAPER 87-065)

The structure of a new type of piezoelectrical sheeting measurement system for recording pressure and shear stress variations in bodies surrounded by flow. A series of measurement results pertaining to transition processes on a 24 deg swept-back

model aircraft wing is reported. The sheet rms values with wall shear values are compared for the same wing. Details of the transition and the excitation process are demonstrated using frequency analysis. Sum and difference signals from the sheet sensors show differential changes over the profile depth, allowing the pressure and shear variations to be determined. Coherent flow structures are recognizable when the pressure variations are normalized, and correlation measurements permit predictions to be made concerning the local signal propagation velocity. C.D.

A89-10543#
FLOW PAST CIRCULAR CYLINDER OF FINITE LENGTH PLACED ON GROUND PLANE
SHIKI OKAMOTO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 414, 1988, p. 343-350. In Japanese, with abstract in English. refs

This paper describes an experimental study of the changes of vortices formation and turbulent wake from a circular cylinder placed on a ground plane. The experiment was carried out in a blow down wind-tunnel having a working section of 500 mm x 5000 mm x 2000 mm in size at Reynolds number 25,000 to 47,000. The surface-pressure distributions on the circular cylinder were measured and the drag coefficient was determined from them. The vortices generated in the flow-field around a circular cylinder have also been observed and the velocity defects and turbulent intensities in the turbulent wake behind the circular cylinder were measured. Consequently, it is found that the flow pattern changes rapidly from H/D = 4, while the shedding vortices change from arch type to Karman type. Author

A89-10573
THE ELECTROCHEMICAL EROSION OF SERVO VALVES BY PHOSPHATE ESTER FIRE-RESISTANT HYDRAULIC FLUIDS
W. D. PHILLIPS (Ciba-Geigy Industrial Chemicals, Manchester, England) (Society of Tribologists and Lubrications Engineers, Annual Meeting, 42nd, Anaheim, CA, May 11-14, 1987) Lubrication Engineering (ISSN 0024-7154), vol. 44, Sept. 1988, p. 758-767. refs

The problem of the electrochemical erosion of servo valves in hydraulic systems using phosphate ester fire-resistant hydraulic fluids is reviewed with reference to past experience in turbine governor controls and commercial aircraft hydraulics. It is shown that the susceptibility of servo valves to electrochemical erosion or pitting corrosion is determined by a variety of factors, such as the pressure drop across the valve or the fluid flow rate through the orifice and the size of the orifice. The zeta potential of the fluid also plays an important but, as yet, unquantified role, while fluid conductivity/resistivity does not appear to be an important factor. V.L.

A89-10670
A FREQUENCY DOMAIN MIMO MODAL IDENTIFICATION METHOD WITH APPLICATION IN THE AIRCRAFT GROUND VIBRATION TEST
LINGMI ZHANG (Nanjing Aeronautical Institute, People's Republic of China) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 499-505. refs
(SAE PAPER 872458)

This paper presents a frequency-domain MIMO identification method. The accuracy, reliability, and ability of handling repeated modes are verified by computer simulation and practical structures. The application to an aircraft ground vibration test is given. The results show: (1) that (compared with the traditional multipoint sine-excitation phase-resonance method) operation is simplified, testing time is reduced, reliability is improved; and (2) that (compared with time-domain MIMO methods developed over the past several years) the order of the system (the number of modes) can be identified directly. The calculating time is reduced, and the need for the user to judge between structural modes and noise modes is avoided. Author

A89-10671
FATIGUE TESTING OF FULL-SCALE ALL-COMPOSITE AIRCRAFT WINGS
N. MILESHKIN, M. L. SCOTT, L. A. WOOD, and D. R. COLLYER (Royal Melbourne Institute of Technology, Australia) IN: International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 13-17, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 507-512.
(SAE PAPER 872459)

A full scale fatigue test program has been established which will test a sailplane wing set to destruction. A flight loads data acquisition program using the instrumented high performance sailplane owned by the Royal Melbourne Institute of Technology has been conducted to determine the loading cases and spectrum. The aircraft structure is of glass fiber reinforced polymeric composite material construction. One wing was new at the commencement of the fatigue test, while the other is a repaired wing salvaged from a damaged sailplane. The test of the repaired wing will enable the fatigue performance of repair techniques to be evaluated. In parallel with the full scale fatigue test, tests on notched and plain glass fiber specimens will be used to establish material scatter factors which can be employed in safe fatigue life estimation. A comprehensive finite element model of the wing is being developed in support of the full scale tests. Author

A89-10676
AEROSPACE AVIONICS EQUIPMENT AND INTEGRATION; PROCEEDINGS OF THE SECOND CONFERENCE, DALLAS, TX, NOV 2-4, 1987
Conference sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE P-205), 1988, 178 p. For individual items see A89-10677 to A89-10692.
(SAE P-205)

The conference presents papers on hybrid MIL-STD-1553B/1773 electrical/optical buses, the use of interrupts on the IBM PC to generate major and minor frame times, and the use of the IBM PC for MIL-STD-1553 testing. Other topics include single-chip solution of MIL-STD-1553A and MIL-STD-1553B data communications, a simulation model of the SAE AE-9B high speed ring bus, and a high performance duel mode synchronous/asynchronous parallel bus controller utilizing the PI bus standard protocol. Consideration is also given to token rotation timer implementation and global positioning system receiver initialization methods for MIL-STD-1760A. K.K.

A89-10677
UT1760A RTS - A LOW-COST MONOLITHIC REMOTE TERMINAL STORES INTERFACE FOR MIL-STD-1760A
JOHN W. PRESSPRICH and MARTIN P. SOQUES (United Technologies Microelectronics Center, Colorado Springs, CO) IN: Aerospace avionics equipment and integration; Proceedings of the Second Conference, Dallas, TX, Nov. 2-4, 1987. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 1-5.
(SAE PAPER 872481)

The paper presents a low-cost monolithic remote terminal stores interface (RTSI) for MIL-STD-1760A applications. The UT1760A RTS can significantly reduce the cost/space problem associated with applying MIL-STD-1553B within MIL-STD-1760A by integrating a dual redundant remote terminal interface and 16K of memory in one 68-pin device. The internal architecture of the part relieves the host from most data management tasks associated with MIL-STD-1553B processing by offering a use-defined RAM addressing scheme. K.K.

A89-10683
SINGLE-CHIP SOLUTION OF MIL-STD-1553A AND MIL-STD-1553B DATA COMMUNICATIONS
ROBERT J. BAUER (United Technologies Microelectronics Center, Colorado Springs, CO) IN: Aerospace avionics equipment and integration; Proceedings of the Second Conference, Dallas, TX, Nov. 2-4, 1987. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 63-69.
(SAE PAPER 872488)

Several versions of the Avionics Time-Multiplexed 1553 serial communication standards are in use. Solutions available for some 1553 protocols are often large and complex, and are not designed to be usable for more than one protocol. This paper describes the basic differences among the 1553 protocols, and discusses the system and architectural aspects of a single-chip solution that meet all requirements for a complete dual-redundant Bus Controller and Remote Terminal (BCRT) for the following 1553 standards: MIL-STD-1553A, MIL-STD-1553B, McDonnell Douglas A3818, McDonnell Douglas A5332, McDonnel Douglas A5690, and Grumman Aerospace SP-G-151A. Easily integrated into a variety of system architectures and requiring little CPU overhead, the single-chip device contains all memory management, error logging, and a simple-to-use processor interface. Author

A89-10686
A CANDIDATE FOR LINEAR TOKEN-PASSING, HIGH-SPEED DATA BUS SYSTEMS
JAMES H. NELSON (Northrop Corp., Aircraft Div., Hawthorne, CA), LARRY T. SHAFER (McDonnell Aircraft Co., Saint Louis, MO), DARYLE B. HAMLIN, and JAMES J. HERRMANN (Unisys Corp., Computer Systems Div., Saint Paul, MN) IN: Aerospace avionics equipment and integration; Proceedings of the Second Conference, Dallas, TX, Nov. 2-4, 1987. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 105-120.
(SAE PAPER 872494)

A candidate high-speed data bus protocol has been developed to meet the needs of data bases for distributed real-time fault-tolerant architectures of the future. Performance characteristics are described with attention given to token-passing protocol, fiber-optics implementation, and host interface. A functional block diagram of a dual redundant HSDB network is provided. K.K.

A89-10687
ON HIGH-SPEED DATA BUS PERFORMANCE ANALYSIS
M. T. LUDVIGSON (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: Aerospace avionics equipment and integration; Proceedings of the Second Conference, Dallas, TX, Nov. 2-4, 1987. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 127-131.
(SAE PAPER 872496)

The use of average throughput analysis in determining the relative performance of high-speed data bus networks is examined. The performance of four different linear bus implementations and the SAE ring bus are considered in terms of low to moderate, high, and worst case throughput delays, and theoretical maximum throughput. It is found that average performance analysis is not a reliable predictor for bus performance at high levels of randomly offered traffic. For linear buses, it was found that preamble, token, and station response time had a significant effect on average performance. It is suggested that ring buses operating at the same data rates will experience significantly longer maximum (worse case) delays than linear buses. K.K.

A89-10688
TOKEN ROTATION TIMER IMPLEMENTATION
M. T. LUDVIGSON (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: Aerospace avionics equipment and integration; Proceedings of the Second Conference, Dallas, TX, Nov. 2-4, 1987. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 133-138.
(SAE PAPER 872497)

Token rotation timers have been shown to be an effective means for offering preferential treatment, in terms of message delays, for certain critical messages in linear (star) high-speed data bus configurations. If a token rotation timer has expired, indicating that a prescribed time has transpired during the current token rotation, then a low priority message will not be sent. If all messages are not sent on the first available token, then some degradation in overall message delay performance occurs. Several methods of token rotation timer implementation are examined to determine the relative impact of each on overall bus performance. Author

A89-10714
OPERATING SAFETY OF AUTOMATIC OBJECTS [BEZOPASNOST' FUNKTSIONIROVANIIA AVTOMATIZIROVANNYKH OB'EKTOV]
ANATOLII VLADIMIROVI MAIOROV, GENRIKH KARLOVICH MOSKATOV, and GEORGII PETROVICH SHIBANOV Moscow, Izdatel'stvo Mashinostroenie, 1988, 264 p. In Russian. refs

Operating-safety assurance for automatic objects (aircraft, spacecraft, and underwater vehicles) is considered in the framework of safety-automata theory and automatic-control considerations. The interaction between the operator and the safety-assurance facilities is considered. Methodological recommendations are presented on the specification of reliability requirements for the vehicles considered, as well as on automata synthesis and analysis considerations, test planning, and the analysis of test results. B.J.

A89-10774
A STUDY OF THE ACCURACY OF WING CALCULATIONS BASED ON DIFFERENT SCHEMES [ISSLEDOVANIE TOCHNOSTI RASCHETA KRYLA PO RAZLICHNYM SKHEMAM]
S. I. PUTILIN and V. T. SAVCHENKO (AN USSR, Institut Gidromekhaniki, Kiev, Ukrainian SSR) Gidromekhanika (ISSN 0367-4088), no. 58, 1988, p. 41-47. In Russian. refs

Solutions obtained for the same flow problem using different vortex and computation point distribution laws are presented. The problem considered here is the plane problem for a plate near a circular contour, which is relevant to the design of wings with optimal load distribution and low aspect ratio wings in a bounded fluid. Ways to improve the accuracy of the results are discussed. V.L.

A89-11028#
AN EXPERIMENTAL INVESTIGATION ON THE BISTABLE BEHAVIORS OF A FLEXIBLE ROTOR-SQUEEZE FILM DAMPER SYSTEM
CHANGSHENG ZHU, XINHAI FENG (Gas Turbine Establishment, Jang You, People's Republic of China), and JIANKANG XU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, April 1988, p. 105-108, 184. In Chinese, with abstract in English. refs

The bistable behaviors of a resonance type which occurred near main resonance speed of the system are investigated, based on experiments with a flexible rotor-squeeze film damper system. The influences of unbalance speed, radial clearance ratio, centralizing spring stiffness, and acceleration process on the behaviors are considered. It is shown that the squeeze film damper is effective only within a certain unbalance range. If the unbalance is large enough, the bistable operation may occur. Author

A89-11029#
THE BISTABLE BEHAVIOR OF A RIGID ROTOR WITH SQUEEZE FILM DAMPER
LITANG YAN, SHIPING ZHANG, QIHAN LI, and FUAN ZHAO (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, April 1988, p. 109-112, 184, 185. In Chinese, with abstract in English.

The bistable behaviors of the rigid rotor with centralizing spring and squeeze film damper are studied by means of calculations and experiments. The bistable behaviors are characterized by the variations of eccentricity, transmissibility and Lagging phase angle. The results calculated and experimental data are in a good agreement. The bistable operation of the rotor can be eliminated at operating speeds if only the bearing parameters including the length and clearance of the film damper, and the stiffness of the centralizing spring are chosen properly over a certain unbalance range of the rotor. Author

A89-11032#
A CIRCULAR CONE SURFACE SHAPING METHOD FOR FAN BLADE
MINGHUI HAN and YAJUN LU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, April 1988, p. 123-126, 186. In Chinese, with abstract in English.

A new method, circular surface shaping method, has been developed to shape the sheet metal twisted blade. By changing the conical point angle and the location of the blade on the conic surface, this method can satisfy the various radial laws and make the shaped blade meet the specifications of this aerodynamic design much better. The forwardswept blade shape can be obtained by controlling the blade location on the circular cone surface. As a result, a new design and manufacturing method is provided for sheet metal twisted blade shaping. The method is of great practical and economic value. Author

A89-11033#
CALCULATION OF COMPRESSIBLE FLOW AND HEAT TRANSFER ON A ROTATING DISK
DINGYI WU and SONGLING LIU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, April 1988, p. 135-139, 187. In Chinese, with abstract in English. refs

In this paper, the 'BOX' method is extended to swirling compressible flow on a body of revolution, after the boundary layer equation is nondimensionalized. The torque coefficients and local heat transfer coefficients in the laminar, turbulent, and transitional flow regions on the rotating disk are calculated. The variable air properties are taken into account in the calculation. The investigation shows that the modified two-layer turbulence model is suitable for the calculation of the flow on the rotating disk. An appropriate analytical formulation of the turbulence model and relevant constants are also given. Author

A89-11039#
A DESIGN METHOD OF 'WIGGLESTRAP' FILM-COOLING CONSTRUCTION OF FLAME TUBE
CHANGLIN LI (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, April 1988, p. 164-166, 190. In Chinese, with abstract in English.

This paper presents a calculation method for the design of three types of 'wigglestrap' film-cooling construction (i.e., the square, the trapeze, and the double circle arc constructions) which are applied to the flame tube of an aeroengine. When the airflow distribution and the corresponding airflow passage section areas are given, all parameters of the construction can be determined. Author

A89-11046#
BEVEL GEAR RESONANCE FAILURES IN CENTRAL GEARING SYSTEM OF AN AEROENGINE
EJUN XU, SHICHANG LIANG, CHUNJIANG CHANG, and BINGYAN SHEN (Shenyang Aeroengine Research Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, July 1988, p. 193-198, 279. In Chinese, with abstract in English.

The resonance failures of the bevel gear in the central gearing system of a specific aircraft engine have been investigated experimentally. The features of the resonance failures, the failure modes, and the structural dynamic characteristics are summarized, and the reasons for resonance are clarified. Some preventive measures against the failures are suggested, and criteria for the dynamic-strength design of this type of gear are specified. Author

A89-11066#
STEADY-STATE UNBALANCE RESPONSES FOR A MULTISPAN ROTOR
PINGZHEN REN (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 3, July 1988, p. 277, 278, 288. In Chinese, with abstract in English.

A node transfer matrix is deduced which considers the angular stiffness and damping in spline coupling. The steady-state unbalance responses for a rotor with several spans are obtained by using the Lund method and the simplified transfer-matrix method. Using a model rotor, the damping ratio, eccentricity, and deflection have been measured with the amplitude-frequency characteristic method. The steady-state unbalance responses have been obtained from these data. The analytical and experimental results are in good agreement. Author

A89-11251
COMPOSITES IN SHOCK AND VIBRATION ISOLATION
H. RAY (U.S. Army, Materials Technology Laboratory, Watertown, MA) Journal of Composites Technology and Research (ISSN 0885-6804), vol. 10, Fall 1988, p. 125-128.
(Contract F49620-82-C-0035)

This paper is concerned with the contol of force on an armor plate of a combat aircraft caused by the central normal impact of a projectile and transmitted to the supports of plates, where there is not enough space for the plate to move normal to the plane of the plate. .The analysis requires the use of composite isolators which allow the plate to rotate in plane, so that less space is required normal to the plane of the plate. In this case, the impact energy is absorbed in the rotational direction in addition to the usual normal to the plane of the plate. To control the force transmitted to the support, the natural frequency of the system must be controlled. The results of the analysis demonstrate the effects of fiber orientation and the material properties of a composite isolator on the natural frequency of the plate and composite support system. It is shown that the natural frequency of the plate-support system can be reduced even if the stiffness of the supports is increased. I.S.

A89-11426
FRACTURE MECHANICS; PROCEEDINGS OF THE NINETEENTH NATIONAL SYMPOSIUM, SAN ANTONIO, TX, JUNE 30-JULY 2, 1986
THOMAS A. CRUSE, ED. (Southwest Research Institute, San Antonio, TX) Symposium sponsored by ASTM and Southwest Research Institute. Philadelphia, PA, American Society for Testing and Materials, 1988, 950 p. For individual items see A89-11427 to A89-11449.

The papers contained in this volume provide an overview of current theoretical and experimental research in the field of fracture mechanics. Topics discussed include three-dimensional issues, computational and analytical issues, damage tolerance and fatigue, elastoplastic fracture, dynamic inelastic fracture, and crack arrest theory and applications. Papers are presented on approximate methods for analysis of dynamic crack growth and arrest, constraint-loss model for the growth of surface fatigue cracks, fatigue crack growth in aircraft main landing gear wheels, and near-threshold crack growth in nickel-base superalloys. V.L.

A89-11860
LASER CONTROL OF VISIBILITY AND CLOUD-BASE HEIGHT IN AIRFIELD REGIONS
MAREK PALYS (Institute of Geodesy and Meteorology, Warsaw, Poland) IN: Laser technology II; Proceedings of the Meeting, Szczecin, Poland, Sept. 7-10, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 267-269. refs

A semiconductor-laser-based method for obtaining cloud-base height measurements for distances of 50-2000 m and an He-Cd-laser-based method for obtaining visibility measurements with a base of order of 1 km are presented, with application to increasing safety in airfield regions. Microstructural changes and thermal fluctuations in the laser beam path are minimized in the case of the height finder by using very short pulses. The study points out the need for measuring the refraction index structure function along with the standard temperature and wind velocity gradients. R.R.

A89-12151#
THE OPERATION OF MODERN AIR-SPACE SURVEILLANCE RADARS [ARBEITSWEISE MODERNER LUFTRAUM-UEBERWACHUNGSRADARE]
ALBRECHT LUDLOFF (AEG AG, Ulm, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), vol. 29, no. 2, 1988, p. 272-282. In German.

The operating principles and technological implementation of state-of-the-art moving-target-detector (MTD) radar systems for ATC and military applications are reviewed and illustrated with extensive diagrams. The limitations of conventional MTI radars are summarized; the advantages of the ground-clutter-adapted Doppler filter set and high-resolution ground-clutter maps of MTD systems are explained; and particular attention is given to the design and function of the MTD programmable digital signal processor, the transmitted signal and block processing, and the use of center-of-gravity algorithms in the MTD parameter-extraction process. T.K.

A89-12252
HEAT TRANSFER IN THE RECIRCULATING REGION FORMED BY A BACKWARD-FACING STEP
E. V. SHISHOV, P. S. ROGANOV, S. I. GRABARNIK, and V. P. ZABOLOTSKY (Moskovskoe Vysshee Tekhnicheskoe Uchilishche, Moscow, USSR) International Journal of Heat and Mass Transfer (ISSN 0017-9310), vo. 31, Aug. 1988, p. 1557-1562. refs

An analysis of experimental data obtained in the present investigation of the vortical structure of a recirculating flow formed by a backward-facing step has allowed the development of an approximate calculation method for predicting velocity and temperature profiles, reattachment length, and local friction and heat-transfer coefficients. An analytical expression for heat transfer in the reattachment region is derived which correlates experimental heat transfer data for different types of flow with a sudden expansion. Author

A89-12276* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE DUAL ELEMENT METHOD OF STRAIN GAUGE TEMPERATURE COMPENSATION
DAVID R. ENGLUND (NASA, Lewis Research Center, Cleveland, OH) IN: SEM, Annual Hostile Environments and High Temperature Measurements Conference, 4th, Windsor Locks, CT, Mar. 24, 25, 1987, Proceedings. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 40-42.

The use of a known temperature compensation technique is suggested to reduce the overall temperature sensitivity of a PdCr strain gauge system being developed for turbine engine research. The temperature compensation technique proposed for this application uses a resistance thermometer in an adjacent leg of the strain gauge bridge circuit to cancel the thermally generated resistance change of the strain gauge. Equations for calculating the required compensation resistor values and the sensitivity of the resulting strain gauge bridge to both temperature and strain are presented. V.L.

A89-12308* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REGRESSED RELATIONS FOR FORCED CONVECTION HEAT TRANSFER IN A DIRECT INJECTION STRATIFIED CHARGE ROTARY ENGINE
CHI M. LEE (NASA, Lewis Research Center, Cleveland, OH) and HAROLD J. SCHOCK (Michigan State University, East Lansing) SAE, International Congress and Exposition, Detroit, MI, Feb. 29-Mar. 4, 1988. 12 p. Previously announced in STAR as N88-13345. refs
(SAE PAPER 880626)

Currently, the heat transfer equation used in the rotary combustion engine (RCE) simulation model is taken from piston engine studies. These relations have been empirically developed by the experimental input coming from piston engines whose geometry differs considerably from that of the RCE. The objective of this work was to derive equations to estimate heat transfer coefficients in the combustion chamber of an RCE. This was accomplished by making detailed temperature and pressure measurements in a direct injection stratified charge (DISC) RCE under a range of conditions. For each specific measurement point, the local gas velocity was assumed equal to the local rotor tip speed. Local physical properties of the fluids were then calculated. Two types of correlation equations were derived and are described in this paper. The first correlation expresses the Nusselt number as a function of the Prandtl number, Reynolds number, and characteristic temperature ratio; the second correlation expresses the forced convection heat transfer coefficient as a function of fluid temperature, pressure and velocity. Author

A89-12337* Yale Univ., New Haven, Conn.
AERODYNAMICALLY-DRIVEN CONDENSATE LAYER THICKNESS DISTRIBUTIONS ON ISOTHERMAL CYLINDRICAL SURFACES
D. E. ROSNER, D. GUNES (Yale University, New Haven, CT), and N. NAZIH-ANOUS Chemical Engineering Communications (ISSN 0098-6445), vol. 24, 1983, p. 275-287. refs
(Contract NAG3-201)

A simple yet rather general mathematical model is presented for predicting the distribution of condensate layer thickness when aerodynamic shear is the dominant mechanism of liquid flow along the surface. The Newtonian condensate film is treated using well-known thin-layer (lubrication theory) approximations, and condensate supply is taken to be the result of either convective diffusion or inertial impaction. Illustrative calculations for a circular cylinder in a crossflow at Re = 100,000 reveal the consequences of alternate condensate arrival mechanisms and the existence of thicker reverse-flow films behind the position of gas boundary-layer separation. The present formulation is readily generalized to include transient liquid layer flows on noncircular objects of variable surface temperature, as encountered in turbine-blade materials testing or operation. Author

A89-12752*# Detroit Diesel Allison, Indianapolis, Ind.
MEASUREMENTS OF HEAT TRANSFER DISTRIBUTION OVER THE SURFACES OF HIGHLY LOADED TURBINE NOZZLE GUIDE VANES
D. A. NEALY, M. S. MIHELC, L. D. HYLTON (General Motors Corp., Detroit Diesel Allison Div., Indianapolis, IN), and H. J. GLADDEN (NASA, Lewis Research Center, Cleveland, OH) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 106, Jan. 1984, p. 149-158. Previously cited in issue 23, p. 3394, Accession no. A83-47910. refs
(Contract NAS3-22761)

N89-10016# Detroit Diesel Allison, Indianapolis, Ind.
FORCED VIBRATION AND FLUTTER DESIGN METHODOLOGY
LYNN E. SNYDER and DONALD W. BURNS *In* AGARD, AGARD Manual on Aeroelasticity in Axial-Flow Turbo Machines. Volume 2: Structural Dynamics and Aeroelasticity 28 p Jun. 1988
Avail: NTIS HC A12/MF A01

The aeroelastic principles and considerations of designing blades, disks, and vanes to avoid high cycle fatigue failure is covered. Two types of vibration that can cause high cycle fatigue, flutter, and forced vibration, will first be defined and the basic governing equations discussed. Next, under forced vibration design the areas of source definition, types of components, vibratory mode shape definitions, and basic steps in design for adequate high cycle fatigue life will be presented. For clarification a forced vibration design example will be shown using a high performance turbine blade/disk component. Finally, types of flutter, dominant flutter parameters, and flutter procedures and design parameters will be discussed. The overall emphasis is on application to initial design of blades, disks, and vanes of aeroelastic criteria to prevent high cycle fatigue failures. Author

N89-10212# National Aerospace Lab., Amsterdam (Netherlands).
DIGITAL RECORDING OF RADAR DATA IN AN AIRCRAFT

H. POUWELS 20 Jul. 1987 24 p In DUTCH; ENGLISH summary Presented at Lecture Course on Digital Signal Processing for Realtime Applications, Utrecht, Netherlands, 27 Feb. 1986; sponsored by NIRIA and KIVI
(PB88-209507; NLR-MP-86057-U) Avail: NTIS HC A03/MF A01 CSCL 17I

In the Netherlands, Side Looking Airborne Radar (SLAT) is operated with a digital recording of the data. A description is given of the airborne recording chain and of the ground based processing. The airborne electronics for the digitizing, formatting and recording of the radar data are described in detail. The system setup is tailored to the use of the SLAR as a research tool.
GRA

N89-10474# Stringfellow and Associates, Atlanta, Ga.
LIGHTNING AND SURGE PROTECTION OF LARGE GROUND FACILITIES
MICHAEL F. STRINGFELLOW *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 328-338 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 13B

The vulnerability of large ground facilities to direct lightning strikes and to lightning-induced overvoltages on the power distribution, telephone and data communication lines are discussed. Advanced electrogeometric modeling is used for the calculation of direct strikes to overhead power lines, buildings, vehicles and objects within the facility. Possible modes of damage, injury and loss are discussed. Some appropriate protection methods for overhead power lines, structures, vehicles and aircraft are suggested. Methods to mitigate the effects of transients on overhead and underground power systems as well as within buildings and other structures are recommended. The specification and location of low-voltage surge suppressors for the protection of vulnerable hardware such as computers, telecommunication equipment and radar installations are considered. The advantages and disadvantages of commonly used grounding techniques, such as single point, multiple and isolated grounds are compared. An example is given of the expected distribution of lightning flashes to a large airport, its buildings, structures and facilities, as well as to vehicles on the ground. Author

N89-10481# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
THE SAFIR LIGHTNING MONITORING AND WARNING SYSTEM, APPLICATIONS TO AEROSPACE ACTIVITIES
P. RICHARD, A. SOULAGE, P. LAROCHE, and J. APPEL *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 383-390 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 13B

A real-time lightning monitoring and warning system developed on the bases of recent advances in the field of lightning characterization are described. Applications and perspectives of the system are discussed, particularly applications for the field of aerospace safety. Author

N89-10484# United Kingdom Atomic Energy Authority, Culham (England). Lightning Studies Unit.
A FILAMENTARY METHOD FOR CALCULATING INDUCED VOLTAGES WITHIN RESISTIVE STRUCTURES IN EITHER THE FREQUENCY OR TIME DOMAIN
C. J. HARDWICK, S. J. HAIGH, and B. J. C. BURROWS *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 401-407 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 09C

A program was developed to predict current distributions resulting from a direct lightning strike to a structure of constant cross section consisting of both metallic and composite conductors. The structure is represented by a set of filaments which are assigned values of both resistance and self inductance. The current can be calculated in either the frequency or time domain; this current distribution then allows either the transfer impedance of wires located within the structure or the induced voltage on these wires as a function of time to be calculated. Author

N89-10493# Department of National Defence, Ottawa (Ontario). Quality Engineering Test Establishment.
ELECTROSTATIC DISCHARGE AND FIELD EFFECTS OF ELECTRONICS SYSTEMS
L. R. DICKS and G. MORIN *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 481-486 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 09C

The effects of static electricity on modern electronics are discussed, as well as a comprehensive approach to electrostatic discharge (ESD) protection measures in all phases of the life cycle of an electronic system. Static electricity has become a potential source of damage to electronic systems used in most applications, including aircraft, ground and shipboard installations. Author

N89-10497# Westinghouse Electric Corp., Baltimore, Md.
SYSTEM PROTECTION FROM ATMOSPHERIC ELECTRICITY FOR AEROSTATS WITH CONDUCTING TETHERS
M. S. WHEELER, G. R. BEACH, P. R. JAKUBOWSKI, and F. A. FISHER (Lightning Technologies, Inc., Pittsfield, Mass.) *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 505-511 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 09C

Aerostat power tethers have demonstrated survival of lightning strikes, but they usually have to be reterminated or replaced afterward. Two requirements are given for the prevention of lightning damage to the tether to about 100 kA: installation of a metal-to-metal contact on the outer tether surface to ground the tether at the base flying sheave at typical flying positions; and installation of a shielding band within the outer tether jacket with a weight of about 0.05 lb/ft for a half-inch tether. This determination was made in part by high current tests and in part by electrical modeling. Author

N89-11065# Joint Publications Research Service, Arlington, Va.
CASCADE FLOW ANALYSIS BY NAVIER-STOKES EQUATION
OSAMU NOZAKI *In its* JPRS Report: Science and Technology: Japan p 18-20 4 Jun. 1987 Transl. into ENGLISH from Kogiken Nyusu (Tokyo, Japan), Aug. 1986 p 7-10
Avail: NTIS HC A05/MF A01

As the performance of the large electronic computer has improved, numerical simulation of the flow around the blade of the aircraft, for instance, is being actively conducted. In the compressor and turbine cascades of aircraft engine, multiple blades are put side by side closely, and the pressure gradient in the flow direction is large. Thus they have more complicated properties than the independent blade. At present, therefore, it is the mainstream to use potential, Euler's equation, etc., as the basic equation but, for knowing the phenomenon caused by the viscosity like the interference of shock waves and boundary layers, it is necessary to solve the Navier-Stokes (N-S) equation. A two-dimensional cascade analysis program was developed by the N-S equation by expanding the two-dimensional high Reynolds number transonic profile analysis code NSFOIL and the lattice formation program AFMESH for the independent blade, which were already developed so as to fit the cascade flow. Author

N89-11068# Joint Publications Research Service, Arlington, Va.
NEW TRIAL OF VIBRATION TESTING METHOD
TETSUHIKO UEDA *In its* JPRS Report: Science and Technology: Japan p 26-28 4 Jun. 1987 Transl. into ENGLISH from Kogiken Nyusu (Toyko, Japan), Sep. 1986 p 3-4
Avail: NTIS HC A05/MF A01

A trial of a vibration testing method which will be used in the time domain is discussed. The vibration test is indispensable for obtaining dynamically elastic characteristics of a structure. In particular, it is necessary to anticipate the flutter phenomenon which will cause structural destruction on the wings of aircraft, fins of rockets, turbine blades of engines, etc. Therefore, the identification of structural characteristics according to vibration tests plays an important role in this anticipation. The sine dwell method and transfer function method can be cited as methods being used widely and presently in such vibration tests. The sine dwell method

is used to search for resonance points, and the transfer function method is used to process data mathematically in the frequency domain by using an fast Fourier transformation analyzer. The VATREM (vibration analysis in the time domain by the real eigenvalue method) is introduced. It is a new trial different from both of the above methods and can be regarded as a kind of time domain method. Author

N89-11077*# Johns Hopkins Univ., Laurel, Md. Applied Physics Lab.
RESULTS OF 1987 MSS HELICOPTER PROPAGATION EXPERIMENT AT UHF AND L BAND IN CENTRAL MARYLAND
JULIUS GOLDHIRSH and WOLFHARD J. VOGEL (Texas Univ., Austin.) *In* JPL, Proceedings of the 12th NASA Propagation Experimenters Meeting (NAPEX 12) p 18-26 Aug. 1988
Avail: NTIS HC A09/MF A01 CSCL 20N

This effort emphasizes several important results pertaining to a mobile satellite system propagation experiment performed in Central Maryland during June 1987. Fade distributions due to multipath and roadside trees at L Band (1.5 GHz) during a period in which the deciduous trees were in full bloom are examined. The multipath statistics for roadside trees are compared with previous multipath measurements made in canyon terrain in North Central Colorado. Also examined is the repeatability of previous UHF measurements made in Central Maryland and the attenuation effects of foliage on trees at UHF. Fade duration for the multipath mode for fade levels of 5 dB and 10 dB is also presented. Author

N89-11080*# Ministry of Posts and Telecommunications, Kashima (Japan). Communications Research Lab.
ETS-V PROPAGATION EXPERIMENTS IN JAPAN
SHINGO OHMORI *In* JPL, Proceedings of the 12th NASA Propagation Experimenters Meeting (NAPEX 12) p 47-54 Aug. 1988
Avail: NTIS HC A09/MF A01 CSCL 20N

Propagation experiments on ship, aircraft, and land mobile earth stations were carried out using the Engineering Test Satellite-V (ETS-V), which was launched in August 1987. The propagation experiments are one of the missions of the Experimental Mobile Satellite System (EMSS). Initial experimental results of ETS-V/EMSS on propagation using ship, aircraft, and land mobiles with ETS-V are given. Author

N89-11155*# Sandia National Labs., Albuquerque, N. Mex. Fluid and Thermal Sciences Dept.
CONTINUUM THEORIES FOR FLUID-PARTICLE FLOWS: SOME ASPECTS OF LIFT FORCES AND TURBULENCE
DAVID F. MCTIGUE, RICHARD C. GIVLER, and JACE W. NUNZIATO *In* NASA, Marshall Space Flight Center, Mixing and Demixing Processes in Multiphase Flows with Application to Propulsion Systems p 15-31 Jul. 1988 Previously announced as N88-24898
(Contract DE-AC04-76DP-00789)
Avail: NTIS HC A09/MF A01 CSCL 20D

A general framework is outlined for the modeling of fluid particle flows. The momentum exchange between the constituents embodies both lift and drag forces, constitutive equations for which can be made explicit with reference to known single particle analysis. Relevant results for lift are reviewed, and invariant representations are posed. The fluid and particle velocities and the particle volume fraction are then decomposed into mean and fluctuating parts to characterize turbulent motions, and the equations of motion are averaged. In addition to the Reynolds stresses, further correlations between concentration and velocity fluctuations appear. These can be identified with turbulent transport processes such as eddy diffusion of the particles. When the drag force is dominant, the classical convection dispersion model for turbulent transport of particles is recovered. When other interaction forces enter, particle segregation effects can arise. This is illustrated qualitatively by consideration of turbulent channel flow with lift effects included. Author

N89-11184# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Aerothermodynamique.
STUDY OF THREE DIMENSIONAL BOUNDARY LAYERS ON THE FRONT OF A FUSELAGE AND AT AN AIR INTAKE [ETUDE DES COUCHES LIMITES TRIDIMENSIONNELLES SUR POINTE AVANT DE FUSELAGE ET SUR ENTREE D'AIR]
C. GLEYZES Dec. 1987 27 p In FRENCH
(Contract AEROSPATIALE-11-000639)
(CERT-OA-22/5025-AYD; DERAT-22/5025-16; ETN-88-93107)
Avail: NTIS HC A03/MF A01

Solutions adopted to define grids adapted to calculation of the three-dimensional boundary layer on the nose of the fuselage of a civil aircraft at low incidence in order to study laminar flow; and at a subsonic air inlet at incidence, are outlined. Examples corresponding to a nose in cryogenic wind tunnel conditions, and a model inlet at high incidence are presented. ESA

N89-11187# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Aerothermodynamique.
BOUNDARY LAYER TRANSITION [TRANSITION DE LA COUCHE LIMITE]
D. ARNAL, J. C. JUILLEN, and F. VIGNAU Feb. 1988 37 p In FRENCH
(Contract DRET-87-002-018)
(CERT-OA-40/5018-AYD; DERAT-40/5018-24; ETN-88-93320)
Avail: NTIS HC A03/MF A01

A calculation method including the effects of interaction between longitudinal and transversal instabilities on a delta wing is presented. The results of calculations made to qualify the effects of wall cooling on a compressible laminar layer are also presented. The transition processes downstream of a backward facing step with and without wall aspiration are investigated. ESA

N89-11188# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
A COMPUTATIONAL STUDY OF COHERENT STRUCTURES IN THE WAKES OF TWO-DIMENSIONAL BLUFF BODIES M.S. Thesis
JEFFREY ALAN PEARCE Aug. 1988 138 p
(AD-A196820; AFIT/CI/NR-88-99) Avail: NTIS HC A07/MF A01 CSCL 20D

The periodic shedding of vortices from bluff bodies was first recognized in the late 1800's. Currently, there is great interest concerning the effect of vortex shedding on structures and on vehicle stability. In the design of bluff structures which will be exposed to a flow, knowledge of the shedding frequency and the amplitude of the aerodynamic forces is critical. The ability to computationally predict parameters associated with periodic vortex shedding is thus a valuable tool. In this study, the periodic shedding of vortices from several bluff body geometries is predicted. The study is conducted with a two-dimensional finite-difference code employed on various grid sizes. The effects of the grid size and time step on the accuracy of the solution are addressed. Strouhal numbers and aerodynamic force coefficients are computed for all of the bodies considered and compared with previous experimental results. Results indicate that the finite-difference code is capable of predicting periodic vortex shedding for all of the geometries tested. Refinement of the finite-difference grid was found to give little improvement in the prediction; however, the choice of time step size was shown to be critical. Predictions of Strouhal numbers were generally accurate, and the calculated aerodynamic forces generally exhibited behavior consistent with previous studies. GRA

N89-11189# Pennsylvania State Univ., University Park. Dept. of Mechanical Engineering.
EXPERIMENTAL RESEARCH ON SWEPT SHOCK WAVE/BOUNDARY LAYER INTERACTIONS Annual Report, 1 Apr. 1987 - 31 Mar. 1988
GARY S. SETTLES 28 Apr. 1988 58 p

(Contract AF-AFOSR-0082-86; AF PROJ. 2307)
(AD-A196938; PSU-ME-R-87/88-0031; AFOSR-88-0637TR)
Avail: NTIS HC A04/MF A01 CSCL 20D

This study of swept shock wave interactions with turbulent boundary layers relied entirely on non-intrusive, laser-based optical flow diagnostics. Experiments were carried out to define the flowfield structure of fin-generated interactions over a Mach number range 2.5 to 3.5 using the laser light-screen flow visualization technique. Further experiments resulted in accurate skin friction measurements in fin-generated swept interactions by way of the Laser Interferometer Skin Friction Meter. Techniques were perfected for the assessment of flowfield fluctuation levels using pulsed-laser holographic interferometry. The results of this research have given new insight into the fin-interaction flowfield structure, which involves a supersonic jet produced by shock wave refraction and impinging on the test surface. High skin friction levels were measured in the vicinity of this jet impingement, which compare well with computational predictions carried out by others. Finally, the observed jet impingement structure is shown to be similar to that of leading-edge shock wave impingement on high-speed flight vehicles. GRA

N89-11192*# General Electric Co., Cincinnati, Ohio. Advanced Technology Operation.
SENSORS FOR CERAMIC COMPONENTS IN ADVANCED PROPULSION SYSTEMS: SUMMARY OF LITERATURE SURVEY AND CONCEPT ANALYSIS, TASK 3 REPORT
W. H. BENNETHUM and L. T. SHERWOOD Aug. 1988 108 p
(Contract NAS3-25140)
(NASA-CR-180900; NAS 1.26:180900) Avail: NTIS HC A06/MF A01 CSCL 14B

The results of a literature survey and concept analysis related to sensing techniques for measuring of surface temperature, strain, and heat flux for (non-specific) ceramic materials exposed to elevated temperatures (to 2200 K) are summarized. Concepts capable of functioning in a gas turbine hot section environment are favored but others are reviewed also. Recommendation are made for sensor development in each of the three areas. Author

N89-11196*# Wyle Labs., Inc., Hampton, Va.
ELECTRICAL NOISE REDUCTION TECHNIQUES CONTRIBUTING TO IMPROVED DATA QUALITY AT THE NATIONAL TRANSONIC FACILITY
J. R. MCPHEE Nov. 1988 38 p
(Contract NAS1-18304)
(NASA-CR-4193; NAS 1.26:4193) Avail: NTIS HC A03/MF A01 CSCL 09C

In initial use, the high-speed digital data acquisition systems at Langley Research Center's National Transonic Facility produced data containing unacceptably high noise levels. Described is a process whereby the contributing noise sources were identified and eliminated. The effects of 60 Hz power, system grounding, EMI/RFI, and other problems are discussed and the corrective action taken is outlined. The overall effort resulted in an improvement of greater than 5:1 in system performance. Although the report describes a system specifically used for wind tunnel data acquisition, the corrective techniques employed are generally applicable to large scale high-speed data systems where signal resolution in the low microvolts range is important. Author

N89-11265# Federal Aviation Agency, Atlantic City, N.J.
LONGITUDINAL IMPACT TEST OF A TRANSPORT AIRFRAME SECTION Final Report, Feb. - Oct. 1987
BARRY WADE and RICHARD JOHNSON (Transportation Research Center of Ohio, East Liberty.) Jul. 1988 286 p
(Contract DTFA03-87-C-00013)
(DOT/FAA/CT-87/26) Avail: NTIS HC A13/MF A01

The results of longitudinally impact testing a 10-foot section of a transport airplane at peak acceleration and corresponding velocity changes of 7.4 g (22.4 ft/sec) and 14.2 g (36 ft/sec), respectively are reported. The purpose of the tests was to measure the responses of the fuselage and floor structure to simulated dynamic crash loads. The airframe test section included a full complement of seats and dummies. Acceleration and load/deflection response measurements were obtained from the instrumented fuselage, floor and seat/dummy installation. Author

N89-11270 Columbia Univ., New York, N.Y.
RESPONSE OF DISCRETELY STIFFENED STRUCTURES AND TRANSMISSION OF STRUCTURE-BORNE NOISE Ph.D. Thesis
CONSTANTINOS SOTIRIO LYRINTZIS 1987 81 p
Avail: Univ. Microfilms Order No. DA8809385

An analytical study is presented to predict the dynamic response and structure-borne noise generation and transmission of complex discretely stiffened and interconnected structures under random loads. The method is based on transfer matrices for the structural response and on modal decomposition for the interior acoustic field. The acoustic enclosure is taken to be rectangular in shape of which a portion of the boundaries is elastic while the remaining surface is acoustically rigid. This formulation can be used for the response and structure-borne noise generation studies in space station and aircraft structures. Numerical results are presented for a variety of acousto-structural problems. It is found that this approach permits easy parametric evaluation and that through proper selection of structural parameters, loading conditions and acoustic characteristics, the vibration response and noise transmission can be reduced. Dissert. Abstr.

N89-11286# Institut de Mecanique des Fluides de Lille (France). Groupe Mecanique des Structures.
AIRCRAFT CRASHES ON THE RUNWAY: DEVELOPMENT OF A SUPER ELEMENT FOR NONLINEAR ANALYSIS OF A BEAM [CRASH DES AVIONS SUR PISTE: DEVELOPPEMENT D'UN SUPER-ELEMENT POUR L'ANALYSE NON LINEAIRE D'UNE POUTRE]
P. GEOFFROY 15 Dec. 1987 35 p In FRENCH
(Contract DRET-85-003)
(REPT-87/56; ETN-88-93101) Avail: NTIS HC A03/MF A01

A thin shell super finite element was developed to study the pre and post elastoplastic buckling behavior of an embedded beam subject to a lateral load. The finite element is derived from a local behavior law analogous in its form to the law of the global behavior of the structure. Analysis results and quasi-static and dynamic tests on reduced scale models of aircraft structures were compared. This element alone cannot be a solution to the response. It is necessary to simultaneously introduce into the finite element model extra degrees of freedom to represent the plastic joints, and to restrain the displacement of the super element nodes to be representative of the real displacements of the structure. By replacing a large part of a structure by a large element, specific to a given behavior, computation time is considerably reduced. ESA

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A89-11221
STRUCTURE AND LIFE CYCLE OF MICROBURST OUTFLOWS OBSERVED IN COLORADO
MARK R. HJELMFELT (National Center for Atmospheric Research, Boulder, CO) Journal of Applied Meteorology (ISSN 0894-8763), vol. 27, Aug. 1988, p. 900-927. Research supported by the National Center for Atmospheric Research and NSF. refs
(Contract DOT-FA01-82-Y-10513)

Observations by Doppler radars and a surface meteorological network are used to analyze the morphology of microburst outflows in Colorado. The microburst outflows are classified into individual

microbursts and microburst lines, and examples of each type are presented. It is shown that microburst lines have longer lifetimes, larger areas of divergence, and can create a greater potential for hazard to aircraft than isolated microburst. Outflow structure was found to resemble features of the laboratory wall jet. Studies of microburst symmetry, as measured across the maximum velocity differential, show that the minimum shear is only about 60 percent of the maximum. R.B.

A89-11554
A NUMERICAL ESTIMATION OF THE DEFORESTATION EFFECTS ON LOCAL CLIMATE IN THE AREA OF THE FRANKFURT INTERNATIONAL AIRPORT
G. GROSS (Darmstadt, Technische Hochschule, Federal Republic of Germany) Beitraege zur Physik der Atmosphaere (ISSN 0005-8173), vol. 61, Aug. 1988, p. 219-231. refs

N89-10429# National Oceanic and Atmospheric Administration, Rockville, Md.
INTERNATIONAL AEROSPACE AND GROUND CONFERENCE ON LIGHTNING AND STATIC ELECTRICITY
Apr. 1988 535 p Conference held in Oklahoma City, Okla., 19-22 Apr. 1988
(PB88-197439) Avail: NTIS HC A23/MF A01 CSCL 04B

Various topics related to lightning and static electricity are discussed. Aircraft strike statistics, lightning propagation models, aerospace vehicles, simulation, aircraft hazards rocket launch hazards, thunderstorms, lightning detection and protection, and mapping systems are among the topics covered.

N89-10430# Tohoku Univ., Sendai (Japan). Dept. of Electrical Engineering.
STATISTICS OF LIGHTNING INTERACTION WITH AIRCRAFT IN JAPAN
YUKIHIRO GOTO and YOSHIHIRO MUROOKA (National Defence Academy, Yokosuka, Japan) *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 1-7 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 04B

A survey of lightning interaction with commercial aircraft in Japan for the past 10 years is given. Aircraft flight conditions during lightning strikes and concomitant synoptic weather which were reported by flight crews were correlated as a percentage of the total number of strikes reported in Japan. Author

N89-10431# Chelton (Electrostatics) Ltd., Marlow (England).
ISRAEL AIR FORCE (IAF) IN-SERVICE AIRCRAFT LIGHTNING STRIKE AND DAMAGE SURVEY
ELYA B. JOFFE *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 8-12 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 04B

A survey of lightning strikes to aircraft, covering all types of aircraft (tactical fighters, transport aircraft and helicopters), is given. The survey results include descriptive data on each strike and the effects. A lightning strike in which an F-16 was struck while in flight is discussed. Some basic problems arising from new requirements for lightning protection are discussed. Author

N89-10432# Computer Resource Management, Inc., Atlantic City, N.J.
LIGHTNING INFORMATION DATABASE
R. L. MCDOWALL and MICHAEL S. GLYNN (Federal Aviation Agency, Atlantic City, N.J.) *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 13-15 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 04B

The Federal Aviation Administration (FAA) is creating a data base of electromagnetic information on lightning. A number of sources of information have been identified and an attempt to acquire and centrally locate the data is being pursued. The data will ultimately be available to general researchers. In certain cases on-line access to database peripheral information such as altitude, temperature, precipitation, turbulence, and peak and average electromagnetic values will be available. It is also anticipated that digitized waveforms will be available. Author

N89-10438*# Electro Magnetic Applications, Inc., Lakewood, Colo.
TRIGGERING OF LIGHTNING BY THE ATLAS CENTAUR VEHICLE
RODNEY A. PERALA and TERENCE H. RUDOLPH *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 47-57 Apr. 1988 Previously announced in IAA as A88-22290 Sponsored in part by NASA. Langley Research Center
Avail: NTIS HC A23/MF A01 CSCL 04B

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 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

N89-10443# SRI International Corp., Menlo Park, Calif.
AN AIRCRAFT-BORNE ELECTRIC FIELD MEASURING SYSTEM FOR ROCKET LAUNCH SUPPORT
JOSEPH E. MANEVICZ, JEFFREY S. THAYER, and HUGH HERITAGE (Aerospace Corp., Los Angeles, Calif.) *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 87-93 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 04B

A new field measuring system and associated instrumentation installed on a NASA 705 Learjet to be flown into a region of a rocket launch trajectory to verify meteorological and electric field conditions relative to lightning strike potential are discussed. The new system is based on an earlier system used for the support of the Apollo/Soyuz and Viking launches. The outputs from a set of four field meters installed in the skin of the vehicle are fed to a real-time analog processor that yields the three components of free-space electric field and aircraft potential. The system also records aircraft navigational parameters and time to permit the data to be correlated with other measurements. Author

N89-10444# Airborne Research Associates, Weston, Mass.
NEW ELECTRIC FIELD INSTRUMENTATION AND THE EFFECTS OF SPACE CHARGE AT KENNEDY SPACE CENTER
RALPH MARKSON and BRUCE ANDERSON *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 94-102 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 04B

A program is being conducted to develop low power consumption electric field sensors for installation at remote sites, where there is no ac power, in order to expand the aerial coverage of the lightning warning network. Both radioactive probe and corona current instruments are being considered. In addition, the layer of space charge which develops over land (due to corona) and water (due to electrode effect) when thundercloud electric fields are present are being investigated since it strongly affects electric field measurements made close to the ground. The space charge layer is being studied through horizontal and vertical profiles obtained from an instrumented aircraft as well as an electrosonde which is raised and lowered through the space charge layer by a tethered balloon system. Author

N89-10447# National Research Council of Canada, Ottawa (Ontario). Div. of Electrical Engineering.
A CASE FOR A UNIFIED LIGHTNING THREAT
ANDREW S. PODGORSKI *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 118-122 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 04B

For the first time a unified set of lightning parameters that can describe the lightning measured at the ground or on towers or airplanes is proposed. This set of parameters can be used to accurately predict the electromagnetic fields generated by lightning. The new set of lightning parameters was obtained from the lightning current measurements conducted at the CN Tower during the 1986 lightning seasons. The measured currents were compensated for the presence of the tower. Author

N89-10449# Office National d'Etudes et de Recherches Aeronautiques, Paris (France).
SUMMARY OF INFLIGHT DATA ON LIGHTNING CURRENTS AND FIELDS
J. P. MOREAU, J. M. REAZER, and P. L. RUSTAN (Defense Nuclear Agency, Washington, D.C.) *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 129-135 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 04B

The peak amplitudes, risetimes and repetition rates of the current and electromagnetic field pulses measured during lightning strikes to a two-engine turbo prop CV-580 aircraft are discussed. The .5 Hz to 500 kHz electric field variations recorded in the aircraft during lightning strikes are summarized. Finally, the current and electric field variations measured in the aircraft are compared with those in the MIL-STD-1757A and the newly recommended draft advisory circular for the SAE committee AE4L-87-3. Author

N89-10470# Mississippi Univ., University. Dept. of Physics.
THE ELECTRICAL STRUCTURE OF THUNDERSTORM ANVILS
THOMAS C. MARSHALL, W. DAVID RUST, WILLIAM P. WINN, and KENNETH E. GILBERT (National Center for Physical Acoustics, University, Miss.) *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 303-309 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 04B

Two electric field soundings through thunderstorm anvil clouds show similar charge structures; negatively charged screening layers on top and bottom surfaces, a layer of positive charge on the interior, and one or two layers of zero charge. Both anvil clouds were strongly electrified; the peak magnitudes of the electric field in the two storms were 70 and 90 kV/m (so, aircraft penetrating anvil thunderstorms run no risk of triggering lightning flashes). The non-zero layers had charge densities comparable to those found in storm cores, ranging in magnitude from 0.4 to 2.7 nC/m cubed. The layers ranged in thickness from 300 to 2000m. The positive charge probably originated in the main positive charge region normally found at high altitudes in the core of thunderstorms. The removal of the positive charge from the storm's core to the anvil may influence the ratio of intra-cloud to cloud-to-ground lightning flashes and the rate of generation of charge in the core. The negatively conducting layers were probably screening layers resulting from the discontinuity in the electrical conductivity at the cloud boundaries. The lower negative screening layer appeared to be carried toward the storm's core by winds below and at the lower anvil boundary. Author

N89-10490# Massachusetts Inst. of Tech., Cambridge. Dept. of Earth, Atmospheric and Planetary Sciences.
INTRACLOUD LIGHTNING AS A PRECURSOR TO THUNDERSTORM MICROBURSTS
E. R. WILLIAMS and R. E. ORVILLE (State Univ. of New York, Albany.) *In* NOAA, International Aerospace and Ground Conference on Lightning and Static Electricity p 454-459 Apr. 1988
Avail: NTIS HC A23/MF A01 CSCL 04B

The intracloud lightning activity of microburst-producing thunderstorms is shown to be a systematic precurser to the maximum outflow velocity at ground level. The time of peak flash rate leads the time of maximum differential velocity by 5 to 10 minutes. The consistent temporal relationship between the electrical phenomenon (lightning rate) and the dynamical phenomenon (the microburst) is attributed to a common cause - ice particles aloft. Author

N89-10499# National Oceanic and Atmospheric Administration, Boulder, Colo. Environmental Sciences Group.
OKLAHOMA-KANSAS PRELIMINARY REGIONAL EXPERIMENT FOR STORM-CENTRAL (O-K PRE-STORM). VOLUME 3: AIRCRAFT MISSION SUMMARY
JOSE G. MEITIN, JR. Feb. 1988 112 p
(PB88-205489; NOAA-TM-ERL-ESG-30-VOL-3) Avail: NTIS HC A06/MF A01 CSCL 04B

Researchers are provided with a synopsis of the flights taken during May and June of 1985 as part of the Oklahoma-Kansas Preliminary Regional Experiment for STORM-Central (PRE-STORM). This is the final report in a series which describes the activities and catalogs the data collected during the field phase of the PRE-STORM project. The principal goals of the aircraft subprogram were to: (1) gather aircraft data in the vicinity of developing and mature convective systems in order to better define their structure, evolution, and physical processes, and (2) develop and test observational strategies for optimal use of long range research aircraft in the mesoscale convective system (MCS) environment in order to help define measurement techniques, for example, the use of airborne Doppler radar in coordination with ground based Doppler radars. Author

N89-11356# Federal Aviation Agency, Atlantic City, N.J.
EVALUATION OF ENHANCEMENTS TO THE LOW LEVEL WIND SHEAR ALERT SYSTEM (LLWAS) AT STAPLETON INTERNATIONAL AIRPORT Final Report, Jul. 1987 - Mar. 1988
JOHN D. BARAB, RICHARD D. PAGE, BRUCE L. ROSENBURG, THOMAS E. ZURINSKAS, and GLENN R. SMYTHE (Data Transformation Corp., Silver Spring, Md.) Aug. 1988 164 p (Contract T12-02Z)
(DOT/FAA/PS-88/14; DOT/FAA/CT-88/6) Avail: NTIS HC A08/MF A01

An operational test and evaluation of enhancements to the 11-station Low Level Wind Shear Alert System (LLWAS) at Stapleton International Airport, Denver, Colorado was conducted during the period August 3 to September 4, 1988. Enhancements included a 12th remote station for gathering wind data, a more sophisticated wind shear microburst detection (WSMD) algorithm, a Digital Equipment Corporation (DEC) PDP 11-73 computer, a DEC VT-240 Cathode Ray Tube (CRT) Display, and an LLWAS message display format, the latter two for local controller use in the air traffic control (ATC) tower cab. Two sets of objectives were associated with this LLWAS evaluation: meteorological and human factors objectives. The methodology and dual scientific analyses performed were discussed, and detailed results with conclusions and recommendations were provided. Based on the conclusions, it was recommended that the WSMD algorithm remain as an operational constituent of the Denver LLWAS and that human factors considerations be further explored in improving the controller LLWAS interface. Author

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LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

A89-10589
TEAS - AN AL BASED THREAT RESPONSE RECOMMENDATION SYSTEM
KEITH DRAKE and STEVE ROTHSTEIN (USAF, Wright-Patterson AFB, OH) IN: Aerospace Behavioral Engineering Technology Conference, 6th, Long Beach, CA, Oct. 5-8, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 115-120. refs
(SAE PAPER 871804)

In the future fighter combat environment, the pilot will be faced with increased workload as he is forced to integrate various on-board sensor, weapons, and other aircraft systems. Specifically, he has less time to react to incoming missiles because of increased missile and aircraft speeds. The Air Force's Threat Expert Analysis System (TEAS) will determine and recommend threat responses to the pilot using all available resources. The system will do much of the data integration for the pilot, thereby reducing his workload. This paper reviews the approach being taken in the TEAS program development. Author

A89-10593
SHOULD TECHNOLOGY ASSIST OR REPLACE THE PILOT?
S. R. LAST (International Federation of Air Line Pilots Associations, Egham, England) IN: Aerospace Behavioral Engineering Technology Conference, 6th, Long Beach, CA, Oct. 5-8, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 151-155.
(SAE PAPER 880774)

This paper presents a survey of computer technology applications in transport aircraft and examines the direction and impact of automation on the flight deck. In particular, an attempt is made to answer the question of whether or not the automation technology is leading the way for the development of pilotless aircraft. It is suggested that, if the human pilot is to remain in control of aircraft operations, there are some trends in the design of both hardware and software which need modification and/or reversal. These trends are discussed. I.S.

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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.

A89-10584
IMAGE QUALITY AND VISUAL SIMULATION OF COLOR MATRIX DISPLAYS
LOUIS D. SILVERSTEIN, ROBERT W. MONTY, JERRY W. HUFF, and KEITH L. FROST (Honeywell Systems and Research Center, Minneapolis, MN) IN: Aerospace Behavioral Engineering Technology Conference, 6th, Long Beach, CA, Oct. 5-8, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 71-76. refs
(SAE PAPER 871789)

A color matrix display (CMD) image simulation system has been developed to support human factors research leading to design specifications for CMD visual parameters. The simulation system consists of color graphics image processing hardware and software, as well as high-resolution display and optical components. The flexibility and fideity with which CMD images can be simulated permit a wide variety of CMD hardware and information format issues to be addressed. Author

A89-11680#
MODAL OBSERVABILITY AND CONTROLLABILITY MEASURES FOR FIRST AND SECOND ORDER LINEAR SYSTEMS AND MODEL REDUCTION
A. M. A. HAMDAN and A. H. NAYFEH (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Sixth VPI&SU/AIAA Symposium, Blacksburg, VA, June 29-July 1, 1987. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1988, p. 453-475. refs

New measures of modal controllability and observability are proposed for the linear time-invariant representation of a dynamic system. Gross measures of controllability of a mode from all inputs and gross measures of observability of a mode in all outputs are also proposed. A closed-form expression relating the norm of the residue matrix and the proposed gross measures of modal controllability and observability is presented, and it is shown that the measures proposed here are directly applicable to second-order models. Possible applications of the measures include large space structures. V.L.

A89-11748
THE SYMBOLICS SCOPE SYSTEM AS A PLATFORM FOR ENVIRONMENTAL ANALYSIS
BRIAN P. BAUER and THOMAS STANZIONE (Symbolics, Inc., Cambridge, MA) IN: Digital image processing and visual communications technologies in meteorology; Proceedings of the Meeting, Cambridge, MA, Oct. 27, 28, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 135-155. Research supported by Symbolics, Inc. refs

The paper describes the design and functionality of the SCOPE system, an image and symbolic computer that manages complexity and can perform goal-directed processing. SCOPE is an integrated workstation consisting of a Symbolics Lisp Machine and PIXAR Image Computer. The SCOPE system provides a platform for the rapid manipulation and display of meteorological data in the context of a knowledge processing system. As an example, SCOPE is currently in operation at an experimental Doppler radar facility for the analysis and forecasting of microburst phenomena around an airport. The SCOPE system is using an expert system for the analysis of wind shear and wind-flow information to evaluate the potential for hazards to aviation from microbursts on a real-time basis. B.J.

A89-11750
RULE-BASED STRING CODE PROCESSOR
DAVID CASASENT and SUNG-IL CHIEN (Carnegie-Mellon University, Pittsburgh, PA) IN: Intelligent robots and computer vision; Proceedings of the Meeting, Cambridge, MA, Nov. 2-6, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 2-12. USAF-supported research. refs

A new and efficient real-time technique to produce a string code description of the contour of an object, such as an (angle, length) = (phi, s) feature space for the arcs describing the contour, is detailed. The use of such a description for an aircraft identification problem case study is demonstrated. The (phi, s) feature space is modified to include a length string code and a convexity string code. This feature space allows both global and local feature extraction. The local feature extraction follows human techniques and is thus quite suitable for a rule-based processor. Aircraft have generic parts and thus are quite suitable for the model-based description. Author

A89-11760
A HIERARCHICAL CONTROL STRATEGY FOR 2-D OBJECT RECOGNITION
MARK F. CULLEN (Perkin-Elmer Corp., New Haven, CT),

CHRISTOPHER L. KUSZMAUL, and TIMOTHY S. RAMSEY IN: Intelligent robots and computer vision; Proceedings of the Meeting, Cambridge, MA, Nov. 2-6, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 220-224.

A control strategy for two-dimensional object recognition has been implemented on a hardware configuration which includes a Symbolics Lisp Machine as a front-end processor to a 16,384 processor Connection Machine (CM). The goal of this ongoing research program is to develop an image analysis system as an aid to human image interpretation experts. Efforts have concentrated on two-dimensional object recognition in aerial imagery specifically, the detection and identification of aircraft near the Danbury, CT airport. This paper reports on the integration of algorithms on the CM, with a hierarchical control strategy to focus and guide the object recognition task to particular objects and regions of interest in imagery. It is shown that these techniques may be used to manipulate imagery on the order of 2k x 2k pixels in near-real-time. Author

A89-12176
COPING WITH LEGACY FACTORS
D. L. BUNDY and J. A. WEISS (McDonnell Aircraft Co., Saint Louis, MO) Engineering with Computers (ISSN 0177-0667), vol. 4, no. 1-2, 1988, p. 11-17.

Implementers of engineering data base management systems inherit a legacy of existing software and data that must be integrated into the new system with minimum disruption of ongoing activities. Some critical issues addressed here include changes in software engineering practices, impact on user training and procedures, and problems connected with traditional or parochial interests. The material covered describes some experiences in coping with these 'legacy factors' during the recent McDonnell Aircraft Company (MCAIR) integrated data base implementation. Author

A89-12405#
A TACTICS EXPERT SYSTEM FOR SCOUT/ATTACK ROTORCRAFT
EDDIE J. TRUJILLO and CHARLES D. HOLLEY (Bell Helicopter Textron, Fort Worth, TX) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 10 p. refs

An examination is conducted of the 'depth' of knowledge and supporting data required for the automation of military rotorcraft crew tasks in a sophisticated antiaircraft threat environment; the AI and expert system technologies that have been proposed are charged with the reduction of cockpit workloads while enhancing mission effectiveness. The expert system software prototype presently developed assists rotorcraft crews with the selection of target observation and firing positions. While the overall system executes in C, supporting graphics functions were developed with FORTRAN and DISSPLA graphics software. O.C.

A89-12410#
REASONING ABOUT DEVICE BEHAVIOR USING QUALITATIVE PHYSICS
T. P. HAMILTON (United Technologies Research Center, East Hartford, CT) and C. JACOBSEN (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 16 p. refs

A computer program has been developed which reasons about the behavior of devices using qualitative models of their structure and function. The ultimate goal of this qualitative reasoning system is to provide a general method for representing and reasoning about behavior throughout a device's life cycle. Current capabilities of the system include reasoning about the normal behavior of a device, detection of abnormal behavior, and diagnosis of failure without prior knowledge of the device's failure modes. A tool to assist in construction of hierarchical qualitative models has also been developed. Applications of qualitative reasoning under development are described. Author

A89-12413#
PI - AN AI APPROACH FOR MAINTENANCE AND DIAGNOSTIC APPLICATIONS
THOMAS A. DUBOIS, WALTER T. STECKLAIR, and GREGORY W. SAUL (Boeing Co., Boeing Computer Services Div., Seattle, WA) IN: Automation applications for rotorcraft; Proceedings of the National Specialists' Meeting, Atlanta, GA, Apr. 4-6, 1988. Alexandria, VA, American Helicopter Society, 1988, 10 p. refs

The Boeing Pi system is an AI approach for the maintenance and diagnosis of complex multicomponent systems. Pi incorporates maintenance and diagnostic knowledge sources that are common to applications within this domain. It implements existing AI techniques to minimize the cost of diagnosing complex systems. The Pi software architecture is suitable for installation on a man-portable unit for use by maintenance personnel in the field. Author

N89-10524*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ON THE DIAGNOSTIC EMULATION TECHNIQUE AND ITS USE IN THE AIRLAB
GERARD E. MIGNEAULT Oct. 1988 28 p
(NASA-TM-4027; L-16397; NAS 1.15:4027) Avail: NTIS HC A03/MF A01 CSCL 09B

An aid is presented for understanding and judging the relevance of the diagnostic emulation technique to studies of highly reliable, digital computing systems for aircraft. A short review is presented of the need for and the use of the technique as well as an explanation of its principles of operation and implementation. Details that would be needed for operational control or modification of existing versions of the technique are not described. Author

N89-10526*# Lockheed-Georgia Co., Marietta.
HARDWARE FAULT INSERTION AND INSTRUMENTATION SYSTEM: EXPERIMENTATION AND RESULTS
J. W. BENSON, D. B. MULCARE, and W. E. LARSON Mar. 1987 80 p Prepared for FAA, Atlantic City, N.J.
(Contract NAS2-11853)
(NASA-CR-182746; NAS 1.26:182746; AD-A189863; DOT/FAA/CT-86/34) Avail: NTIS HC A05/MF A01 CSCL 01D

This report describes the motivation, conduct, and analysis of some 2500 low-level hardware fault cases applied in automated testing at the NASA Ames Reconfigurable Digital Flight Control System (RDFCS) Facility. Fault detection was correlated with hardware and software fault monitoring, and in limited cases, with sensitivity to flight program execution modes. Results obtained have been statistically assessed to ascertain system-level reliability implications based on a model that is described herein. The overall methodology/facility itself has been critiqued and found to constitute a promising enhancement to current practice. GRA

N89-10563# National Aerospace Lab., Tokyo (Japan).
GENERATION OF A GRID FOR A FINITE DIFFERENCE CALCULATION OF FLOWS AROUND AN AIRCRAFT IN CARTESIAN COORDINATES
1987 18 p In JAPANESE; ENGLISH summary
(NAL-TR-956; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

The generation of a grid for an infinite difference calculation of flows around an aircraft in Cartesian coordinates is examined. The main equations governing the generation are plane and line equations in the three-dimensional field. The external form of the aircraft is shaped from a large number of small triangular planes. The grid is formed by three groups of lines perpendicularly intersecting each other. The quantitative relations between the external form of the aircraft and points of the grid are obtained by algebraic treatment of the plane and line equations. In the same manner, views of the aircraft are drawn using these equations. Author

N89-10565# National Aerospace Lab., Tokyo (Japan).
PROGRAMMING TECHNIQUES FOR HIGH-SPEED PROCESSING ON THE SUPERCOMPUTER FUJITSU VP-SYSTEM

MASAHIRO YOSHIDA, KINUYO NAKAMURA, KEIICHIRO UCHIDA, and YOSHIYUKI TANAKURA 1986 78 p In JAPANESE; ENGLISH summary
(NAL-TR-915; ISSN-0389-4010) Avail: NTIS HC A05/MF A01

Various methods of effective FORTRAN programming for supercomputers are presented. These programming methods are designed to increase vectorization rates and to facilitate high-speed processing of FORTRAN programs. The methods were used to improve the following NAL application software packages: the FVMCAS program for analyzing inviscid compressible flow through three-dimensional cascades and the USTF3 program for unsteady transonic potential flow over oscillating three-dimensional wings. The vectorized codes are executed on the supercomputer FUJITSU VP-400. Computing times compared with those of the original programs show the excellent usefulness of the vectorizing methods. Author

N89-10833# Electronique Serge Dassault, St. Cloud (France).
A HIGHLY RELIABLE COMPUTER FOR AIRBORNE APPLICATIONS
MICHEL MUENIER *In* AGARD, Computing Systems Configuration for Highly Integrated Guidance and Control Systems 17 p Jun. 1988
Avail: NTIS HC A08/MF A01

The reliability features of the CMF (French Military Computer) AIR embedded computer supporting its operational software are described. This computer was designed to meet the requirements of the ACE (European Combat Aircraft)/RAFALE D aircraft. Therefore, it has to be highly dependable to satisfy severe physical requirements (size, weight, power consumption, etc.) and to support real-time software execution (this software being written in high-level languages such as Ada and LTR3, a French Pascal-like real-time language). The general structure of the computer is first presented, emphasis being placed on the technological choices (for example, the use of ASICs: Application Specific Integrated Circuits). The various protective mechanisms provided at the level of the machine (hardware and microcode) are then presented: data access control and code execution control. Finally, a short presentation of the software production environment is given. In conclusion, the compromise made between operational dependability and performance characteristics are summarized. Author

N89-10837# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Avionics Lab.
HIGH SPEED PARALLEL PROCESSING NETWORKS FOR ADVANCED ARCHITECTURES
D. REED MORGAN *In* AGARD, Computing Systems Configuration for Highly Integrated Guidance and Control Systems 17 p Jun. 1988
Avail: NTIS HC A08/MF A01

Many force multiplier improvements in vehicle control, situation awareness and crew decision aiding will be made possible if affordable, flyable supercomputers and associated software can be developed for next-generation military aircraft. New functional architectures will emerge because dramatic improvements in processing speed can be implemented through tightly coupled networks. Unconstrained system architectures can be developed where the system designer will have the capability to fuse together needed logical functions irrespective of previous boundaries. In addition, increased local processing (e.g., smart sensors) will be made possible to improve threat and target classification. Robust use of real-time artificial intelligence at both local, functional and system levels will be achievable, along with inprovements in fault tolerance and system diagnostics. Author

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PHYSICS

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

A89-10112*# United Technologies Corp., Windsor Locks, Conn.
RESULTS OF ACOUSTIC TESTS OF A PROP-FAN MODEL
F. B. METZGER and P. C. BROWN (United Technologies Corp., Windsor Locks, CT) Journal of Aircraft (ISSN 0021-8669), vol. 25, July 1988, p. 653-658. Previously cited in issue 20, p. 3285, Accession no. A87-45282.
(Contract NAS3-24222)

A89-11101#
ACOUSTICS OF TRANSONIC BLADE-VORTEX INTERACTIONS
A. R. GEORGE and A. S. LYRINTZIS (Cornell University, Ithaca, NY) AIAA Journal (ISSN 0001-1452), vol. 26, July 1988, p. 769-776. Research supported by the McDonnell Douglas Helicopter Co. Previously cited in issue 22, p. 3337, Accession no. A86-45476. refs

A89-11102#
NOISE FIELD OF A PROPELLER WITH ANGULAR INFLOW
R. STUFF (University of Petroleum and Minerals, Dhahran, Saudi Arabia) AIAA Journal (ISSN 0001-1452), vol. 26, July 1988, p. 777-782. refs

The propeller blade forces are replaced by doublet and quadrupole distributions for the acceleration potential. An essential step in the solution is the derivation of a near-field and a far-field formula for the pressure due to a point force in arbitrary motion within a uniformly moving acoustic medium. The discrete frequency spectrum and the three-dimensional directionality of the noise radiated from a propeller with angular inflow are obtained by a conventional Fourier series expansion of the signature. The final analytical formulas can be evaluated with simple calculation. Author

A89-12561*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CRUISE NOISE OF THE 2/9 SCALE MODEL SR-7A PROPELLER
JAMES H. DITTMAR (NASA, Lewis Research Center, Cleveland, OH) and DAVID B. STANG (Sverdrup Technology, Inc., Cleveland, OH) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 740-746. Previously cited in issue 04, p. 570, Accession no. A88-16565. refs

A89-12563*# Southwest Research Inst., San Antonio, Tex.
STRUCTURE-BORNE NOISE CONTROL FOR PROPELLER AIRCRAFT
JAMES F. UNRUH (Southwest Research Institute, San Antonio, TX) Journal of Aircraft (ISSN 0021-8669), vol. 25, Aug. 1988, p. 752-757. Previously cited in issue 04, p. 569, Accession no. A88-16541. refs
(Contract NAS1-17921)

N89-10601*# Planning Research Corp., Hampton, Va.
ON THE APPROPRIATENESS OF APPLYING CHI-SQUARE DISTRIBUTION BASED CONFIDENCE INTERVALS TO SPECTRAL ESTIMATES OF HELICOPTER FLYOVER DATA
CHARLES K. RUTLEDGE Aug. 1988 65 p

(Contract NAS1-18000)
(NASA-CR-181692; NAS 1.26:181692) Avail: NTIS HC A04/MF A01 CSCL 20A

The validity of applying chi-square based confidence intervals to far-field acoustic flyover spectral estimates was investigated. Simulated data, using a Kendall series and experimental acoustic data from the NASA/McDonnell Douglas 500E acoustics test, were analyzed. Statistical significance tests to determine the equality of distributions of the simulated and experimental data relative to theoretical chi-square distributions were performed. Bias and uncertainty errors associated with the spectral estimates were easily identified from the data sets. A model relating the uncertainty and bias errors to the estimates resulted, which aided in determining the appropriateness of the chi-square distribution based confidence intervals. Such confidence intervals were appropriate for nontonally associated frequencies of the experimental data but were inappropriate for tonally associated estimate distributions. The appropriateness at the tonally associated frequencies was indicated by the presence of bias error and noncomformity of the distributions to the theoretical chi-square distribution. A technique for determining appropriate confidence intervals at the tonally associated frequencies was suggested. Author

N89-10603*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE EFFECT OF FRONT-TO-REAR PROPELLER SPACING ON THE INTERACTION NOISE AT CRUISE CONDITIONS OF A MODEL COUNTERROTATION PROPELLER HAVING A REDUCED DIAMETER AFT PROPELLER
JAMES H. DITTMAR, ELIOTT B. GORDON (Sverdrup Technology, Inc., Cleveland, Ohio.), and ROBERT J. JERACKI Oct. 1988 30 p
(NASA-TM-101329; E-4340; NAS 1.15:101329) Avail: NTIS HC A03/MF A01 CSCL 20A

The effect of forward-to-aft propeller spacing on the interaction noise of a counterrotation propeller with reduced aft diameter was measured at cruise conditions. In general, the tones at 100 percent speed decreased from close to nominal spacing as expected from a wake decay model. However, when the spacing was further increased to the far position, the noise did not decrease as expected and in some cases increased. The behavior at the far spacing was attributed to changing forward propeller performance, which produced larger wakes. The results of this experiment indicate that simple wake decay model is sufficient to describe the behavior of the interaction noise only if the aerodynamic coupling of the two propellers does not change with spacing. If significant coupling occurs such that the loading of the forward propeller is altered, the interaction noise does not necessarily decrease with larger forward-to-aft propeller spacing. Author

N89-10856*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NOISE OF THE HARRIER IN VERTICAL LANDING AND TAKEOFF
PAUL T. SODERMAN and JOHN D. FOSTER *In its* The 1987 Ground Vortex Workshop p 167-190 Feb. 1988
Avail: NTIS HC A10/MF A01 CSCL 01A

The noise of the Harrier AV8C aircraft in vertical takeoff and landing was measured 100 feet to the side of the aircraft where jet noise dominates. The noise levels were quite high - up to 125 dB overall sound level at 100 feet. The increased noise due to jet impingement on the ground is presented as a function of jet height to diameter ratio. The impingement noise with the aircraft close to the ground was 14 to 17 dB greater than noise from a free jet. Results are compared with small-scale jet impingement data acquired elsewhere. The agreement between small-scale and full-scale noise increase in ground effect is fairly good except with the jet close to the ground. It is proposed that differences in the jet Reynolds numbers and the resultant character of the jets may be partially responsible for the disparity in the full-scale and small-scale jet impingement noise. The difference between single-jet impingement and multiple-jet impingement may also have been responsible for the small-scale and full-scale disagreement. Author

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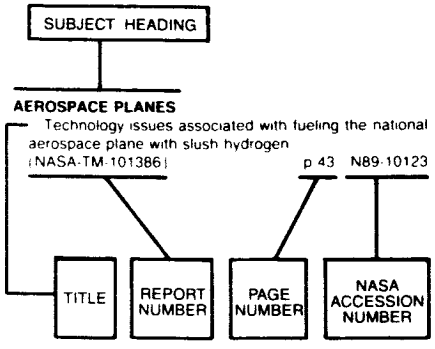
GENERAL

A89-10537
THE NONRIGID AIRSHIP OF THE SIEMENS-SCHUCKERT WORKS [DAS PRALLE LUFTSCHIFF DER SIEMENS-SCHUCKERT-WERKE]
H. MOENKE (DGLR, Stein an der Traun, Federal Republic of Germany) IN: Yearbook 1987 I; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 443-449. In German. refs
(DGLR PAPER 87-055)

The design, construction, and test-flight performance of the large nonrigid airships built by Siemens in the period 1907-1911 are reviewed and illustrated with drawings and photographs. The final version of the airship was 118 m long and 13.5 m in diameter and had a gas volume of 15,000 cu m, divided into four compartments; it was powered by four 125-hp engines and had a maximum speed of 19.8 m/sec. Consideration is given to the preliminary tests and design process, the fabrication of the full-scale prototype, test flights in 1911, the rotating hangar (permitting enclosure or release with the airship facing the wind), and the reasons why the program was finally abandoned. It is pointed out that the only airships in operation today employ the same design concept as the Siemens airship. T.K.

Typical Subject Index Listing



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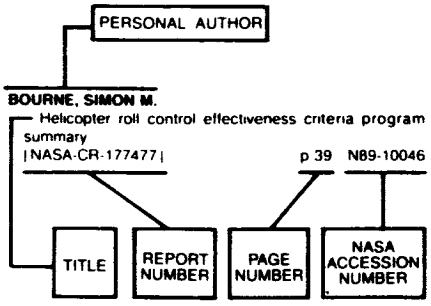

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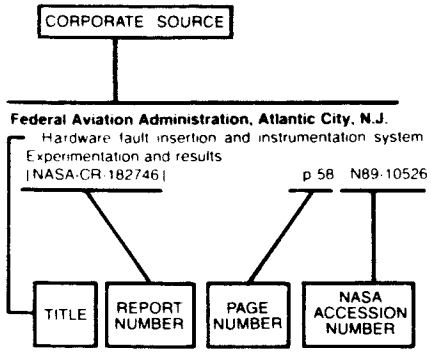

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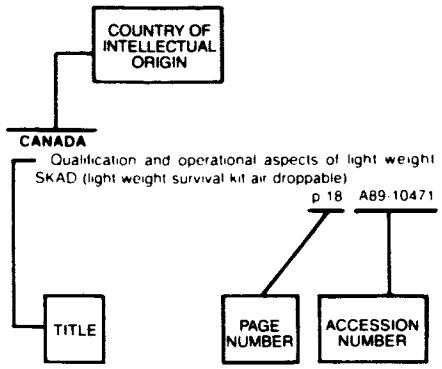

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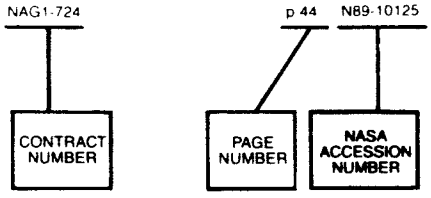

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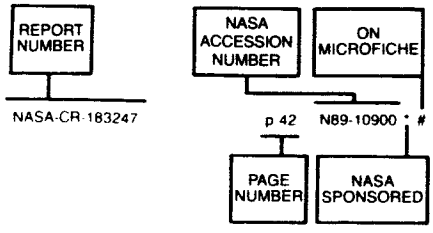

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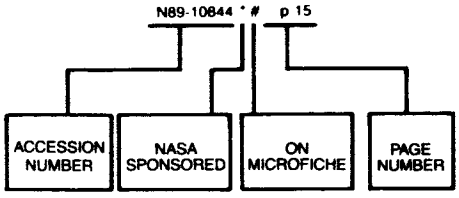

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NASA SP-7037 (236)		

4. Title and Subtitle	5. Report Date
Aeronautical Engineering A Continuing Bibliography (Supplement 236)	February 1989
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
	10. Work Unit No.

9. Performing Organization Name and Address	11. Contract or Grant No.
National Aeronautics and Space Administration Washington, DC 20546	13. Type of Report and Period Covered

12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code

15. Supplementary Notes

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Documents Division
Missoula, MT 59812
(406) 243-6700

NEBRASKA

UNIVERSITY OF NEBRASKA - LINCOLN
Love Library
Documents Department
Lincoln, NE 68588-0410
(402) 472-2562

NEVADA

UNIVERSITY OF NEVADA LIB.
Govt. Pub. Department
Reno, NV 89557-0044
(702) 784-6579

NEW JERSEY

NEWARK PUBLIC LIBRARY
5 Washington Street
Newark, NJ 07101-0630
(201) 733-7812

NEW MEXICO

UNIVERSITY OF NEW MEXICO
Zimmerman Library
Government Pub. Dept.
Albuquerque, NM 87131
(505) 277-5441

NEW MEXICO STATE LIBRARY
Reference Department
325 Don Gaspar Avenue
Santa Fe, NM 87503
(505) 827-3826

NEW YORK

NEW YORK STATE LIBRARY
Empire State Plaza
Albany, NY 12230
(518) 474-5563

NORTH CAROLINA

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
Davis Library
BA/SS Documents Division
Chapel Hill, NC 27515
(919) 962-1151

NORTH DAKOTA

UNIVERSITY OF NORTH DAKOTA
Chester Fritz Library
Documents Department
Grand Forks, ND 58202
(701) 777-4629
In cooperation with North Dakota State Univ. Library

OHIO

STATE LIBRARY OF OHIO
Documents Department
65 South Front Street
Columbus, OH 43266-0334
(614) 462-7051

OKLAHOMA

OKLAHOMA DEPT. OF LIB.
Government Documents
200 NE 18th Street
Oklahoma City, OK 73105
(405) 521-2502 ext. 252

OKLAHOMA STATE UNIV. LIB.
Documents Department
Stillwater, OK 74078
(405) 624-6546

OREGON

PORTLAND STATE UNIV. LIB.
Documents Department
P.O. Box 1151
Portland, OR 97207
(503) 229-3673

PENNSYLVANIA

STATE LIBRARY OF PENN.
Government Pub. Section
P.O. Box 1601
Harrisburg, PA 17105
(717) 787-3752

TEXAS

TEXAS STATE LIBRARY
Public Services Department
P.O. Box 12927—Cap. Sta.
Austin, TX 78711
(512) 475-2996

TEXAS TECH. UNIV. LIBRARY
Govt. Documents Department
Lubbock, TX 79409
(806) 742-2268

UTAH

UTAH STATE UNIVERSITY
Merrill Library, U.M.C. 30
Logan, UT 84322
(801) 750-2682

VIRGINIA

UNIVERSITY OF VIRGINIA
Alderman Lib.—Public Doc.
Charlottesville, VA 22903-2498
(804) 924-3133

WASHINGTON

WASHINGTON STATE LIBRARY
Documents Section
Olympia, WA 98504
(206) 753-4027

WEST VIRGINIA

WEST VIRGINIA UNIV. LIB.
Documents Department
Morgantown, WV 26506-6069
(304) 293-3640

WISCONSIN

MILWAUKEE PUBLIC LIBRARY
814 West Wisconsin Avenue
Milwaukee, WI 53233
(414) 278-3065

ST. HIST LIB. OF WISCONSIN
Government Pub. Section
816 State Street
Madison, WI 53706
(608) 262-4347

WYOMING

WYOMING STATE LIBRARY
Supreme Ct. & Library Bld.
Cheyenne, WY 82002
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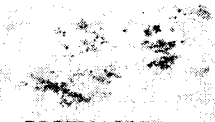

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