NASA SP-7037(238)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 238)

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 March 1989 in

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

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Office of Management
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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 458 reports, journal articles and other documents originally announced in March 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 11	**Chemistry and Materials** Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.	**185**

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Category 13 Geosciences 195
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Category 14 Life Sciences N.A.
Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.

Category 15 Mathematical and Computer Sciences 197
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.

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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 204
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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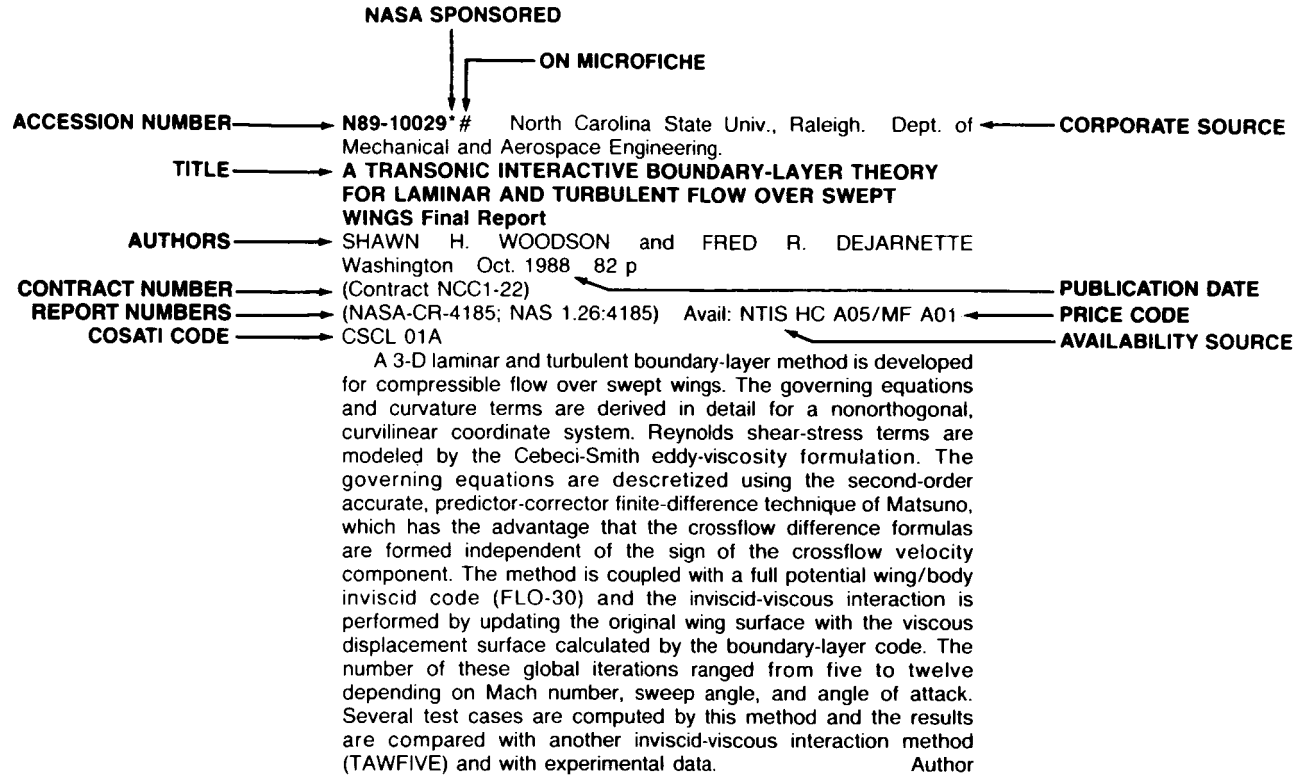
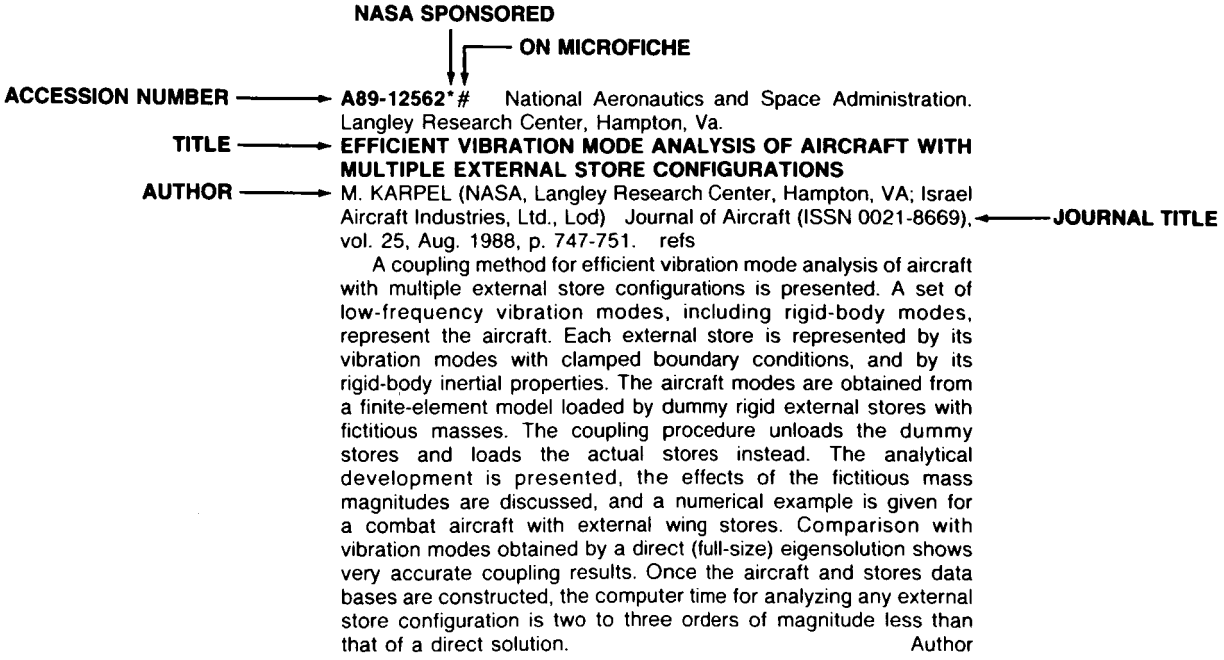
TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 238)

APRIL 1989

01

AERONAUTICS (GENERAL)

A89-18011
AVIONICS TESTING IN THE MILITARY BARE-BASE ENVIRONMENT
A. PADGETT PETERSON (Martin Marietta Electronic Systems Center, Orlando, FL) IN: AUTOTESTCON '88; Proceedings of the IEEE International Automatic Testing Conference, Minneapolis, MN, Oct. 4-6, 1988. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 103-106.

The bare-base support environment for avionics is examined with emphasis on the units to be tested, operator sheltering, unsupplied duration, portable vs. semiportable equipment, and the criteria necessary for testing current and developing avionics. The current multisquadron intermediate-level test equipment is compared with the requirements arising from the deployment of small numbers (6-10) of aircraft in forward areas. Data derived from the Air Force Coronet Warrior exercise is presented to demonstrate actual testing requirements for avionics equipment, as projected onto the bare-base support task. I.E.

A89-18023
INTEGRATED DIAGNOSTIC CONCEPTS FOR ADVANCED TECHNOLOGY ROTORCRAFT
JAN-DAVID MARCUS, JAMES MAHANNA, and ROBERT GRUESSNER (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AUTOTESTCON '88; Proceedings of the IEEE International Automatic Testing Conference, Minneapolis, MN, Oct. 4-6, 1988. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 171-177.

It is proposed to achieve integrated diagnostic systems for advanced rotorcraft by melding together design-for-testability (DFT), expert systems, advanced maintenance architectures, portable maintenance aids, and electronic publications. Mechanical and avionic systems of the rotorcraft would both be covered by the diagnostic system. The problem is broken down into mechanical diagnostics, in-flight diagnostics, and ground-based diagnostics. I.E.

A89-18025
THE ENEMY IS FA, CND, AND RTOK
J. M. ANDERSON and J. M. LASKEY (General Electric Co., Automated Systems Dept., Burlington, MA) IN: AUTOTESTCON '88; Proceedings of the IEEE International Automatic Testing Conference, Minneapolis, MN, Oct. 4-6, 1988. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 185-189.

Integrated diagnostic requirements of a modern avionic subsystem are identified. A conceptual integrated diagnostic approach to meeting these requirements is postulated. Its essential elements, layered onboard built-in test (BIT), flight-line BIT augmentation, depot automatic test equipment (ATE), and a diagnostic support information system are described. Modern maintenance concepts into which these must be embedded are outlined and discussed. Mechanisms for false alarm (FA), cannot duplicate (CND), and retest OK (RTOK) events are identified, and their adverse impact assessed using both historical data and analytical examples. Corrective approaches are identified and their potential effectiveness examined. Criteria for evaluating ID tradeoffs in this milieu are identified. I.E.

A89-18053#
MODULAR AVIONICS SYSTEMS ARCHITECTURE (MASA) - SEEDS OF DESTRUCTION OR SEEDS OF PROGRESS?
ROBERT P. LAVOIE IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 8-15.
(AIAA PAPER 88-3851)

This paper identifies payoffs, risks, and some negative business implications involved in the adoption of standard electronics and avionics modules. The potential impact on the technical base that has permitted conventional avionics products to come far in the last two decades is explored. A course of action that would focus the standard module concept, critically examine the payoffs, identify offsetting cost penalties, and limit damage to current product lines is proposed. C.D.

A89-18347
DOWN WITH DRAG
CHRIS DREWER Flight International (ISSN 0015-3710), vol. 134, Oct. 22, 1988, p. 26-28.

Current research into LFC benefits from novel manufacturing techniques that allow boundary layer suction to be accomplished through the electron beam or laser drilling of microscopic holes on wing surfaces. Additional techniques under investigation by such agencies as NASA for near-term implementation are large eddy-breakup devices, noise reduction on aerodynamic surfaces near engines, and 'riblet' V-grooves aligned with the flow. The intriguing sonic-boom and surface temperature-reduction consequences of LFC for SSTs are noted. O.C.

A89-18851
AHS, ANNUAL FORUM, 44TH, WASHINGTON, DC, JUNE 16-18, 1988, PROCEEDINGS
Forum sponsored by AHS. Alexandria, VA, American Helicopter Society, 1988, 910 p. For individual items see A89-18852 to A89-18930.

The present conference discusses topics in helicopter and tilt-rotor vehicle aerodynamics, military operations, avionics and systems, product-support, structural dynamics, structures and materials, configuration design, manufacturing method and product assurance, handling qualities, acoustics, advanced propulsion, and testing and evaluation methods. Attention is given to rotor/airframe interaction in tilt-rotor aircraft, the evolution of the V-22 tilt-rotor toward ASW, airframe and propulsion assessment for the LHX, human factors in the V-22's cockpit design, helicopter vibration analysis and control, structural dynamics of a helicopter rotor blade system, and five candidate designs for civil tilt-rotor aircraft. Also discussed are the processing and properties of Al-Li alloys, the aeroelastic optimization of a helicopter rotor, the determination of control laws for a single-pilot helicopter, the sand and ice ingestion behavior of dual centrifugal compressors, active acoustical control for cylindrical fuselage structures, and air-to-air combat helicopter development. O.C.

A89-18859
AIR COMBAT TACTICS FOR THE EVALUATION OF ROTORCRAFT CHARACTERISTICS IN THE LOW AIR WAR OF 2010
DAVID L. GREEN (Starmark Corp., Arlington, VA) and JACK V. MACKMULL IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 119-137. refs

The characteristics of an aerial battlefield below 100-m altitude are postulated for 2010-timeframe technologies. This scenario is applied, together with a conceptual high-performance rotorcraft system, to a holistic analytical method for the synthesis of air combat tactics. The utility of a rotorcraft possessing a large power margin and speed advantage over its adversary is evaluated through the iterative application of an action-reaction analysis which converges on tactics and rules-of-engagement. A sample set of these synthesized tactics are presented to indicate the king of tactical advantage thus achievable. O.C.

A89-18860
US ARMY AIRCRAFT COMBAT MAINTENANCE/BATTLE DAMAGE REPAIR PROGRAM
MING-LEUNG LAU (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 139-142.

This paper discusses the research and development efforts conducted by the U.S. Army Aviation Applied Technology Directorate (AATD) under the Aircraft Combat Maintenance/Battle Damage Repair (ACM/BDR) program. Under the ACM/BDR program, battle damage repair (BDR) kits for aircraft systems and battle damage assessment and repair (BDAR) manuals for helicopters are being developed, evaluated and fielded. Fielding of the BDR kits and BDAR manuals will provide Army aviation units with the maintenance resources needed to support increased maintenance workloads associated with sustained combat operations. Author

A89-18862
TILTROTOR EVOLUTION LEADS TO ASW REVOLUTION
MIKE JAGIELSKI, JACK LATCHFORD, DICK SPIVEY (Bell Helicopter Textron, Inc., Fort Worth, TX), and R. P. KRULIS (U.S. Navy, Naval Air Systems Command, Washington, DC) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 149-157.

The 'missionization' of the SV-22 for ASW is analyzed. Evolving SV-22 requirements are profiled from the perspective of the increasing Soviet submarine threat. The unique flexibility of the SV-22 to respond to a wide variety of ASW tactical situations, ranging from carrier-based operations to other ship-based missions that demand operations from smaller surface combatants capable of supporting only VTOL aircraft, is highlighted. The SEAHUNT computer model is used to analyze and graphically demonstrate the SV-22's contribution to Navy battle group survivability. Author

A89-18869
AH-64A CONTRACTOR LOGISTIC SUPPORT - THE CONTRACTORS' PERSPECTIVE
JOHN E. REAGAN and JACK WOOD (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 235, 236.

This paper provides an overview of the AH-64A Apache Contractor Logistics Support (CLS) Program from first flight, January 26, 1984, through the formal end of CLS, February 1, 1987. To gain an understanding of the magnitude of the tasks accomplished during the CLS phase, 270 Apaches were fielded. Additionally, more than 10,000 lines of spares and repair parts, trainers, and test program sets were delivered, along with spares and repair parts to support fielding of 10 Authorized Stockage Lists and eight Prescribed Load List. Author

A89-18873
IMPROVED LIFE CYCLE 'REPS' SERVICES - V-22 ENGINEERING TECHNICAL SERVICES AND LOGISTICS PLANNING
CRESSWELL D. ELMORE (U.S. Navy, Naval Air Systems Command, Washington, DC) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 255-259.

The V-22 Integrated Logistics Support Program capitalizes on the early implementation of Cognizant Field Activity (CFA) capabilities to reduce armed services' dependency on contractor-purveyed engineering services. This has entailed the formulation of firm, fixed-price requirements for V-22 full-scale engineering development, as well as option items contract specifications that call for early incremental training for depot-level support. CFA will ensure that the Naval Air Engineering Support Unit's personnel are trained during the late full-scale engineering development and early operations phases. O.C.

A89-19551
AEROSPACE SIMULATION III; PROCEEDINGS OF THE SCS MULTICONFERENCE, SAN DIEGO, CA, FEB. 3-5, 1988
MONTE UNG, ED. (Southern California, University, Los Angeles, CA) Conference sponsored by the Society for Computer Simulation International. San Diego, CA, Society for Computer Simulation International (Simulation Series. Volume 19, No. 2, Apr. 1988), 1988, 316 p. For individual items see A89-19552 to A89-19573.

The conference presents papers on hardware-in-the-loop, aircrafts and rotorcrafts, missile applications, space applications, SDI, and research and developments. Particular attention is given to scene generation for real-time missile flight test, imaging missile simulations, and X-29 validation methodology for simulation and flight control system. Other topics include real-time simulation of the Space Station mobile service center, a model of the earth's magnetic field as applied to missile attitude reference, and AHIS-detailed endoatmospheric endgame digital simulation. K.K.

A89-19864#
COMPARISON OF FAA DO-178A AND DOD-STD-2167A APPROACHES TO SOFTWARE CERTIFICATION
MICHAEL P. DEWALT (FAA, Seattle, WA) AIAA, Digital Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988. 8 p.
(AIAA PAPER 88-4044)

There are two popular standards for developing avionics software. The standard used for commercial aircraft is RTCA/DO-178A, Software Considerations in Airborne Systems and Equipment Certification whereas military environment uses DOD-STD-2167A, Military Standard Defense System Software Development. This paper compares these two standards and demonstrates that, with some minor additional documentation changes, software developed under the military standard DOD-STD-2167A could be compatible with certification requirements imposed by the Federal Aviation Administration through RTCA/DO-178A for commercial aircraft. Author

A89-20226
YEARBOOK 1987 II; DGLR, ANNUAL MEETING, BERLIN, FEDERAL REPUBLIC OF GERMANY, OCT. 5-7, 1987, REPORTS [JAHRBUCH 1987 II; DGLR, JAHRESTAGUNG, BERLIN, FEDERAL REPUBLIC OF GERMANY, OCT. 5-7, 1987, VORTRAEGE]
Meeting sponsored by DGLR. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, 567 p. In German and English. For individual items see A89-20227 to A89-20245.

Various papers on aerodynamics and space flight are presented. The topics addressed include: technological tasks in aerothermodynamics; uses and technologies of future regenerative communications satellites; German-Italian program in microgravity research; new testbeds for future space travel developments and hypersonic flight; primary and regenerative fuel cell systems for the European space flight scenario; BIOTEX project for biological experiments in microgravity; balloon-borne microgravity experiments; numerical methods for hypersonic flows. Also

discussed are: MPC 75 project for advanced regional air traffic; progress towards a commercial aircraft design expert system; concept and testing of a modern longitudinal movement controller using an inverse model; flight guidance technology; design and integration of air-breathing propulsion systems of space flight and hypersonic flight vehicles; ruggedness of dynamically loaded power inlets in fiber-reinforced composite rotors; fiber-reinforced composite materials for supersonic flight.

A89-20242
INTRODUCTION OF NEW TECHNOLOGIES IN THE STRUCTURAL AREA FROM THE VIEWPOINT OF IABG [EINFUEHRUNG NEUER TECHNOLOGIEN AUF DEM STRUKTURGEBIET AUS DEM BLICKFELD DER IABG]
K. WOITHE (Industrieanlagen-Betriebsgesellschaft mbH, Ottobrunn, Federal Republic of Germany) IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 867-872. In German.
(DGLR PAPER 87-107)

An overview is presented of significant developments in the application of reinforced fiber composites to aircraft structures in West Germany. Helicopters, fighter aircraft, commercial aviation, and general aviation are considered. Goals for the future in this area are examined. C.D.

A89-20744
V-22 OSPREY ENABLING TECHNOLOGIES
STANLEY MARTIN and ALLEN H. SCHOEN (Bell Helicopter Textron, Inc., Fort Worth, TX) Vertiflite (ISSN 0042-4455), vol. 34, Nov.-Dec. 1988, p. 46-50.

The technologies most essential to the success of the V-22 tilt-rotor VTOL aircraft were largely identified in the course of the VX-15 tilt-rotor research aircraft program, which also established flight envelope contours required by the variety of Navy and Marine Corps missions for which the V-22 is intended. The technologies that will ensure such missions' success encompass digital fly-by-wire controls, in the form of a triplex self-monitored primary flight control system with triplicated and separated hydraulics, and composite primary structures capable of satisfying not only the obvious stiffness and lightness criteria, but the high ballistic tolerance necessary for military missions as well. O.C.

A89-20747
NASA/AHS ROTORCRAFT NOISE REDUCTION PROGRAM - MCDONNELL DOUGLAS HELICOPTER COMPANY ACCOMPLISHMENTS
R. D. JANAKIRAM (McDonnell Douglas Helicopter Co., Phoenix, AZ) Vertiflite (ISSN 0042-4455), vol. 34, Nov.-Dec. 1988, p. 64-68.

The contributions of a major U.S. aircraft manufacturer to the NASA Advanced Helicopter Systems noise reduction program are evaluated. These efforts have encompassed NASA-Wallops and NASA-Langley main rotor noise-dominant MD500E helicopter test flights and HARP rotor anechoic wind tunnel tests. Major contributions have also been made to the development and evaluation of prediction methodologies such as NASA-Langley's ROTONET; this provides component source aerodynamic and noise prediction models of varying complexity, and allows the substantiation of user-generated prediction modules. O.C.

02

AERODYNAMICS

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

A89-17147#
DETECTION OF LAMINAR-TURBULENT TRANSITION BY INFRARED THERMOGRAPHY
G. GAUFFRE (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 2, 1988, p. 11-22. refs

An aerodynamic flow results in major heat transfers between an aircraft and the fluid it is flying through. These transfers differ greatly depending on the laminar or turbulent state of the boundary layer. Using the infrared radiation from the body itself, it is possible to establish an approximate thermal mapping and thereby localize the transition between the regions of laminar and turbulent flow. In the first part of the present paper, we study the creation of the thermal distribution on the surface of the model and the phenomena that disturb this map. The infrared systems used are then described, along with the precautions to be taken to obtain significant thermal images. Very probative results have already been obtained throughout the subsonic domain and the extension to the supersonic and hypersonic domains is now under way. Author

A89-17150#
COMPUTATION OF THE PRESSURE IN AN INCOMPRESSIBLE ROTATIONAL FLOW OF INVISCID FLUID
B. CANTALOUBE and C. REHBACH (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 2, 1988, p. 57-61. refs

In an unsteady flow of inviscid incompressible fluid with vorticity, the static pressure is computed by solving a type 2 Fredholm integral equation. This is the logical complement of the integral solution known for the velocity field, and avoids introducing the idea of the velocity potential of a vortex field that appears in the unsteady Bernoulli integral usually used for evaluating the pressure. Author

A89-17460
SPATIAL MARCHING TECHNIQUES FOR APPROXIMATE SOLUTIONS TO THE HYPERSONIC BLUNT BODY PROBLEM
FREDERICK G. BLOTTNER (Sandia National Laboratories, Albuquerque, NM) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 8, Oct. 1988, p. 1331-1347. refs
(Contract DE-AC04-76DP-00789)

Two reduced forms of the Euler equations which allow spatial marching in subsonic flow regions are investigated for solving the inviscid blunt-body problem. An analysis of the eigenvalues to determine the properties of the steady and unsteady forms of the governing equations is performed. Numerical results from the thin-layer equations are less accurate, and the suitability of this approach in a global iteration procedure is questioned, as the analysis shows information is not transmitted upstream. The pressure-gradient splitting method gives more accurate results with a single downstream march and appears better suited for use in a global iteration procedure to obtain the complete solution of the Euler equations. Author

A89-17874#
STUDY THE AERODYNAMICS CHARACTERISTICS OF AIRFOIL ON VECTOR PROCESSORS
LAI-CHEN CHIEN, WEN-YUAN HSU, and HSIN-HUA TSUEI (National Central University, Chung-Li, Republic of China) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p. refs
(IAF PAPER ST-88-09)

The time-dependent, two-dimensional Euler equation in conservative form is taken into account to study the problem

considered. The modified differential quadrature method is incorporated with a Runge-Kutta time integration scheme to solve the governing equations. In the modified differential quadrature method, the spatial derivatives are approximated by a weighted sum of unknown function at properly chosen neighboring points to generate a set of differential equations in time. Then the set of ordinary equations is solved by a vectorized fourth-order Runge-Kutta time integration scheme using a vector processor. The details of the vectorization process are presented. Author

A89-17940*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EULER ANALYSIS OF A SWIRL RECOVERY VANE DESIGN FOR USE WITH AN ADVANCED SINGLE-ROTATION PROPFAN
CHRISTOPHER J. MILLER (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 15 p. Previously announced in STAR as N88-29771. refs
(AIAA PAPER 88-3152)

Recent work has demonstrated the propulsive efficiency improvement available from single- and counter-rotation propfans as compared with current technology high bypass ratio turbofans. The concept known as swirl recovery vanes (SRV) is examined through the use of a 3-D Euler code. At high speed cruise conditions, the SRV can improve the efficiency level of a single-rotation propfan, but a concern is to have adequate hub choke margin. The SRV was designed with 2-D methods and was predicted to have hub choking at Mach 0.8 cruise. The 3-D Euler analysis properly accounts for sweep effects and 3-D relief, and predicts that at cruise the SRV will recover roughly 5 percent of the 10 percent efficiency loss due to swirl and have a good hub choke margin. Author

A89-18355
CALCULATION OF THE UNSTEADY AERODYNAMIC CHARACTERISTICS OF BODIES IN THE CASE OF SEPARATED FLOW [RASCHET NESTATSIONARNYKH AERODINAMICHESKIKH KHARAKTERISTIK TEL PRI OTRYVNOM OBTEKANII]
V. A. APARINOV, S. M. BELOTSERKOVSKII, I. K. LIFANOV, and A. A. MIKHAILOV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 28, Oct. 1988, p. 1558-1566. In Russian. refs

A method is developed for the numerical simulation of three-dimensional separated flow past bluff bodies with fixed points of flow separation. An integrodifferential mathematical model for the three-dimensional separated flow is derived, and a calculation example is presented. B.J.

A89-18357
CALCULATION OF HYPERSONIC FLOW PAST THE WINDWARD SIDE OF A LOW-ASPECT-RATIO WING AT HIGH ANGLES OF ATTACK [RASCHET GIPERZVUKOVOGO OBTEKANIIA NAVETRENNOI STORONY KRYLA MALOGO UDLINENIIA PRI BOL'SHIKH UGLAKH ATAKI]
V. N. GOLUBKIN and V. V. NEGODA Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 28, Oct. 1988, p. 1586-1594. In Russian. refs

The paper presents a theoretical analysis of the hypersonic flow past a thin low-aspect-ratio wing at an angle of attack close to pi/2. An asymptotic method is used to study the two-layer structure of compressed-gas flow between the bow shock and the windward side of the wing. B.J.

A89-18546
CONVECTIVE HEAT TRANSFER IN A BOUNDARY LAYER BEHIND A SHOCK WAVE PROPAGATING ALONG A FLAT PLATE WITH A SHARP LEADING EDGE - A CALCULATION METHOD AND A COMPARISON WITH EXPERIMENTAL DATA [KONVEKTIVNYI TEPLOOBMEN V POGRANICHNOM SLOE ZA UDARNOI VOLNOI, DVIZHUSHCHEISIA VDOL' PLOSKOI PLASTINY S OSTROI PEREDNEI KROMKOI - METOD RASCHETA I SRAVNENIE S EKSPERIMENTAL'NYMI DANNYMI]
V. I. ZUEV and V. K. SHIKOV (AN SSSR, Institut Vysokikh Temperatur, Moscow, USSR) Teplofizika Vysokikh Temperatur (ISSN 0040-3644), vol. 26, Sept.-Oct. 1988, p. 909-917. In Russian. refs

A89-18669
SELF-SIMILAR PROBLEM OF THE SEPARATED FLOW OF AN IDEAL FLUID PAST AN EXPANDING PLATE [AVTOMODEL'NAIA ZADACHA OTRYVNOGO OBTEKANIIA RASSHIRIAIUSHCHEISIA PLASTINY IDEAL'NOI ZHIDKOST'IU]
V. I. KOPCHENOV, A. N. KRAIKO, and S. K. SHCHIPIN Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1988, p. 62-69. In Russian. refs

The self-similar problem of nonstationary plane-parallel separated flow of an ideal fluid past a plate expanding from a point at a constant rate is analyzed with emphasis on flow topology. In particular, attention is given to the structure of conical flow lines and their runoff and spread points (for a special nonlinear law of plate expansion and variable incoming flow speed). A comparison of results produced by vortex sheet and vortex filament models is carried out over a wide range of flow parameters. V.L.

A89-18671
MATHEMATICAL MODELING OF LAMINAR AND TURBULENT SUPERSONIC FLOW PAST CONVEX-CONCAVE BODIES [MATEMATICHESKOE MODELIROVANIE LAMINARNOGO I TURBULENTNOGO SVERKHZVUKOVOGO OBTEKANIIA TEL VYPUKLO-VOGNUTOI FORMY]
A. M. GRISHIN and O. I. POGORELOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1988, p. 138-145. In Russian. refs

Laminar and turbulent supersonic flow past two convex-concave bodies is analyzed on the basis of Navier-Stokes equations. For laminar flow, the effect of the Reynolds number on the shock layer structure, pressure distribution, and heat flux is investigated. For turbulent flow, the calculated results are compared with the calculations and experimental data of recent studies. It is shown that, in the separation region, the pressure distributions on the body and the position and shape of the shock wave based on the Navier-Stokes equations are found to be in better agreement with experimental data than results based on the Euler and viscous shock layer equations. V.L.

A89-18675
DETERMINATION OF THE PERTURBATIONS OF THE FLOW FIELDS OF SUPERSONIC WIND TUNNELS FROM MEASURED AERODYNAMIC COEFFICIENTS [OPREDELENIE VOZMUSHCHENII POLEI POTOKOV SVERKHZVUKOVYKH AERODINAMICHESKIKH TRUB PO IZMERENNYM ZNACHENIIAM AERODINAMICHESKIKH KOEFFITSIENTOV]
V. V. EREMIN, IU. M. LIPNITSKII, and S. E. FILIPPOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Sept.-Oct. 1988, p. 183-185. In Russian.

A new approach is proposed for determining the perturbations of flow fields in supersonic wind tunnels, including the downwash. The approach is based on solving the inverse problem whereby the real values of these perturbations are reconstructed from the measured values of the integral aerodynamic characteristics of the model moving in the test section of the wind tunnel. The method is illustrated by a specific example. V.L.

A89-18749#
RECENT DEVELOPMENTS IN TRANSONIC FLOW COMPUTATION
P. NIYOGI (Indian Institute of Technology, Kharagpur, India) Institution of Engineers (India), Journal, Aerospace Engineering Division (ISSN 0257-3423), vol. 68, Sept. 1987-Mar. 1988, p. 12-23. refs

This paper is a brief survey of some of recent developments in transonic flow computation carried out in India over the past few years. The survey is divided into two parts: the first deals with results obtained through integral method, and the second reports works in transonic flow, using finite difference method. Author

A89-18750#
COMPUTATION OF AXISYMMETRIC SUPERSONIC JET USING SPACE MARCHING TECHNIQUE
M. A. RAMASWAMY (Indian Institute of Science, Bangalore, India) and N. MADHAVAN (Aeronautical Development Agency, Bangalore, India) Institution of Engineers (India), Journal, Aerospace Engineering Division (ISSN 0257-3423), vol. 68, Sept. 1987-Mar. 1988, p. 24-30.

An efficient space marching technique which has been applied earlier for computing inviscid supersonic flow over complex bodies has been applied to compute the flow field of axisymmetric supersonic free jets. Application of this technique to free jet flows involves modifications to take care of constant pressure boundary condition and the singularity of the axisymmetric equation at the axis. The present results are compared with those obtained from experiments and from the method of characteristics. The agreement is found to be quite satisfactory. This gives confidence in applying this technique to compute more complicated three-dimensional free jets. Author

A89-18803
COMPUTATIONAL ANALYSIS OF UNSTEADY SUPERSONIC CAVITY FLOWS DRIVEN BY THICK SHEAR LAYERS
X. ZHANG and J. A. EDWARDS (Cambridge University, England) Aeronautical Journal (ISSN 0001-9240), vol. 92, Nov. 1988, p. 365-374. Research supported by the Ministry of Defence Procurement Executive. refs

Supersonic cavity flows driven by a thick shear layer at Mach 1.5 and 2.5 are studied by solving the two-dimensional unsteady compressible Navier-Stokes equations in terms of mass-averaged variables. The length to depth ratio of the rectangular cavity is three. The numerical scheme used is the finite-difference algorithm by Brailovskaya. A two-layer eddy-viscosity turbulence model is used. The results are compared with experimental data. The computations show the self-sustained oscillations at Mach 1.5 and 2.5. The continuous formation and downstream shedding of leading edge vortices is demonstrated. The oscillatory modes are correctly predicted. The first mode is attributed to a large unsteady trailing edge vortex moving in the transverse direction. Based on the analysis, it is considered that the oscillation in the length to depth ratio three cavity is a longitudinal one and is controlled by a fluid dynamic mechanism rather than a purely acoustic one. Author

A89-18853
FREE WAKE CALCULATION OF ROTOR FLOW FIELDS FOR INTERACTIONAL AERODYNAMICS
TODD R. QUACKENBUSH (Continuum Dynamics, Inc., Princeton, NJ) and DONALD B. BLISS (Duke University, Durham, NC) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 29-43. refs
(Contract DAAL03-87-C-0013)

An evaluation is made of the applicability of novel vortex-dynamics analyses to rotorcraft interactional aerodynamics problems. A novel full-span rotor wake representation constructed on the basis of curved vortex elements is noted to yield both qualitatively and quantitatively accurate predictions of wake velocity data in low- and high-speed forward flight, and to illustrate the radical changes occurring in the wake velocity field with increasing speed. Also presented are new analysis methods for the intimate interactions between vortices and fixed surfaces which include a specialized treatment of the vortex velocity field for close interactions with paneled surfaces. O.C.

A89-18855* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ROTOR INFLOW VARIABILITY WITH ADVANCE RATIO
DANNY R. HOAD, SUSAN L. ALTHOFF, and JOE W. ELLIOTT (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 57-72. refs

A comparative study is conducted for the results of inflow calculations based on several analytical wake methods and laser-velocimeter rotor inflow measurements near a rectangular four-bladed rotor system operating in forward flight. The induced-flow characteristics at all advance ratios were found to be unsymmetrical about the longitudinal centerline, with maximum downwash in the rear portion of the disk, and skewed toward the advancing blade-side. Comparisons among analytical methods show that the region of induced upflow over the rotor disk was effectively modeled only at an advance ratio value of 0.15. O.C.

A89-18856
A CORRELATION STUDY OF ROTOR INFLOW IN FORWARD FLIGHT
BRUCE D. CHARLES and AHMED A. HASSAN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 73-85. refs

Correlation of the experimental inflow data obtained in the NASA Langley 14- by 22-Foot Subsonic Tunnel with the predicted inflow using Scully and Sadler free wake models has been performed. The sensitivity of time averaged induced velocities to wake geometry variations is examined here using the CAMRAD prescribed wake model. A comparison of the predicted free wake velocities is made with the time varying data to illustrate the influence of blade and vortex passage near the measurement point. A computational fluid dynamic model of the rotor, based on the solution of the unsteady full potential equation, has been employed to examine velocities induced at points passing near the blade. The experimental and full potential results are compared with velocities predicted using the lifting line bound vortex methodology inherent in the wake analysis. Author

A89-18857* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN ENTROPY AND VISCOSITY CORRECTED POTENTIAL METHOD FOR ROTOR PERFORMANCE PREDICTION
JOHN O. BRIDGEMAN (Woodside Summit Group, Inc., Mountain View, CA), ROGER C. STRAWN, and FRANCIS X. CARADONNA (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 87-98. refs

An unsteady Full-Potential Rotor code (FPR) has been enhanced with modifications directed at improving its drag prediction capability. The shock generated entropy has been included to provide solutions comparable to the Euler equations. A weakly interacted integral boundary layer has also been coupled to FPR in order to estimate skin-friction drag. Pressure distributions, shock positions, and drag comparisons are made with various data sets derived from two-dimensional airfoil, hovering, and advancing high speed rotor tests. In all these comparisons, the effect of the nonisentropic modification improves (i.e., weakens) the shock strength and wave drag. In addition, the boundary layer method yields reasonable estimates of skin-friction drag. Airfoil drag and hover torque data comparisons are excellent, as are predicted shock strength and positions for a high speed advancing rotor. Author

A89-18858
AN EXAMINATION OF SOME ROTOR AERODYNAMIC MODELS USING THE RSRA/X-WING MODEL TEST DATA
S. JON DAVIS, JOHN P. SHANLEY, and PAUL BUETTIKER (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 99-110. refs

A serious deficiency in a drag-calculating Prandtl-model's accuracy in determining the value for an X-wing's fixed operational mode has prompted the present imposition of simple loading distributions on forward- and aft-swept wings, using both the Prandtl lifting-line model and a combination of the Weissinger (1947) L-method and Munk's (1921) stagger theorem. Substantial differences are found between the total induced drag predicted by the two methods for elliptical, uniform, and triangularly tip-loaded lift distributions. Attention is also given to the results of a CRUISE5 configuration-performance analysis of the X-wing in conjunction with body-interference velocities calculated by the VSAERO panel code. O.C.

A89-18915
IMPROVEMENTS TO TRANSONIC FLOWFIELD CALCULATIONS
D. S. PRICHARD and L. N. SANKAR (Georgia Institute of Technology, Atlanta) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 785-796. Research supported by the McDonnell Douglas Helicopter Co. refs

Several improvements have been made to a transonic full potential flow code, to allow more accurate and flexible analysis of helicopter rotor blade flowfields. Rigid body motion about flapping, pitch, and lead-lag hinges has been incorporated into the grid, with flow velocities due to blade motion incorporated into the solution explicitly through grid velocity terms. Along with explicit handling of blade motion, inflow due to the farfield wake has been recast in terms of a velocity parallel to the shaft axis. Boundary layer effects have been incorporated into the potential flow code by using a strip-theory approach in conjunction with a 2-D boundary layer analysis in a coupled viscous-inviscid interaction. This work provides skin friction information as well as modification of the inviscid flow behavior. Also, a Newton iteration method has been developed to reduce the number of time steps required for a given analysis and to minimize errors due to approximate solution of the linear system. Author

A89-18916
AN EVALUATION OF A NAVIER-STOKES CODE FOR CALCULATIONS OF RETREATING BLADE STALL ON A HELICOPTER ROTOR
J. C. NARRAMORE (Bell Helicopter Textron, Inc., Fort Worth, TX), L. N. SANKAR (Georgia Institute of Technology, Atlanta), and R. VERMELAND (Cray Research, Inc., Mendota Heights, MN) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 797-808. Army-supported research. refs

A hybrid time-marching technique for the numerical solution of the three-dimensional unsteady, Reynolds-averaged, Navier-Stokes equations has been used to compute the three-dimensional retreating blade stall characteristics on a helicopter rotor. An evaluation of the results from this solution is being carried out. Forces computed by the Navier-Stokes code are compared to results from a modularized, two-dimensional strip, blade element theory method that includes a free wake analysis module, an unsteady aerodynamics module, and an aeroelastic rotor module. Initial results from the three-dimensional Navier-Stokes analysis indicate that there is an outflow in the separated region of the retreating blade. This three-dimensional separation phenomenon generates forces that cannot be predicted by current state-of-the-art analysis codes that use two-dimensional airfoil stall characteristics to predict the rotor blade characteristics. Author

A89-18917
A UNIFIED THEORETICAL-COMPUTATIONAL APPROACH FOR VISCOUS UNSTEADY ROTOR AERODYNAMICS
J. C. WU and I. H. TUNCER (Georgia Institute of Technology, Atlanta) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 809-818. Army-supported research. refs
(Contract AF-AFOSR-86-0121)

A unified theoretical-computation approach for viscous unsteady aerodynamic analysis is presented. This approach is shown to be valid under general circumstances and to possess the ability of confining aerodynamic analysis to the viscous region of the flow. In addition, it is shown that the approach permits the flow zones coexisting in the viscous region to be analyzed individually. Predictive methods using the unified approach which are described are shown to be highly efficient and accurate. Selected results for the blade-vortex interaction problem and the oscillating airfoil problem are presented and discussed. Author

A89-18918
HELICOPTER FREE WAKE PREDICTION OF COMPLEX WAKE STRUCTURES UNDER BLADE-VORTEX INTERACTION OPERATING CONDITIONS
T. ALAN EGOLF (United Technologies Research Center, East Hartford, CT) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 819-832. refs

A free wake method for helicopter rotor application is described which removes many simplifying and limiting assumptions concerning the structure of the rotor wake geometry. In this method the complete wake surface is modeled using a vortex lattice structure. The method was successfully applied to both a main rotor and a tail rotor operating under Blade-Vortex Interaction conditions. The analysis predicted complex multiple tip vortex-like structures which have been observed experimentally for the tail rotor conditions studied. Author

A89-18919
ROTORCRAFT AEROMECHANICAL ANALYSIS USING A NONLINEAR UNSTEADY AERODYNAMIC MODEL
ANDREW S. ELLIOTT (McDonnell Douglas Helicopter Co., Mesa, AZ), J. GORDON LEISHMAN, and INDERJIT CHOPRA (Maryland, University, College Park) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 833-845. refs

A unified, two-dimensional, time domain model has been developed for calculating unsteady nonlinear aerodynamic forces throughout the rotor flight envelope, including compressible and separated flows. The model is conceptually and computationally separated into three parts: (1) a linear, attached flow solution, (2) a nonlinear, separated flow solution, and (3) a dynamic stall solution. It has been validated against test data for the HHO2 airfoil undergoing unsteady forcing, including dynamic stall. The process dynamics of each model constituent are expressed as equivalent continuous time state space subsystems which augment the system state equations. The model is incorporated into a finite element rotor dynamics code and demonstrates the importance of nonlinear aerodynamic effects when the rotor is highly loaded or operating at high advance ratio. Author

A89-18939* Notre Dame Univ., IN.
SEVEN HOLE PROBE MEASUREMENT OF LEADING EDGE VORTEX FLOWS
F. M. PAYNE, T. T. NG, and R. C. NELSON (Notre Dame, University, IN) Experiments in Fluids (ISSN 0723-4864), vol. 7, no. 1, 1989, p. 1-8. Research supported by the University of Notre Dame. refs
(Contract NAG2-258)

This paper discusses the use of a seven-hole probe on measurements of leading edge vortices of highly sweep delta wing planforms. Intrusive probe data taken with the pressure probe were compared with nonintrusive measurements made with laser Doppler anemometry system. In addition to probe size, the natural

position of breakdown and the sweep angle of the wing are also factors in determining sensitivity of the flow to probe interference. At low angles of attach vortex breakdown does not occur in the vicinity of the model and the seven hole probe was found to yield reasonably accurate measurements. When the angle of attack of the model was increased so that vortex breakdown was near the trailing edge, introducing the probe over the wing would cause the breakdown position to move ahead of the probe. However, when breakdown naturally occurred ahead of the mid-chord of the wing the vortices were found to be less sensitive to a probe placed behind the breakdown point. Vortex breakdown on a lower swept wing is found to be more sensitive to interference. Near the breakdown region, seven hole probe measurement is less accurate due to a combination of probe interference and flow reversal. Author

A89-18940
THE USE OF SWEEP-FREQUENCY EXCITATION FOR UNSTEADY PRESSURE MEASUREMENT
B. L. WELSH and C. R. PYNE (Royal Aircraft Establishment, Bedford, England) Experiments in Fluids (ISSN 0723-4864), vol. 7, no. 1, 1989, p. 9-16. refs

The use of sweep-frequency excitation for rapid measurement of time-dependent pressures on wind-tunnel models is examined. Results obtained from two different wind-tunnels covering the Mach number range from 0.2 to 0.85, and a wide range of flow conditions, are compared with measurements made using the slower, traditional method of discrete-frequency excitation. It is concluded that the sweep-frequency excitation method can reduce testing time in certain flow conditions with no significant loss in accuracy. Author

A89-18946
MEASUREMENT AND ANALYSIS OF UNSTEADY FLOW STRUCTURES IN ROTOR BLADE WAKES
V. R. CAPECE and S. FLEETER (Purdue University, West Lafayette, IN) Experiments in Fluids (ISSN 0723-4864), vol. 7, no. 1, 1989, p. 61-67. USAF-supported research. refs

Unsteady flow phenomena leading to differences in the instantaneous rotor blade wake data are investigated, and the variations in the data are analyzed by developing a mathematical model of the rotor blade exit flow field, with a vortex sheet structure for the blade wake. Predictions of the mathematical model are then used to interpret the instantaneous rotor blade exit flow field data and demonstrate the existence of a vortex street structure in the rotor blade wake. This wake vortex street flow structure is shown to be analogous to the unsteady flow field behind bluff bodies due to classical von Karman vortex shedding. V.L.

A89-19167
CHARACTERIZATION OF BOUNDARY LAYER CONDITIONS IN WIND TUNNEL TESTS THROUGH IR THERMOGRAPHY IMAGING
GIOVANNI M. CARLOMAGNO, LUIGI DE LUCA (Napoli, Universita, Naples, Italy), GUIDO BURESTI, and GIOVANNI LOMBARDI (Pisa, Universita, Italy) IN: Applications of infrared technology; Proceedings of the Meeting, London, England, June 9, 10, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 23-29. CNR-supported research. refs

A computerized infrared (IR) imaging system is evaluated as a diagnostic tool for aerodynamic research by performing experimental tests in a subsonic wind tunnel. In particular, the IR technique is used to characterize the behavior of the boundary layer on two wing models, having different cross-sections, by measuring the temperature distribution over their heated surfaces. The results show that IR thermography is capable of immediately yielding accurate information on the location and extent of the transition between laminar and turbulent flow and on the region of separation, for the whole boundary layer over the surface of a model wing. Author

A89-19625* Georgia Inst. of Tech., Atlanta.
DYNAMIC INFLOW FOR PRACTICAL APPLICATIONS
DAVID A. PETERS (Georgia Institute of Technology, Atlanta) and NINH HAQUANG (Boeing Helicopters, Philadelphia, PA) American Helicopter Society, Journal (ISSN 0002-8711), vol. 33, Oct. 1988, p. 64-68. Army-supported research. refs
(Contract NAS2-12341)

A derivation is presented which gives both the nonlinear dynamic inflow model and the perturbation dynamic inflow model in a general coordinate system. The perturbation model includes perturbations in hub motions, in skew angle, and in yaw angle. The governing equations may be switched to their dimensional forms prior to application. K.K.

A89-19660
ANALYSIS OF A FIGHTER TYPE AIRCRAFT CONFIGURATION WITH THE HISSS PANEL METHOD AT SUBSONIC AND SUPERSONIC SPEEDS
S. HEISS and L. FORNASIER (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) (DGLR, Jahrestagung, Berlin, Federal Republic of Germany, Oct. 5-7, 1987) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 12, July-Aug. 1988, p. 224-232. refs
(DGLR PAPER 87-085)

HISSS is a computer program for predicting subsonic or supersonic linear potential flow about arbitrary configurations. The program was used for calculations on a complex fighter-type aircraft design with a canard, delta wing, and an underbelly intake. The range of problems for which the program gives adequate solutions was analyzed by comparing the lift and pitch moment predictions for zero lift with an experimental database for the model at different Mach numbers. The lift and pitch moment coefficients for the model with deflected trailing edge flaps were computed for M (infinity) = 0.4 and M (infinite) = 1.2 and compared with experiment. A separate model of the air duct was used to analyze the duct flow for the subsonic Mach number M (infinity) = 0.585. The recently added streamline capability was used to assess the predicted flow visually. Author

A89-19664
AN ANALYTICAL DESCRIPTION OF UNSTEADY TRANSONIC LAVAL-NOZZLE FLOW
F. OBERMEIER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 12, July-Aug. 1988, p. 253-257. refs

Unsteady pressure waves in an otherwise stationary transonic Laval-nozzle flow are studied by the method of strained coordinates. In particular, the steepening of weak perturbations fed into the flow in the subsonic region behind an initially stationary shock wave and their effects on the movement of this shock wave are predicted in terms of the amplitude and the frequency of the perturbation. The results agree with those obtained by more extended numerical calculations. Author

A89-19788#
A NEW APPROACH FOR COMPUTING FULL UNSTEADY AERODYNAMIC CHARACTERISTICS
ZHENGYIN YE, LINGCHENG ZHAO, and YONGNIAN YANG (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, July 1988, p. A307-A312. In Chinese, with abstract in English. refs

A new numerical method, the velocity potential-difference method, is developed for predicting the aerodynamic force on fully unsteady wings in subsonic flow. The method is capable of computing the varying aerodynamic force or velocity field in time domain over wings with arbitrary motion. The computed results of some test cases are compared with those of other computational methods and experiments and are found to be in good agreement. Author

A89-19801#
THE RELATIONSHIP BETWEEN THE AERODYNAMIC CHARACTERISTICS OF DOUBLE-DELTA WINGS AND VORTICES WITH SIDESLIPS AT HIGH ANGLES OF ATTACK
GUOHUA BAO (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Aug. 1988, p. B317-B323. In Chinese, with abstract in English.

An experimental study of the aerodynamic forces on double-delta wings with sideslips is presented. Force, pressure, spatial flow measurements, and flow visualizations have been carried out. Results show that the sideslip delays the joining vortices on the windward side, but the vortex will break down earlier; on the leeward side, the opposite is true. The asymmetric vortex breakdown has important effects on the aerodynamic forces, and makes rolling moment unstable at high angle of attack. Author

A89-19805#
MEASUREMENTS OF THE BUFFET BOUNDARY OF WINGS IN TRANSONIC FLOW WITH HOT-FILM METHOD
QIAOSEN WANG, XUEJUN QIU, and ZHAOMING ZHANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Aug. 1988, p. B346-B351. In Chinese, with abstract in English. refs

This paper presents a new hot film method (HFM) for measuring the buffeting onset of wings, and describes the principle and technique for using HFM to measure wing buffeting onset. The experimental results are quite consistent with the available data. The present work indicates that the HFM can be used for measuring the buffeting onset of wings. Author

A89-19904#
MULTIGRID ACCELERATION OF A RELAXATION PROCEDURE FOR THE REDUCED NAVIER-STOKES EQUATIONS
A. HIMANSU and S. G. RUBIN (Cincinnati, University, OH) (Computational Fluid Dynamics Conference, 8th, Honolulu, HI, June 9-11, 1987, Technical Papers, p. 478-489) AIAA Journal (ISSN 0001-1452), vol. 26, Sept. 1988, p. 1044-1051. Previously cited in issue 18, p. 2800, Accession no. A87-42091. refs
(Contract N00014-79-C-0849; F49620-85-C-0027)

A89-19905#
INTERACTIVE AND LARGE-DOMAIN SOLUTIONS OF HIGHER-ORDER VISCOUS-FLOW EQUATIONS
F. STERN, S. Y. YOO, and V. C. PATEL (Iowa, University, Iowa City) AIAA Journal (ISSN 0001-1452), vol. 26, Sept. 1988, p. 1052-1060. refs
(Contract N00014-83-K-0136)

Two approaches for the solution of the partially parabolic Reynolds equations are evaluated using the same numerical techniques and turbulence model. Comparisons are made between interactive viscous-inviscid solutions and noninteractive large-domain solutions for the flow over the tail and in the wake of axisymmetric and three-dimensional bodies to highlight the differences between the two strategies. Both approaches yield satisfactory results, although the interaction solutions appear to be computationally more efficient for the three-dimensional bodies. Author

A89-19908*# Old Dominion Univ., Norfolk, VA.
FULL-POTENTIAL INTEGRAL SOLUTION FOR TRANSONIC FLOWS WITH AND WITHOUT EMBEDDED EULER DOMAINS
OSAMA A. KANDIL and HONG HU (Old Dominion University, Norfolk, VA) AIAA Journal (ISSN 0001-1452), vol. 26, Sept. 1988, p. 1079-1086. Previously cited in issue 18, p. 2810, Accession no. A87-42472. refs
(Contract NAG1-648)

A89-19924#
INTERFERENCE EFFECTS ASSOCIATED WITH A PLATE-SUPPORTED HALF-MODEL IN HYPERSONIC FLOW
G. R. HUTT and R. A. EAST (Southampton, University, England) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, Sept.-Oct. 1988, p. 382-384. Research supported by the Ministry of Defence Procurement Executive. refs

An experimental investigation has been conducted into the pitch stability characteristics of a plate-supported half-model in hypersonic flow that is held by an axial gas bearing; this novel support method facilitates the study of oscillation amplitudes greater than those generally available on sting support. The test program conducted indicates that the interference-free static pitch stability data desired at low angles of attack is not thus obtainable, due to the presence of the reflection plate surface ahead of the model nose region. O.C.

A89-19927
EXPERIMENTAL STUDY ON UNSTEADY AERODYNAMIC CHARACTERISTICS OF AN OSCILLATING CASCADE WITH TIP CLEARANCE
TOSHINORI WATANABE (Tokyo University of Agriculture and Technology, Koganei, Japan) and SHOJIRO KAJI (Tokyo, University, Japan) JSME International Journal, Series II (ISSN 0914-8817), vol. 31, Nov. 1988, p. 660-667.

An experimental study was conducted for revealing unsteady aerodynamic characteristics of oscillating cascades with tip clearance. To obtain aerodynamic forces acting on blades, the surface pressure was measured in both the chordwise and spanwise directions. To evaluate the aerodynamic forces due to oscillations of arbitrary interblade phase angle, the method of influence coefficients was adopted. Tip clearances were changed from 0.056 to 2.8 percent of the blade span. The aerodynamic blade loading was also changed. Results show that the tip clearance has a strong influence on the distribution of unsteady aerodynamic forces along the blade span: when tip clearance exists, aerodynamic damping forces decrease considerably over a large portion of the blade span. However, when steady aerodynamic loading acts on the blades, the influence of tip clearance is suppressed. The tip vortex increases the absolute value of the unsteady aerodynamic force in the region near the blade tip. Author

A89-20131#
A STUDY ON AERODYNAMIC HEATING IN THE INTERACTION REGIONS OF SHOCK WAVES AND TURBULENT BOUNDARY LAYERS INDUCED BY SHARP FINS
MASANORI HAYASHI, SHIGERU ASO, ANZHONG TAN, and HIROAKI MURAKAMI Kyushu University, Technology Reports (ISSN 0023-2718), vol. 61, Aug. 1988, p. 465-471. In Japanese, with abstract in English. refs

A study on aerodynamic heating in the interaction regions of shock waves and turbulent boundary layers induced by sharp fins is performed at a Mach number of 4 and under the cold wall conditions. Attack angles of fins are 4, 10 and 16 degrees. Heat transfer distributions are measured by multilayered thin film heat transfer gauges. The results of oil-flow tests and wall pressure measurements are compared with the heat transfer distributions in the flowfields. Heat transfer distributions at 4 and 10 degrees have a similar tendency qualitatively. Both have a peak before the separation line and a trough near the separation line, and at the downstream of the shock waves heat flux begins to increase again. At 16 degrees, where secondary separation line is observed, the heat transfer has a peak after the primary separation line, and then drops till the midway to the secondary separation line, and two kinks are observed near the secondary separation line and near the position of the shock wave. Author

A89-20132#
A STUDY ON HYPERSONIC SHOCK TUNNEL
MASANORI HAYASHI, SHIGERU ASO, MASASHI MATSUMOTO, and AKIO ONO Kyushu University, Technology Reports (ISSN 0023-2718), vol. 61, Aug. 1988, p. 473-477. In Japanese, with abstract in English. refs

A hypersonic shock tunnel is designed and constructed. In the design of nozzle contour the effect of boundary layer along the nozzle wall on Mach number profile in the test section is

investigated. Two contour nozzles of Mach 8, with and without boundary layer correction, are prepared for the experiments. Cresci's method is used for the design of nozzle contour and Tucker's method for boundary layer correction. The results show that the development of boundary layer along the nozzle wall is remarkable and the correction of boundary layer along the nozzle wall is necessary. Also, the boundary layer along the nozzle wall is overestimated by Tucker's method. The results show that a more precise boundary layer correction method should be developed. Author

A89-20133*# JAI Associates, Mountain View, CA.
NAVIER-STOKES CALCULATIONS OF HOVERING ROTOR FLOWFIELDS
G. R. SRINIVASAN (JAI Associates, Inc., Mountain View, CA) and W. J. MCCROSKEY (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 865-874. refs
(Contract DAAG29-85-C-0002)
(AIAA PAPER 87-2629)

Unsteady, thin-layer Navier-Stokes equations written in rotor coordinates are solved using a partially flux-split, implicit numerical algorithm to calculate the flowfields of a hovering rotor blade at subsonic and transonic conditions. Numerical results are in good agreement with experimental data for both nonlifting and lifting rectangular blades. For the lifting case, the rotor wake effects are modeled by applying a correction to the geometric angle of attack of the blades. Alternate methods of calculating the hovering rotor flowfields in blade-fixed mode that have the same circulation distribution as a hovering blade are explored. All of the results presented in this paper were computed on a Cray-2 supercomputer. Author

A89-20134*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TRANSONIC NAVIER-STOKES SOLUTIONS FOR A FIGHTER-LIKE CONFIGURATION
JOLEN FLORES, STEVEN G. REZNICK, TERRY L. HOLST (NASA, Ames Research Center, Moffett Field, CA), and KAREN GUNDY Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 875-881. Previously cited in issue 09, p. 1191, Accession no. A87-24906. refs

A89-20137*# Douglas Aircraft Co., Inc., Long Beach, CA.
FURTHER COMPARISONS OF INTERACTIVE BOUNDARY-LAYER AND THIN-LAYER NAVIER-STOKES PROCEDURES
K. C. CHANG, TUNCER CEBECI (Douglas Aircraft Co., Long Beach, CA), N. ALEMDAROGLU (California State University, Long Beach), and UNMEEL MEHTA (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 897-903. Previously cited in issue 08, p. 1039, Accession no. A87-22625. refs

A89-20140#
VALIDATION OF APPROXIMATE INDICIAL AERODYNAMIC FUNCTIONS FOR TWO-DIMENSIONAL SUBSONIC FLOW
J. G. LEISHMAN (Maryland, University, College Park) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 914-922. Army-supported research. refs

Approximations for two-dimensional indicial (step) aerodynamic responses due to angle of attack and pitch rate are obtained and generalized to account for compressibility effects up to a Mach number of 0.8. Using the Laplace transform method, these indicial functions are manipulated to produce explicit solutions for idealized harmonic forcings. These explicit solutions are subsequently compared with experimentally obtained pitch and plunge aerodynamic data in the reduced frequency domain. The results of this comparison are used to relate back and substantiate the generalization of the compressible indicial lift and moment functions. Author

A89-20141#
EXPERIMENTAL INVESTIGATION OF A JET IMPINGING ON A GROUND PLANE IN CROSSFLOW
J. M. CIMBALA, D. R. STINEBRING, A. L. TREASTER, M. L. BILLET (Pennsylvania State University, University Park), and M. M. WALTERS (U.S. Navy, Naval Air Development Center, Warminster, PA) (International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings, p. 243-251) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 923-931. Navy-supported research. Previously cited in issue 15, p. 2391, Accession no. A88-37195. refs

A89-20142*# West Virginia Univ., Morgantown.
WINGLETS ON LOW-ASPECT-RATIO WINGS
JOHN M. KUHLMAN and PAUL LIAW (West Virginia University, Morgantown) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 932-941. Previously cited in issue 21, p. 3339, Accession no. A87-49097. refs
(Contract NAG1-625)

A89-20145*# Sterling Federal Systems, Inc., Palo Alto, CA.
UNSTEADY TRANSONIC AERODYNAMICS AND AEROELASTIC CALCULATIONS AT LOW-SUPERSONIC FREESTREAMS
GURU P. GURUSWAMY (Sterling Federal Systems, Inc., Palo Alto, CA) and PETER M. GOORJIAN (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 955-961. USAF-supported research. refs

A computational procedure is presented to simulate transonic unsteady flows and corresponding aeroelasticity of wings at low-supersonic freestreams. The flow is modeled by using the transonic small-perturbation theory. The structural equations of motions are modeled using modal equations of motion directly coupled with aerodynamics. Supersonic freestreams are simulated by properly accounting for the boundary conditions based on pressure waves along the flow characteristics in streamwise planes. The flow equations are solved using the time-accurate, alternating-direction implicit finite-difference scheme. The coupled aeroelastic equations of motion are solved by an integration procedure based on the time-accurate, linear-acceleration method. The flow modeling is verified by comparing calculations with experiments for both steady and unsteady flows at supersonic freestreams. The unsteady computations are made for oscillating wings. Comparisons of computed results with experiments show good agreement. Aeroelastic responses are computed for a rectangular wing at Mach numbers ranging from subtransonic to upper-transonic (supersonic) freestreams. The extension of the transonic dip into the upper transonic regime is illustrated. Author

A89-20147#
LOW-SPEED PRESSURE DISTRIBUTION ON AXISYMMETRIC ELLIPTIC-NOSED BODIES
ERIK S. LARSON (Flygtekniska Forsoksanstalten, Bromma, Sweden) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 969, 970. Research sponsored by the Swedish Armed Forces.

A semiempirical representation of the pressure distribution of ellipsoids of revolution and elliptic-nosed semiinfinite bodies of revolution in axial incompressible potential flow. These analytic expressions, which are obtained by the peak velocity ratio and the normalized thickness-dependent angle between body axis and radius vector, should prove satisfactory for the rapid estimation of velocity and pressure distributions in the cases of nose-slenderness ratios up to and including unity. O.C.

A89-20148#
THREE-DIMENSIONAL VORTEX SYSTEMS OF FINITE WINGS
PETER FREYMUTH (Colorado, University, Boulder) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 971, 972. refs
(Contract F49620-84-C-0065)

Global flow-visualizations, in which the flow-trace smoke-producing titanium tetrachloride is introduced as

homogeneously as possible into areas of vorticity production, are capable of documenting the connection and reconnection of vortices. Attention is given to the photographically recorded results thus obtained for half-wings and delta-wings. Complete flow resolution is noted to remain an elusive goal; it becomes impossible in a strongly turbulent regime. O.C.

A89-20149#
ROTATING AIR SCOOP AS AIRFOIL BOUNDARY-LAYER CONTROL
F. MOKHTARIAN, V. J. MODI, and T. YOKOMIZO (British Columbia, University, Vancouver, Canada) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 973-975.
(Contract NSERC-A-2181)

An evaluation is made of the results of an experimental program aimed at determining the effectiveness of a scooped-cross section configuration of leading edge rotating cylinder on a Joukowsky airfoil. Although the rotating airscoop appears to redirect more air over the upper surface, the higher rates of cylinder rotation cause it to behave as a simple, unscooped cylinder, precluding the lower-rotation flow advantages. O.C.

A89-20176*# JAI Associates, Mountain View, CA.
NUMERICAL SIMULATION OF TIP VORTICES OF WINGS IN SUBSONIC AND TRANSONIC FLOWS
G. R. SRINIVASAN (JAI Associates, Inc., Mountain View, CA), W. J. MCCROSKEY, J. D. BAEDER, and T. A. EDWARDS (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 26, Oct. 1988, p. 1153-1162. Previously cited in issue 17, p. 2469, Accession no. A86-38456. refs
(Contract DAAG29-85-C-0002)

A89-20179#
COMPUTATION OF ROTATIONAL TRANSONIC FLOWS USING A DECOMPOSITION METHOD
K. GIANNAKOGLOU, P. CHAVIAROPOULOS, and K. D. PAPAILIOU (Athens, National Technical University, Greece) AIAA Journal (ISSN 0001-1452), vol. 26, Oct. 1988, p. 1175-1180. Research supported by Avions Marcel Dassault Breguet Aviation. refs

Any vector field may be decomposed, in a unique way, into an irrotational and a rotational part, if appropriate boundary conditions are imposed to the scalar and vector potentials introduced by the above decomposition. In the present work, the transformation is applied to the mass flux vector, in order to calculate two-dimensional, steady, rotational, transonic flows in arbitrarily shaped ducts and plane cascades. The whole procedure is discussed from an analytical and a numerical point of view, while finite difference-finite volume schemes are used to derive numerical results. Author

A89-20180*# North Carolina State Univ., Raleigh.
NAVIER-STOKES CALCULATIONS USING CARTESIAN GRIDS. I - LAMINAR FLOWS
PAUL D. FRYMIER, JR., H. A. HASSAN (North Carolina State University, Raleigh), and M. D. SALAS (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 26, Oct. 1988, p. 1181-1188. refs
(Contract NCC1-22)

A finite-volume formulation for the Navier-Stokes equations using Cartesian grids is used to study flows past airfoils. In addition to the solution of the complete equations, solutions for two simplified versions of the governing equations were obtained and compared with those using body-fitted grids. Results are presented for two airfoil sections, NACA 0012 and RAE 2822, for a range of Mach numbers, angles of attack, and Reynolds numbers. It is shown that the results are highly dependent on the smoothness of the surface grid. Without such smoothness, the skin friction and pressure converge to nonuniform distributions. On the other hand, when surface cells with smoothly varying areas are used, the results compared favorably with calculations employing body-fitted grids. Author

A89-20181#
VORTICAL WAKES OVER A PROLATE SPHEROID
C. E. COSTIS and D. P. TELIONIS (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 26, Oct. 1988, p. 1189-1193. Previously cited in issue 22, p. 3179, Accession no. A84-46120. refs
(Contract N00167-84-C-0044)

A89-20182#
INTERACTIONS BETWEEN TURBULENT WAKES AND BOUNDARY LAYERS
D. AGOROPOULOS and L. C. SQUIRE (Cambridge University, England) AIAA Journal (ISSN 0001-1452), vol. 26, Oct. 1988, p. 1194-1200. refs

Experimental measurements and numerical computations are presented for five cases of two-dimensional turbulent wakes mixing with boundary layers. These were set up so as to simulate the positive streamwise pressure gradient and wake structure found on multielement aerofoils. The algebraic stress turbulence model of Rodi, in conjunction with the boundary-layer equations, successfully postdicted all five test cases, outperforming an improved version of the k-epsilon model. A minor failure of both methods to postdict accurately the edge of the wake may be attributed to its intermittency. Author

A89-20184#
TIME-ITERATIVE SOLUTIONS OF VISCOUS SUPERSONIC NOZZLE FLOWS
CHAU-LYAN CHANG, YIGAL KRONZON, and CHARLES L. MERKLE (Pennsylvania State University, University Park) AIAA Journal (ISSN 0001-1452), vol. 26, Oct. 1988, p. 1208-1215. USAF-sponsored research. Previously cited in issue 18, p. 2806, Accession no. A87-42364. refs

A89-20235
NUMERICAL METHODS FOR HYPERSONIC FLOWS [NUMERISCHE METHODEN FUER HYPERSCHALLSTROEMUNGEN]
C. WEILAND (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany), H. OERTEL (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, Federal Republic of Germany), and B. WAGNER (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 691-703. In German. refs
(DGLR PAPER 87-084)

Numerical studies in hypersonic flows are necessary for the development of future spacecraft. The types of such spacecraft are reviewed, and the very complex physical phenomena involved in hypersonic flows are considered. The relevant theoretical and numerical prediction methods are examined, including the continuum region Euler, boundary layer, viscous shock layer, and Navier-Stokes procedures as well as the gas-kinetic region simulation methods for solving the Boltzmann equations. Solutions using these methods for hypersonic flows about test configurations and realistic spacecraft are addressed. It is shown that a significant development step involves extending these methods to real gas flows. C.D.

A89-20311#
MOVING WALL EFFECTS IN UNSTEADY FLOW
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 977-990. Previously cited in issue 08, p. 1052, Accession no. A87-22504. refs

A89-20312#
VORTEX BREAKDOWN MEASUREMENTS ON A 70 DEG SWEEPBACK DELTA WING
JOHN F. MCKERNAN, FRANCIS M. PAYNE, and ROBERT C. NELSON (Notre Dame, University, IN) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 991, 992. refs

An investigation of the breakdown of the leading edge vortices on a flat plate delta wing having a leading edge sweep angle of 70 deg was studied using flow visualization and surface pressure measurements. The progression of the vortex breakdown position was determined from flow visualization experiments as a function of angle of attack and sideslip angle and correlated with the force and moment data obtained from integrating surface pressure measurements. Tests were conducted at low subsonic speeds, and the Reynolds number, based upon the centerline chord, was 225,000. Vortex breakdown was observed to play a strong role in the nonlinear behavior of the rolling moment. Author

A89-20313#
DOWNSTREAM VORTICITY MEASUREMENTS FROM ULTRASONIC PULSES
WOLFGANG SEND (DFVLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 1190-1200) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 993, 994. Previously cited in issue 24, p. 3532, Accession no. A86-49102. refs

A89-20316*# Texas A&M Univ., College Station.
TRANSONIC WING DESIGN USING INVERSE METHODS IN CURVILINEAR COORDINATES
THOMAS A. GALLY and LELAND A. CARLSON (Texas A & M University, College Station) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 1009-1017. Previously cited in issue 21, p. 3340, Accession no. A87-49103. refs
(Contract NAG1-619)

A89-20317#
AERODYNAMIC CHARACTERISTICS OF RECTANGULAR CROSS-SECTIONAL BODIES AT M = 0.85
ASHER SIGAL (Technion - Israel Institute of Technology, Haifa) (Israel Annual Conference on Aviation and Astronautics, 18th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Papers, p. 81-86) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 1018-1022. Research supported by the Technion - Israel Institute of Technology and Rafael Armament Development Authority. Previously cited in issue 14, p. 2104, Accession no. A87-35012. refs

A89-20319#
FLOW UNSTEADINESS CONSIDERATIONS IN HIGH-ALPHA TESTING
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 1033-1037. Previously cited in issue 07, p. 927, Accession no. A88-22040. refs

A89-20325#
DRAG REDUCTION FACTOR DUE TO GROUND EFFECT
YOUNG B. SUH and CYRUS OSTOWARI (Texas A & M University, College Station) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 1071, 1072. refs

A theoretical working-formula is derived for the increasing lift-curve slope and decreasing induced drag experienced by wings in ground effect. The derivation has its basis in Oswald's wing efficiency, which is a measure of departure from the ideal elliptical loading in the induced drag portion of the aerodynamic system. The results obtained are compared with extant experimental data. O.C.

A89-20635#
EXPERIMENTAL STUDY ON LOW-SPEED AERODYNAMIC CHARACTERISTICS OF NON-AXISYMMETRIC SLENDER BODIES
MASAYOSHI MATSUZAKA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 416, 1988, p. 410-417. In Japanese, with abstract in English. refs

Low speed aerodynamic characteristics of non-axisymmetric slender bodies are experimentally investigated. The model shapes are elliptic cone, semi-circular cone and cone. The test range of attack angle is from 0 to 90 deg. Forces/moments are measured with 5 load cells and flow is visualized with oil flow technique and mini-tuft method. Their aerodynamic characteristics have strong nonlinearities especially in side-force coefficient. Presence of the side force is related to that of the maximum normal force coefficient which can be seen from oil flow patterns. Author

N89-13395*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A WATER TUNNEL STUDY OF GURNEY FLAPS
DAN H. NEUHART (PRC Systems Services Co., Hampton, Va.) and ODIS C. PENDERGRAFT, JR. Nov. 1988 21 p Original contains color illustrations
(NASA-TM-4071; L-16467; NAS 1.15:4071) Avail: NTIS HC A03/MF A01 CSCL 01A

Several Gurney flap configurations were tested in the NASA Langley 16 x 24 inch Water Tunnel. These devices provided an increased region of attached flow on a wing upper surface relative to the wing without the flaps. The recirculation region behind the flap was visualized and shown to be consistent with hypotheses stated in previous research. Although the test Reynolds number for this study was several orders of magnitude below those in previous investigations, the effect of the Gurney flaps is in qualitative agreement with them. This is as would be expected from first order effects for high lift devices. Author

N89-13396*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THEORETICAL DERIVATION AND CALIBRATION TECHNIQUE OF A HEMISPHERICAL-TIPPED, FIVE-HOLE PROBE
SCOTT O. KJELGAARD Dec. 1988 27 p
(NASA-TM-4047; L-16454; NAS 1.15:4047) Avail: NTIS HC A03/MF A01 CSCL 01A

A technique is presented for the calibration of a hemispherical tipped 0.125 inch diameter 5-hole probe. The derivation of equations from the potential flow over a sphere relating the flow angle and velocity to pressure differentials measured by the probe is presented. The technique for acquiring the calibration data and the technique used to calculate the calibration coefficients are presented. The accuracy of the probe in both the uniform calibration flow field and the nonuniform flow field over a 75 degree swept delta wing is discussed. Author

N89-13399*# Flow Research, Inc., Kent, WA.
USER'S MANUAL FOR AN AERODYNAMIC OPTIMIZATION SCHEEME THAT UPDATES FLOW VARIABLES AND DESIGN PARAMETERS SIMULTANEOUSLY Flow Report No. 444
MAGDI H. RIZK Jul. 1988 33 p
(Contract NAS3-24855)
(NASA-CR-182180; NAS 1.26:182180) Avail: NTIS HC A03/MF A01 CSCL 01A

This user's manual is presented for an aerodynamic optimization program that updates flow variables and design parameters simultaneously. The program was developed for solving constrained optimization problems in which the objective function and the constraint function are dependent on the solution of the nonlinear flow equations. The program was tested by applying it to the problem of optimizing propeller designs. Some reference to this particular application is therefore made in the manual. However, the optimization scheme is suitable for application to general aerodynamic design problems. A description of the approach used in the optimization scheme is first presented, followed by a description of the use of the program. Author

N89-13400*# Vigyan Research Associates, Inc., Hampton, VA.
WALL ADJUSTMENT STRATEGY SOFTWARE FOR USE WITH THE NASA LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL ADAPTIVE WALL TEST SECTION
STEPHEN W. D. WOLF Nov. 1988 188 p
(Contract NAS1-17919)
(NASA-CR-181694; NAS 1.26:181694) Avail: NTIS HC A09/MF A01 CSCL 01A

The Wall Adjustment Strategy (WAS) software provides successful on-line control of the 2-D flexible walled test section

of the Langley 0.3-m Transonic Cryogenic Tunnel. This software package allows the level of operator intervention to be regulated as necessary for research and production type 2-D testing using and Adaptive Wall Test Section (AWTS). The software is designed to accept modification for future requirements, such as 3-D testing, with a minimum of complexity. The WAS software described is an attempt to provide a user friendly package which could be used to control any flexible walled AWTS. Control system constraints influence the details of data transfer, not the data type. Then this entire software package could be used in different control systems, if suitable interface software is available. A complete overview of the software highlights the data flow paths, the modular architecture of the software and the various operating and analysis modes available. A detailed description of the software modules includes listings of the code. A user's manual is provided to explain task generation, operating environment, user options and what to expect at execution. Author

N89-13401*# Analytical Services and Materials, Inc., Hampton, VA.
DEVELOPMENT OF THREE-DIMENSIONAL CODE FOR THE ANALYSIS OF JET MIXING PROBLEM. PART 1: LAMINAR SOLUTION
KHALED S. ABDOL-HAMID Washington NASA Dec. 1988 49 p
(Contract NAS1-18599)
(NASA-CR-4200; NAS 1.26:4200) Avail: NTIS HC A03/MF A01 CSCL 01A

Future aircraft will eventually feature nonaxisymmetric or rectangular nozzles. Developing a three-dimensional code to stimulate the characteristics of the jet exhaust plume, issuing from nonaxisymmetric nozzles, in general, at different flight conditions, is very important. Two three-dimensional codes were developed to simulate the shock-cell structure of circular nozzles. These codes were developed to solve the parabolized and simplified Navier-Stokes equations respectively. Both codes are based on a method previously developed by Newsome et al. These codes are fully vectorized on the VPS 32 at NASA Langley Research Center. The axisymmetric underexpanded supersonic jet flow problem, exhausting into still air, was used as a test case for developing an efficient three-dimensional problems and preserving crossplane symmetry of the flow downstream of the jet exit.
Author

N89-13402# General Dynamics/Fort Worth, TX.
UNSTEADY LOW-SPEED WINDTUNNEL TEST OF A STRAKED DELTA WING, OSCILLATING IN PITCH. PART 4: PLOTS OF TIME HISTORIES OF PRESSURES AND OVERALL LOADS Final Report, Jun. 1985 - Aug. 1987
A. M. CUNNINGHAM, JR., R. G. DEN BOER, C. S. DOGGER, E. G. GEURTS, and A. J. PERSOON Apr. 1988 274 p Prepared in cooperation with National Aerospace Lab., Amsterdam (Netherlands)
(Contract F33615-85-C-3013)
(AD-A198682; AFWAL-TR-87-3098-PT-4) Avail: NTIS HC A12/MF A01 CSCL 01A

Results of a wind tunnel test of an oscillating straked wing. The report provides 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. In part 4, the plots of time history data for both pressures and overall air loads for continuous oscillating model are presented for conditions in which non-linearities and higher harmonics are expected. Appendix A includes the pressure plots in a carpet format which shows the distributions at every 45 deg of phase angle in a manner similar to the unsteady flow visualization photos. The distributions are shown similarly for all four pressure sections. A survey of the test conditions and their runnumbers is given in table 10 of part 1. Appendix B includes plots of overall air loads vs. incidence for continuous oscillating model. A survey of the runnumbers of these plots is given in table 11 of part 1. GRA

N89-13403# General Dynamics/Fort Worth, TX.
UNSTEADY LOW-SPEED WINDTUNNEL TEST OF A STRAKED DELTA WING, OSCILLATING IN PITCH. PART 5: POWER SPECTRAL DENSITY PLOTS OF THE OVERALL LOADS FOR HARMONIC OSCILLATION AND THE RESPONSE OF OVERALL LOADS TO (1-COS) INPUTS Final Report, Jun. 1985 - Aug. 1987
A. M. CUNNINGHAM, JR., R. G. DEN BOER, C. S. DOGGER, E. G. GEURTS, and A. J. PERSOON Apr. 1988 292 p Prepared in cooperation with National Aerospace Lab., Amsterdam (Netherlands)
(Contract F33615-85-C-3013)
(AD-A198683; AFWAL-TR-87-3098-PT-5) Avail: NTIS HC A13/MF A01 CSCL 01A

Results are discussed of a wind tunnel test of an oscillating straked wing. The report provides 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. The power spectral densities for various conditions present the relative frequency content of selected overall loads at continuous oscillating model conditions ranging from nearly linear (first harmonic dominant) to highly nonlinear (many higher harmonics) characteristics. A survey of the selected runs and their test conditions is given including the components of the balance and the corresponding plot numbers of the spectra presented. The time history plots are given of incidence and all air loads for (1-cos) pitch pulses that simulate transient aircraft maneuvers. Included are half pulse data which represent a pitch-up and hold at a higher angle of attack as well as a pitch-down and hold at a lower angle of attack. To give an idea of the reproducibility plots for all three runs of the balance components vs. incidence for two test conditions are also enclosed at the end. GRA

N89-13404# General Dynamics/Fort Worth, TX.
UNSTEADY LOW-SPEED WINDTUNNEL TEST OF A STRAKED DELTA WING, OSCILLATING IN PITCH. PART 6: PRESENTATION OF THE VISUALIZATION PROGRAM Final Report, Jun. 1985 - Aug. 1987
A. M. CUNNINGHAM, JR., R. G. DEN BOER, C. S. DOGGER, E. G. GEURTS, and A. J. PERSOON Apr. 1988 108 p
(Contract F33615-85-C-3013)
(AD-A198684; AFWAL-TR-87-3098-PT-6) Avail: NTIS HC A06/MF A01 CSCL 01A

Results of a wind tunnel test of an oscillating straked wing are presented. The report provides unsteady airloads and pressure distributions for a range of incidence (-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. In part 6 results of the flow visualization investigation are presented in the appendix in the form of tables and plots of vortex core positions, both as a function of phase angle during one cycle of oscillation. Table 13a through c in part 1 provides a convenient cross-reference of test conditions and the table numbers in this part. The phase angles are varied in steps on 45 deg so that a time history is developed during one cycle. When it was impossible to measure vortex core positions, due to either vortex burst or overexposure, no values are given in the tables and plots. Results are presented for the three laser light screen positions. The entries in the table for the aft position near the wing trailing edge are limited because very few core position measurements were possible due to vortex bursting.
GRA

N89-13405# Boeing Commercial Airplane Co., Seattle, WA.
COUPLING LINEARIZED FAR-FIELD BOUNDARY CONDITIONS WITH NONLINEAR NEAR-FIELD SOLUTIONS IN TRANSONIC FLOW Final Report, 1 Jul. 1983 - 29 Feb. 1988
WILLIAM S. ROWE and F. E. EHLERS 29 Feb. 1988 175 p
(Contract F49620-83-C-0118)
(AD-A198721; D6-52895; AFOSR-88-0719TR) Avail: NTIS HC A08/MF A01 CSCL 01A

Research has been conducted to evaluate the feasibility of coupling linearized far-field solutions with near-field finite difference equations to reduce the number of unknowns and thus the computer resources required in transonic flow calculations. For two dimensional flow, changes to an existing finite difference program involved distributing sources on the grid boundary in order to obtain the proper far field outgoing wave boundary conditions on a reduced grid. Validation of the matching procedure was made for zero thickness airfoils by comparison of the results with those of the kernel function method. For airfoils with finite thickness, a criterion based on the gradient of the flowfield Mach number was developed for establishing the minimum size finite difference region necessary for accurate unsteady calculations. This approach could not be applied directly to three-dimensional flow because of the large number of variables required in the exterior solution. However, it is shown that the number of unknowns can be reduced to a practical number by using both source and doublet distributions on the boundaries, describing these distributions with low-order polynomials, and using a least squares procedure to satisfy the matching conditions across the boundaries. GRA

N89-13408*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AERODYNAMIC DESIGN VIA CONTROL THEORY Final Report
ANTONY JAMESON Nov. 1988 42 p Submitted for publication
(Contract NAS1-18107)
(NASA-CR-181749; ICASE-88-64; NAS 1.26:181749) Avail: NTIS HC A03/MF A01 CSCL 01A

The question of how to modify aerodynamic design in order to improve performance is addressed. Representative examples are given to demonstrate the computational feasibility of using control theory for such a purpose. An introduction and historical survey of the subject is included. Author

N89-13409*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LASER VELOCIMETER MEASUREMENTS OF THE FLOWFIELD GENERATED BY AN ADVANCED COUNTERROTATING PROPELLER
GARY G. PODBOY and MARTIN J. KRUPAR 1989 33 p Prepared for presentation at the 27th Aerospace Sciences Meeting, Reno, Nev., 9-12 Jan. 1989; sponsored by AIAA
(NASA-TM-101437; E-4525; NAS 1.15:101437; AIAA-89-0434) Avail: NTIS HC A03/MF A01 CSCL 01B

Results are presented of an investigation to measure the flowfield generated by an advanced counterrotating pusher propeller model similar to the full-scale Unducted Fan demonstrator engine. A laser Doppler velocimeter was used to measure the velocity field in several planes normal to the centerline of the model at axial stations upstream and downstream of each rotor. During this investigation, blades of the F4/A4 type were installed on the model which was operating in a freestream Mach 0.72 regime, with the advance ratio of each rotor set at 2.80. The measured data indicate only a slight influence of the potential field of each front rotor blade on the flowfield upstream of the rotor. The data measured downstream of the front rotor characterize the tip vortices, vortex sheets and potential field nonuniformities generated by the front rotor. The unsteadiness of the flow in the rotating frame of reference of the aft rotor is also illustrated. Author

N89-13410*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HUB LOADS ANALYSIS OF THE SA349/2 HELICOPTER
R. M. HEFFERNAN, G. K. YAMAUCHI, M. GAUBERT, and W. JOHNSON (Johnson Aeronautics, Palo Alto, Calif.) Dec. 1988 40 p Presented at the 14th European Rotorcraft Forum, Milano, Italy, 20-23 Sep. 1988
(NASA-TM-101061; A-88270; NAS 1.15:101061) Avail: NTIS HC A03/MF A01 CSCL 01C

The forces and moments at the rotor hub of an Aerospatiale SA349/2 helicopter were investigated. The study included three main topics. First, measured hub forces and moments for a range of level flight conditions (mu = 0.14 to 0.37) were compared with predictions from a comprehensive rotorcraft analysis to examine the influence of the wake model on the correlations. Second, the effect of changing the blade mass distribution and blade chordwise center of gravity location on the 3/rev nonrotating frame hub loads was studied for a high-speed flight condition (mu = 0.37). Third, the use of higher harmonic control to reduce nonrotating frame 3/rev hub shear forces was investigated. The last two topics were theoretical studies only. Author

N89-13411*# Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.
DESIGN OF HIGH-REYNOLDS-NUMBER FLAT-PLATE EXPERIMENTS IN THE NTF Final Report
WILLIAM S. SARIC 19 Dec. 1988 18 p
(Contract NCC1-89)
(NASA-CR-184627; NAS 1.26:184627) Avail: NTIS HC A03/MF A01 CSCL 01A

The design of an experiment to measure skin friction and turbulent boundary layer characteristics at Reynolds numbers exceeding 1 x 10 to the 9th is described. The experiment will be conducted in a zero-pressure-gradient flow on a flat plate in the National Transonic Facility (NTF). The development of computational codes to analyze the aerodynamic loads and the blockage is documented. Novel instrumentation techniques and models, designed to operate in cryogenic environments, are presented. Special problems associated with aerodynamic loads, surface finish, and hot-wire anemometers are discussed. Author

N89-13412*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PREDICTIONS OF AIRFOIL AERODYNAMIC PERFORMANCE DEGRADATION DUE TO ICING
ROBERT J. SHAW, MARK G. POTAPEZUK, and COLIN S. BIDWELL 1988 16 p Presented at the 4th Symposium on Numerical and Physical Aspects of Aerodynamic Flows, Long Beach, Calif., 16-19 Jan. 1989; sponsored by California State Univ.
(NASA-TM-101434; E-4541; NAS 1.15:101434) Avail: NTIS HC A03/MF A01 CSCL 01A

An overview of NASA's ongoing efforts to develop an airfoil icing analysis capability is developed. An indication is given to the approaches being followed to calculate the water droplet trajectories past the airfoil, the buildup of ice on the airfoil, and the resultant changes in aerodynamic performance due to the leading edge ice accretion. Examples are given of current code capabilities/limitations through comparisons of predictions with experimental data gathered in various calibration/validation experiments. A brief discussion of future efforts to extend the analysis to handle three dimensional components is included. Author

N89-14213*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THRUST-REVERSER FLOW INVESTIGATION ON A TWIN-ENGINE TRANSPORT
GREGORY M. GATLIN and P. FRANK QUINTO Washington, DC Dec. 1988 156 p
(NASA-TP-2856; L-16426; NAS 1.60:2856) Avail: NTIS HC A08/MF A01 CSCL 01A

An investigation was conducted in the NASA Langley 14 x 22 foot Subsonic Tunnel to study the effects of engine thrust reversing on an aft-mounted twin-engine transport and to develop effective testing techniques. Testing was done over a fixed and a moving-belt

ground plane and over a pressure instrumented ground board. Free-stream dynamic pressure was set at values up to 12.2 psf, which corresponded to a maximum Reynolds number based on the mean aerodynamic chord of 765,000. The thrust reversers examined included cascade, target and four-door configurations. The investigation focused on the range of free-stream velocities and engine thrust-reverser flow rates that would be typical for landing ground-roll conditions. Flow visualization techniques were investigated, and the use of water or smoke injected into the reverser flow proved effective to determine the forward progression of the reversed flow and reingestion limits. When testing over a moving-belt ground plane, as opposed to a fixed ground plane, forward penetration of the reversed flow was reduced. The use of a pressure-instrumented ground board enabled reversed flow ground velocities to be obtained, and it provided a means by which to identify the reversed flow impingement point on the ground. Author

N89-14216*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TWO-DIMENSIONAL AERODYNAMIC CHARACTERISTICS OF THE OLS/TAAT AIRFOIL
MICHAEL E. WATTS, JEFFREY L. CROSS, and KEVIN W. NOONAN (Army Aviation Research and Development Command, Hampton, VA.) Apr. 1988 92 p
(NASA-TM-89435; A-87132; NAS 1.15:89435) Avail: NTIS HC A05/MF A01 CSCL 01A

Two flight tests have been conducted that obtained extension pressure data on a modified AH-1G rotor system. These two tests, the Operational Loads Survey (OLS) and the Tip Aerodynamics and Acoustics Test (TAAT) used the same rotor set. In the analysis of these data bases, accurate 2-D airfoil data is invaluable, for not only does it allow comparison studies between 2- and 3-D flow, but also provides accurate tables of the airfoil characteristics for use in comprehensive rotorcraft analysis codes. To provide this 2-D data base, a model of the OLS/TAAT airfoil was tested over a Reynolds number range from 3 x 10 to the 6th to 7 x 10 to the 7th and between Mach numbers of 0.34 to 0.88 in the NASA Langley Research Center's 6- by 28-Inch Transonic Tunnel. The 2-D airfoil data is presented as chordwise pressure coefficient plots, as well as lift, drag, and pitching moment coefficient plots and tables. Author

N89-14217*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INVESTIGATION OF A MOVING-MODEL TECHNIQUE FOR MEASURING GROUND EFFECT
GUY T. KEMMERLY and JOHN W. PAULSON, JR. Washington, DC Jan. 1989 35 p
(NASA-TM-4080; L-16481; NAS 1.15:4080) Avail: NTIS HC A03/MF A01 CSCL 01A

A ground-based testing technique is under development for the measurement of dynamic or time-dependent ground effects which may be present during aircraft approach and landing. The technique utilizes a model moving horizontally over an upwardly-inclined ground plane to simulate rate of descent. Results were obtained in the Langley Research Center (LaRC) Vortex Research Facility (VRF) for a generic 60 delta wing and for an F-18 configuration, both with and without thrust reversing, at forward speeds up to 100 ft/sec. These same models and support hardware were also tested in the LaRC 14 by 22 Foot Subsonic Tunnel at identical conditions (but without rate of descent) with and without a moving-belt ground plane to obtain data for comparison. Author

N89-14219# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
NUMERICAL GRID GENERATION AND POTENTIAL AIRFOIL ANALYSIS AND DESIGN M.S. Thesis
MATO F. SILADIC 1988 138 p
(AD-A197972; AFIT/CI/NR-88-72) Avail: NTIS HC A07/MF A01 CSCL 20D

The primary objective of this thesis is to explore the feasibility of using parabolic partial differential equation techniques for numerical grid generation for two-dimensional aerodynamic configurations. The contents include a discussion of grid generation concepts and schemes in the literature, iterative methods for numerical grid generation and two differential grid generation schemes: (1) an elliptic, and (2) a parabolic scheme. A detailed mathematical and numerical representation of both schemes is given. The main purpose in the treatment of the elliptic scheme is to introduce the necessary transformations to provide equations that will establish the particular parabolic scheme development. Surface singularity methods are found to be a good means for solution of potential flow problems. They can handle both single and multicomponent airfoils in analysis and design processes. The stream function approach appears to be very stable and a simple panel method applicable for practical initial analysis and design airfoil problems. The method provides reduction in the number of panels in comparison with other surface singularity methods and the best results were obtained with 40 to 60 panels per airfoil section. The modified approach for computing the actual position of the trailing edge provides designed airfoils with smooth shapes and stable design process. GRA

N89-14223 Technische Hogeschool, Delft (Netherlands). Faculteit der Luchtvaart- en Ruimtevaarttechniek.
A WALK ALONG INTERFACES [EEN WANDELING LANGS RAAKVLAKKEN]
R. J. ZWANN 1988 41 p In DUTCH
(B8817008; ISSN-9-06-275445-7; ETN-89-93456) Avail: Delft University Press, Stevinweg 1, 2628 CN Delft, Netherlands

Aeroelasticity and its relation to other disciplines is reviewed. Examples of aeroelastic problems are presented. Research items that can play a role in the evaluation, development, and certification of aircraft types are discussed. Transonic adjacent flow, transonic buffet and buzz, and free vortex planes are described. Problems in aircraft vibration are introduced. The investigation of flutter in wind tunnels and during flight is discussed. Aeroelastic tailoring, active control technology, and aeroelastic designs are introduced. ESA

N89-14224* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HIGH LIFT, LOW PITCHING MOMENT AIRFOILS Patent
KEVIN W. NOONAN, inventor (to NASA) 11 Oct. 1988 19 p Filed 5 Sep. 1986 Supersedes N87-14282 (25 - 06, p 715)
(NASA-CASE-LAR-13215-1; US-PATENT-4,776,531; US-PATENT-APPL-SN-904132; US-PATENT-CLASS-244-35-R; US-PATENT-CLASS-416-223-R) Avail: US Patent and Trademark Office CSCL 01A

Two families of airfoil sections which can be used for helicopter/rotorcraft rotor blades or aircraft propellers of a particular shape are prepared. An airfoil of either family is one which could be produced by the combination of a camber line and a thickness distribution or a thickness distribution which is scaled from these. An airfoil of either family has a unique and improved aerodynamic performance. The airfoils of either family are intended for use as inboard sections of a helicopter rotor blade or an aircraft propeller.
Official Gazette of the U.S. Patent and Trademark Office

N89-14897*# College of William and Mary, Williamsburg, VA. Dept. of Mathematics.
OPTIMIZATION OF SLENDER WINGS FOR CENTER-OF-PRESSURE SHIFT DUE TO CHANGE IN MACH NUMBER Abstract Only
CARL M. ANDERSEN *In* Hampton Inst., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program 1988 p 36-37 Sep. 1988
Avail: NTIS HC A07/MF A01 CSCL 01A

It is observed that the center of pressure on a wing shifts as the Mach number is changed. Such shifts are in general undesirable and are sometimes compensated for by actively shifting the center of gravity of the aircraft or by using active stability controls. To avoid this complication, it is desirable to design the wings of a

high speed aircraft so as to minimize the extent of the center-of-pressure shifts. This, together with a desire to minimize the center-of-pressure shifts in missile control surfaces, provides the motivation for this project. There are many design parameters which affect center-of-pressure shifts, but it is expected that the largest effects are due to the wing planform. Thus, for the sake of simplicity, this study is confined to an investigation of thin, flat, (i.e., no camber or twist), relatively slender, pointed wings flying at a small angle of attack. Once the dependence of the center of pressure on planform and Mach number is understood, we can expect to investigate the sensitivity of the center-of-pressure shifts to various other parameters. Author

03

AIR TRANSPORTATION AND SAFETY

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

A89-18883
THE DEVELOPMENT OF THE V-22 OSPREY ARMORED ENERGY-ABSORBING CREWSEAT ASSEMBLY
HOWARD A. LINDSAY, JOSEPH W. COLTMAN (Simula, Inc., Phoenix, AZ), and CHARLIE V. EDNIE (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 391-397.

The design and development of the crewseat for the joint services V-22 Osprey tiltrotor aircraft is described. The seat is armored for ballistic protection and energy absorbing for enhanced crash survivability. As the V-22 Osprey was developed under stringent weight criteria, innovative concepts were designed into both the energy absorption mechanism and the armor system: the energy-absorbing support structure was bulkhead mounted to minimize weight and the armored seat bucket incorporates the first production use of an ultra-lightweight Spectra/boron carbide armor system. Advancements made in the design of the V-22 crewseat resulted in a weight reduction of approximately 23 percent compared to current crewseats that perform the same function. Author

A89-18909
ANALYTICAL DETERMINATION AND EXPERIMENTAL COMPARISON OF PERFORMANCE DEGRADATION ON A HELICOPTER MAIN ROTOR DUE TO ICE ACCRETION
R. C. JOHNSON, A. A. PETERSON (Boeing Helicopters, Philadelphia, PA), K. D. KORKAN (Texas A & M University, College Station), and R. K. BRITTON IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 683-693. refs

A series of computer codes have been integrated into one routine to calculate the performance degradation due to ice accretion on a helicopter main rotor. Performance degradation is found in terms of aerodynamic lift and drag increments related to ice formation which results in a significant rotor torque rise as a function of time. The routine permits the calculation of the potential flowfield, particle trajectories, and the two-dimensional energy balance which determines the type and extent of ice accumulation. Aerodynamic coefficient correlations are then applied to obtain lift, drag and moment increments to be utilized in a helicopter performance code. A centrifugal force/shedding model and heat transfer model are also included. This analysis has been compared to actual icing data for a Boeing CH-47 helicopter in terms of torque rise on the rotor as a function of time, with acceptable agreement. Several areas for future studies are also identified along with suggested improvements to the current methodology. Author

A89-18910
DOLPHIN EATS SNOW
JOHN A. MURPHY (Aerospatiale Helicopter Corp., Grand Prairie, TX) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 695-706. refs

The paper describes the solution to the engine surge problem connected with the flight of the Coast Guard HH-65A Dolphin helicopter in snow. The solution chosen was an engine plenum inlet which added a plenum chamber at the inlet of a modified engine. The plenum inlet successfully completed snow certification testing on April 1, 1985. B.J.

A89-19810#
THE GENERAL RULE OF BIRDS COLLIDING AGAINST AEROPLANES AND ANTICOLLISION MEASURES
QIYING LI (Air Force PR China, Second Training School of Aviation Technology, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Aug. 1988, p. B383-B386. In Chinese, with abstract in English. refs

Bird collision is one type of the frequently occurring accidents that threaten flight security and cause economic losses. On the basis of statistical materials from home and abroad, this article gives an analysis to the general rule of birds' bumping against aeroplane and makes explanations and comments on some efficient anticollision methods. Design requirements of airplanes and engines for preventing then from colliding with birds have been given in this article as well. Author

A89-20314#
PERFORMANCE PREDICTION ANALYSIS FOR FULLY DEPLOYED PARACHUTE CANOPIES
T. YAVUZ (Karadeniz Technical University, Trabzon, Turkey) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 995-1000. Previously cited in issue 03, p. 291, Accession no. A87-13809. refs

A89-20320#
DYNAMIC TIRE/SOIL CONTACT SURFACE INTERACTION MODEL FOR AIRCRAFT GROUND OPERATIONS
W. S. PI (Northrop Corp., Hawthorne, CA) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, Apr. 15-17, 1985, Technical Papers. Part 2, p. 321-329) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 1038-1044. Research supported by the Northrop Independent Research and Development Program. Previously cited in issue 13, p. 1847, Accession no. A85-30358. refs

A89-20321#
NEW SOLUTION METHOD FOR STEADY-STATE CANOPY STRUCTURAL LOADS
W. D. SUNDBERG (Sandia National Laboratories, Albuquerque, NM) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 1045-1051. Previously cited in issue 03, p. 291, Accession no. A87-13816. refs
(Contract DE-AC04-76DP-00789)

N89-13413# National Transportation Safety Board, Washington, DC. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 4 OF 1987 ACCIDENTS
27 May 1988 399 p
(PB88-916908; NTSB/AAB-88/08) Avail: NTIS HC A17/MF A01; also available on subscription, North American Continent HC $185.00/year; all others write for quote CSCL 01C

Reports of selected aircraft accidents that occured in U.S. civil and foreign aviation operations during 1987 are given in brief format. Approximately 200 general aviation and air carrier accidents contained in the publication represent a random selection. The facts, conditions, circumstances and probable cause(s) for each accident are given. GRA

N89-13414*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Chemistry and Mechanical Engineering.
A FUNDAMENTAL APPROACH TO THE STICKING OF INSECT RESIDUES TO AIRCRAFT WINGS Final Report
O. YI, N. S. EISS, and J. P. WIGHTMAN Sep. 1988 117 p
(Contract NAG1-300)
(NASA-CR-183041; NAS 1.26:183041; REPT-118; CAS/CHEM-29-88) Avail: NTIS HC A06/MF A01 CSCL 01C

The aircraft industry is concerned with the increase of drag on planes due to the sticking of insects on critical airfoil areas. The objectives of the present study were to investigate the effects of surface energy and elasticity on the number of insects sticking onto the polymer coatings on a modified aircraft wing and to determine the mechanism by which insects stick onto surfaces during high velocity impact. Analyses including scanning electron microscopy, electron spectroscopy for chemical analysis and contact angle measurements of uncoated and polymer coated aluminum surfaces were performed. A direct relation between the number of insects sticking on a sample and its surface energy was obtained. Since the sticky liquid from a burst open insect will not spread on the low energy surface, it will ball up providing poor adhesion between the insect debris and the surface. The incoming air flow can easily blow off the insect debris and thus reducing the number of insects that remain stuck on the surface. Also a direct relation between the number of insect sticking onto a surface and their modulus of elasticity was obtained. Author

N89-13415# Science and Engineering Associates, Inc., Seattle, WA.
LIGHTNING SIMULATION TEST TECHNIQUE EVALUATION Final Report, Sep. 1984 - Sep. 1987
WILLIAM W. COOLEY and DEBORAH L. SHORTESS Oct. 1988 130 p
(Contract DTFA03-84-C-00064)
(DOT/FAA/CT-87/38) Avail: NTIS HC A07/MF A01

The results of four separate lightning simulation tests on a specially designed test bed aircraft is documented. The simulation techniques utilized are low-level swept continuous wave, low-level fast rise pulse, moderate-level pulse, and shock-excitation. The test bed is made up of advanced composite materials with built-in lightning protection and electrical equipment installations. This configuration is electrically and geometrically representative of a general aviation heavy single engine aircraft. Comparative data was developed to determine the effectiveness of the four test methods and used to quantify differences between them. Analysis necessary to extrapolate the results of the tests to the severe lightning environment is discussed. Predicted values from computer models are compared with test results. Author

N89-13417# Army Aeromedical Research Unit, Fort Rucker, AL.
DISORIENTATION ACCIDENTS AND INCIDENTS IN U.S. ARMY HELICOPTERS, 1 JANUARY 1980 - 30 APRIL 1987 Final Report
P. VYRNWY-JONES Mar. 1988 65 p
(AD-A198720; USAARL-88-3) Avail: NTIS HC A04/MF A01 CSCL 01C

Accident data was obtained from the U.S. Army Safety Center for all U.S. Army helicopter spatial disorientation accidents which occurred during the period beginning on 1 January 1980 and ending on 30 April 1987. During this time, there were 120 accidents caused by spatial disorientation which were responsible for 37 fatalities and 56 disabling injuries. Major causal factors are analyzed and recommendations made for changes in aircrew training, education and aircraft instrumentation. Also discussed are the effects of operations undertaken in hostile environments. GRA

N89-13418# Sverdrup Technology, Inc., Arnold Air Force Station, TN.
AN EMPIRICAL LOOK AT TOLERANCES IN SETTING ICING TEST CONDITIONS WITH PARTICULAR APPLICATION TO ICING SIMILITUDE Final Report, Apr. 1986 - Jan. 1987
C. SCOTT BARTLETT Aug. 1988 57 p Prepared in cooperation with AEDC, Arnold AFS, Tenn.
(AD-A198941; AEDC-TR-87-23; DOT/FAA/CT-87/31) Avail: NTIS HC A04/MF A01 CSCL 01B

An investigation was conducted of the requirements for setting icing test conditions for aircraft engine certification tests. Experimental data were gathered and analyzed to determine how much each of the ice scaling parameters could be allowed to deviate from specified conditions without affecting the similarity of the ice accretions. Also studied were how changes in the ice scaling parameters and changes in the icing test conditions themselves affected the resulting ice shapes. The results indicate that: (1) icing similitude criteria must be established in advance of the test; (2) changes in the scaling parameters do not necessarily indicate a change in the ice shape; (3) experimental data are useful in determining allowable changes in the icing test conditions; (4) determination of allowable tolerances for icing test parameters will depend on which icing regime one is operating in; and (5) scaling laws used in this report cannot solely be used to determine tolerances in setting icing test conditions. GRA

N89-13419# Federal Aviation Administration, Washington, DC. Office of Aviation Policy and Plans.
TERMINAL AREA FORECASTS: FISCAL YEARS 1988-2000
Mar. 1988 433 p
(AD-A198079; FAA-APO-88-3) Avail: NTIS HC A19/MF A01 CSCL 01E

This report contains forecasts of aviation activity for 847 airports in the United States for fiscal years 1988 to 2000. These include 399 airports with FAA air traffic control towers and radar approach control service and 14 FAA contract towers. For each airport, detailed forecasts are made for the four major users of the air traffic system: air carriers, air taxi/commuters, general aviation, and military. Summary tables contain national, FAA regional, and state aviation data and other airports specific highlights. The forecasts have been prepared to meet the budget and planning needs of the constituent units of the FAA headquarters and regional offices and to provide airport-specific information that can be used by state and local aviation authorities, the aviation industry, as a whole, and the general public. GRA

N89-14225# Army Aviation Engineering Flight Activity, Edwards AFB, CA.
EVALUATION OF THE IMPROVED OV-1D ANTI-ICING SYSTEM Final Report, 28 Jan. - 21 Feb. 1988
JOSEPH MIESS, MICHAEL BLACKER, and JOSEPH PIOTROWSKI Apr. 1988 68 p
(AD-A198438; USAAEFA-87-25) Avail: NTIS HC A04/MF A01 CSCL 01C

The U.S. Army Aviation Engineering Flight Activity evaluated the improved OV-1D anti-icing system from 28 January to 21 February 1988 at Duluth, Minnesota. Ten flights (6.5 hours cloud immersion) in artificial conditions and four flights (5.8 hours cloud immersion) in natural conditions were conducted. One enhancing characteristics, nine deficiencies, and three shortcomings were identified. The windshield anti-ice system, when working, enhances safe mission accomplishment. The nine deficiencies were: the inability of the pneumatic deicing system to remove wing and empennage leading edge ice accumulations; the excessive number of AC generator drive shaft failures; the ice accretion characteristics of the engine inlet cowl at temperatures colder than -15 C; the ice accretion and shedding characteristics of the propeller spinner afterbody; the numerous dropouts of one or both windshield anti-ice systems and lack of failure warning to the pilot; the numerous dropouts of the AC generators during flight, the increased pilot workload required to reset them and the distraction caused by illumination of the Master Caution light: the numerous converter dropouts during normal operations, the increased pilot workload required to reset them, and the resulting pilot distractions caused by illumination of the Master Caution light; and the numerous inverter dropouts and the ensuing delay and actions required to reestablish flight essential and normal inverter loads. GRA

N89-14226# Aeronautical Systems Div., Wright-Patterson AFB, OH. Crew Station Design Facility.
COMPARISON OF THE GENERAL DYNAMICS GROUND CLOBBER ALGORITHM WITH THE GCAS AND LAWS ALGORITHMS Final Report, Mar. 1986 - Apr. 1988
M. A. DIPADUA, R. GEISELHART, J. GAVERN, and P. LOVERING (Midwest Systems Research, Inc., Dayton, OH.) April. 1988 170 p
(AD-A198479; ASD-TR-88-5022) Avail: NTIS HC A08/MF A01 CSCL 01D

Three ground avoidance algorithms were evaluated over a variety of mission profiles to determine their effectiveness in avoiding Controlled Flight into Terrain (CFIT) mishaps. Eight Air Force pilots flew nine data collection missions each while subjectively evaluating the system's nuisance warnings. During each mission one of the three algorithms was on-line while the other two were being flown off-line. This provided a mechanism to directly compare each algorithms' performance over identical flight conditions. There were 107 crashes in the experiment resulting in 107 crash plots used for the comparison. The crash plots indicated no significant difference between algorithm performance with regard to crash frequency. The algorithms did differ slightly when performance was evaluated over specific flight regimes, to include diving into flat terrain, level flight into rising terrain, and diving into rising terrain. Subjective evaluation of nuisance warnings indicate significant philosophical differences between the algorithms. GRA

N89-14227# Boeing Advanced Systems Co., Seattle, WA.
FIRE EXTINGUISHING AGENT EVALUATION IN THE AIRCRAFT ENGINE NACELLE FIRE TEST SIMULATOR (AENFTS) Final Report, Jan. 1985 - Mar. 1987
ALAN M. JOHNSON Jun. 1988 169 p
(Contract F33615-84-C-2431)
(AD-A198523; D180-30962-1; AFWAL-TR-88-2022) Avail: NTIS HC A08/MF A01 CSCL 01B

Fire tests and extinguishant concentration tests were conducted using a simulated portion of the F-16 aircraft engine compartment in the Aircraft Engine Nacelle Fire Test Simulator (AENFTS) at Wright-Patterson Air Force Base. Engine compartment ventilation airflow pressure and temperature were varied to simulate a variation in altitude and ram air pressure. Combat damage simulation included inflow with ambient temperature, simulating outer compartment wall penetration and inflow at elevated temperature simulating fan case perforation or engine bleed air line damage. The length of time between ignition and agent release was found critical, particularly when ventilation air pressure greater than sea level ambient was simulated. The existing Halon 1301 specifications were found to be adequate but a revision is proposed to encourage actual agent release tests with high realism for all planned flight conditions, discourage the use of Halon 1202 and include survivability/vulnerability considerations. GRA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A89-17183* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IRREDUCIBLE ERROR RATE IN AERONAUTICAL SATELLITE CHANNELS
F. DAVARIAN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Electronics Letters (ISSN 0013-5194), vol. 24, Oct. 13, 1988, p. 1332, 1333.

The irreducible error rate in aeronautical satellite systems is experimentally investigated. It is shown that the introduction of a delay in the multipath component of a Rician channel increases the channel irreducible error rate. However, since the carrier/multipath ratio is usually large for aeronautical applications, this rise in the irreducible error rate should not be interpreted as a practical limitation of aeronautical satellite communications. C.D.

A89-18093#
RECENT STUDIES OF MLS APPLICATION
BARRY C. SCOTT (FAA, Technical Field Office, Moffett Field, CA) and TSUYOSHI GOKA (Seagull Technology, Inc., Sunnyvale, CA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 283-293.
(AIAA PAPER 88-3916)

This paper discusses the results of two recent simulation studies examining the effects of the MLS capabilities in the terminal area environment. In the first study, multiple scenarios involving ILS and MLS capabilities and using models of the New York Terminal Areas were simulated in an effort to evaluate air traffic control procedures and to identify future efforts needed to ensure air traffic control personnel can facilitate the use of the MLS capabilities. The test disclosed several procedural issues that require further effort and showed there was a significant reduction in controller workload in an all-MLS environment. The second study examined the use of back azimuth guidance for missed approaches and departures. The issues addressed included deviation display sensitivity, methods for selecting and annunciating the back azimuth function, and determining the maximum operationally acceptable offset angle upon which procedures may be based. The results indicate that the MLS back azimuth signal can support use of up to a 30-deg offset radial during either takeoffs or missed approaches and that the switch from front to back azimuth guidance should be automatic. Author

A89-18127#
DIGITAL AUDIO APPLICATIONS IN BUSINESS AND REGIONAL AIRLINE AIRCRAFT
H. W. BENINGFIELD (Rockwell International Corp., Melbourne, FL) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 528-534.
(AIAA PAPER 88-3958)

A digital audio system for business and regional air carrier aircraft reduces installation complexity and noise pickup, and provides significant performance enhancements. To meet the marketplace requirements, a new electrical data bus concept was developed to permit connecting stations freely at any points along an electrically long bus. The same protocol and bus management circuits may be used for a fiber optic version of the data bus. With most of the aircraft audio signals available in digital form, digital signal processing and computation techniques make possible both audio quality improvements and operational improvements to reduce pilot workload and stress. Author

A89-18143#
COMBINED NUMERICAL AND SYMBOLIC PROCESSING FOR AIRBORNE SURVEILLANCE
THOMAS KURIEN and ADAM CAROMICOLI (Alphatech, Inc., Burlington, MA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 622-631. refs
(Contract N00014-87-C-0757)
(AIAA PAPER 88-3985)

In this paper, an architecture for an airborne surveillance decision aid consisting of both numerical and symbolic processing algorithms is defined and analyzed. Numerical algorithms are based on the mathematics of estimation theory and are applicable to the problem of multisensor multitarget tracking and identification. Symbolic algorithms are based on the domain knowledge of the airborne surveillance mission and are applicable to the problem

of threat evaluation. The numerical algorithms have been implemented in FORTRAN and the symbolic algorithms have been implemented in PROLOG. Results obtained with a prototype of the decision aid show that evaluated threat conditions are consistent with those actually simulated. Author

A89-18145#
MULTIPLE SAMPLE POLYGONAL CORRELATION ALGORITHM FOR THE DETERMINATION OF GROUND EMITTER LOCATION
S. J. FU, J. L. VIAN, and D. L. GROSE (Boeing Military Airplanes, Wichita, KS) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 640-643. refs
(AIAA PAPER 88-3987)

Passive techniques to locate ground emitters from an airborne platform provide threat warning to aircraft in hostile airspace while maintaining the electronic silence of the vehicle. These techniques are based on triangulation methods and extended Kalman filters using only bearing measurements. In this paper a new approach, which takes into consideration of the maximum measurement error of the sensor and approximates an area of uncertainty of the emitter location by polygons, is proposed. The performance of this algorithm is demonstrated by simulation results and an example is shown for the comparison of this algorithm and the extended Kalman filter approach. Author

A89-18151*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A SIMULATION STUDY OF DATA LINK MESSAGE EXCHANGE - FLIGHT DECK PERSPECTIVE
MARVIN C. WALLER (NASA, Langley Research Center, Hampton, VA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 672-678.
(AIAA PAPER 88-3993)

Data link message exchange for Air Traffic Control (ATC) offers the potential of increasing flight safety and efficiency by reducing communication errors and enabling more information to be exchanged between aircraft and ground facilities. Digital communication also presents an opportunity to relieve the overloading of air traffic control radio frequencies, which hampers efficient message exchange during peak traffic periods in many busy terminal areas. A study has been completed at NASA Langley Research Center to compare the use of data link, for tactical ATC messages and ATIS reports, to conventional voice communication. The results indicate that flight crews prefer the data link message exchange for routine communication with air traffic control facilities. The data link communication process, however, entailed delays related to the physical characteristics of the link and the nature of the interface explored in this study. Consequently, the crews preferred voice radio when exchanging time critical messages. Author

A89-18152#
OCEANIC CLEARANCE DELIVERY VIA AIR/GROUND DATA LINK
SHY AITKEN (Transport Canada, Air Navigation Systems Directorate, Ottawa) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 679-683.
(AIAA PAPER 88-3994)

This paper describes ongoing tests utilizing a VHF data link to transmit Air Traffic Control (ATC) oceanic clearances from a ground based automated ATC system directly to aircraft in flight. The motivation for these trials is to reduce cockpit workload, alleviate frequency congestion through reduced pilot-controller voice communications and increase integrity of information transfer. The trial activities are described along with an explanation of the operation of the total system. Enhancements that are contemplated are outlined, including developmental activities related to the validation of the concept of Automatic Dependent Surveillance (ADS) in which aircraft navigational information is data linked from the aircraft directly to ATC facilities. It is concluded that ATC operational use of VHF data link has sufficient potential to warrant further consideration. Author

A89-18153#
MODE S DATA LINK APPLICATIONS RESEARCH IN THE UK
A. J. HUGHES, M. F. WORSLEY (Royal Signals and Radar Establishment, Malvern, England), P. A. PLATT (Civil Aviation Authority, London, England), and N. WITT (Royal Aircraft Establishment, Bedford, England) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 684-688.
(AIAA PAPER 88-3996)

This paper summarizes three aspects of the UK program aimed at developing a Mode S data link. Firstly, the existing experimental data link equipment and capability is reviewed and probable future enhancements discussed. Secondly, data link applications requiring air-crew access to ground data bases are considered, taking as an example the provision of an automatic VOLMET service. Finally, the transmission and use of air-derived meteorological data is described and the potential benefits discussed. Preliminary results obtained using an elementary wind model are presented. Author

A89-18154#
AIR TRAFFIC CONTROL (ATC) AND AIR/GROUND DIGITAL COMMUNICATIONS - DEMONSTRATION AND EVALUATION
LYNNE FELLMAN and JOHN CHRIS MOODY (Mitre Corp., McLean, VA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 689-694.
(AIAA PAPER 88-3998)

An approach for providing a data-link interface to the flight crew has been designed and a prototype system built. This interface is described, and its use is illustrated through a hypothetical flight scenario. The scenario, showing sample data-link transactions, covers all phases of flight: preflight, departure, en route domestic, en route oceanic, and arrival. Author

A89-18155#
THE MODE S DATA LINK - EXPERIMENTAL WORK AND POSSIBLE FUTURE APPLICATIONS IN WESTERN EUROPE
MAURICE E. COX (EUROCONTROL, Brussels, Belgium) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 695-703. refs
(AIAA PAPER 88-3999)

Since the early 1970s, because of an anticipated growth in air traffic in Europe, studies have been undertaken by Eurocontrol to determine a suitable basis for the control of higher traffic densities in continental airspace. This work has led to proposals for a concept of ATC based on the use of accurate trajectory prediction techniques and the automatic monitoring of traffic to minimize the risk of conflict situations, which, in turn, would permit controllers to handle a greater volume of traffic. The SSR Mode S digital data link has been identified as having a key role in this concept, and work has been undertaken to demonstrate the feasibility of using it accordingly. Author

A89-18156#
THE FUTURE OF AEROMOBILE DIGITAL COMMUNICATIONS
RICHARD A. RUCKER and GEORGE W. FLATHERS (Mitre Corp., McLean, VA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 704-710.
(AIAA PAPER 88-4001)

An aeronautical telecommunications network (ATN) to provide

digital links between ground and airborne users is described and illustrated with diagrams. The ATN architecture and hardware implementation are discussed, and specific types of utilization are considered, including links to ACARS, SatCom, and Mode S systems and mixed radiotelephone and digital communication with ATC and AOC facilities. Examples of ATN use at different flight phases are provided. T.K.

A89-18157#
DATA LINK ORGANIZATION IN MODE S SECONDARY SURVEILLANCE RADAR SYSTEMS - OPERATIONAL COMPATIBILITY WITH OTHER MODE S SYSTEMS
A. BOLSHEV (All-Union Scientific Research Institute of Radio Equipment, Leningrad, USSR) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 711-713.
(AIAA PAPER 88-4003)

The current status of Mode S SSR data-link technology in the USSR is briefly surveyed, and particular attention is given to problems of compatibility on an international level. The major types of uplink and downlink messages are discussed, including collision-avoidance messages, ATC service messages, pilot-initiated messages, and replies to ground queries. The need for international standard message transmission and formatting protocols is indicated. T.K.

A89-18173#
TERMINAL NAVIGATION FOR THE COMBAT TALON II AIRCRAFT
N. F. TODA, S. C. FELTER, and F. H. SCHLEE (IBM, Systems Integration Div., Owego, NY) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 809-814.
(AIAA PAPER 88-4021)

This paper describes the Terminal Navigation System (TNS) of the MC-130H Combat Talon II aircraft. The system provides a capability for autonomous instrument approach to landing, satisfying an operational need for precision landings on austere airfields. The TNS is initiated during cruise flight, proceeds with aircraft transition onto a glideslope, and ends just prior to aircraft flare and landing. A Kalman filter, an onboard inertial navigation unit, FLIR, and/or a radar tracker estimate aircraft inertial position and velocity relative to the runway. Author

A89-18175#
FAULT TOLERANT INERTIAL NAVIGATION SYSTEM
KEVIN VANDERWERF and KNUT WEFALD (Honeywell, Inc., Minneapolis, MN) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 821-829. refs
(AIAA PAPER 88-4024)

This paper describes the sensor redundancy management concept employed in a fault-tolerant inertial reference system. The concept uses a sensor hexad and employs separate fault detection and isolation (FDI) algorithms for navigation computations and outputs to the FCS. The FDI algorithm implementation is based on the generalized likelihood ratio test (GLRT). Enhancements to the failure isolation logic virtually eliminate the probabilities of false detection and wrong isolation inherent with the basic GLRT concept, thus making the GLRT scheme practical in the real world of high reliability requirements. Author

A89-18176#
ARRIVAL-TIME GUIDANCE IN VARIABLE WINDS
SAM LIDEN (Honeywell, Inc., Air Transport Systems Div., Phoenix, AZ) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 830-838.
(AIAA PAPER 88-4025)

Changes in the winds over time assure that there will always be error in wind forecasts, and forecast error is the major problem in achieving high-accuracy arrival-time guidance by a flight management system. Through a series of simulations, two methods for compensating for forecast errors are evaluated. The first method, used in current systems, blends measured aircraft wind with forecast wind to achieve some improvement in prediction accuracy. Thsi method is found to be unsatisfactory for arrival-time guidance. A second method is proposed where the flight speed is adjusted by the current forecast error. It appears to provide improved arrival-time performance. Author

A89-18180#
AUTOMATIC DEPENDENT SURVEILLANCE DATA TRANSFER
THOMAS D. JUDD (Boeing Commercial Airplanes, Seattle, WA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 858-864. refs
(AIAA PAPER 88-3997)

Automatic dependent surveillance (ADS) and the newly developed and developing communication paths available to the aeronautical community are discussed. These paths are modeled after the OSI communication model. The OSI model divides the digital communication process into seven separate functions, which can be conceptualized as seven layers. Each layer's specific digital communication function is explored in this paper. The standardization of the communications system allows each path to be open for use by applications such as ADS. Author

A89-18181#
TERMINAL INFORMATION FOR DATA LINK
FREDERICK KUHL (Mitre Corp., Civil Systems Div., McLean, VA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 865-870.
(AIAA PAPER 88-4000)

The Automatic Terminal Information Service (ATIS) has often been mentioned as a candidate application of Mode Select Beacon System Data Link. It is intended that the prototype ATIS work station will be evaluated in an operational setting at the Atlantic City, NJ, Airport. A significant part of this effort has been the identification of a vocabulary for ATIS messages and the estimation of the degree to which any vocabulary would need to be adapted for use at various airports. This paper discusses the preliminary vocabulary proposed for the Atlantic City Airport, the size and required adaptation of ATIS vocabularies, the implications for data link coding of ATIS messages, and the prototype work station intended to generate data link ATIS. Author

A89-18182#
DEVELOPMENT OF THE TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM III (TCAS III)
LAWRENCE J. NIVERT, JOSEPH A. WALSH, and JOHN J. WOJCIECH (FAA, Washington, DC) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 871-876. refs
(AIAA PAPER 88-4002)

TCAS III is the most complex and versatile member of the TCAS family of airborne collision-avoidance systems currently being developed and evaluated by the FAA. TCAS III has the capability not only to recognize potential collision threats but also to display to the flight crew recommended horizontal and vertical escape maneuvers for avoiding these threats. This paper provides both programmatic and technical overview concerning the TCAS III development effort. Author

A89-18183#
TCAS III - BRINGING OPERATIONAL COMPATIBILITY TO AIRBORNE COLLISION AVOIDANCE
W. DWIGHT LOVE (Mitre Corp., McLean, VA) IN: AIAA/IEEE

Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 877-881.
(AIAA PAPER 88-4004)

TCAS II is an airborne system that can alert a pilot to the presence of a nearby aircraft and recommend a vertical escape maneuver to avoid a possible midair collision. TCAS III is intended to be a more capable version of TCAS; more accurate bearing measurements will enable TCAS III to recommend escape maneuvers in the horizontal dimension in addition to the vertical dimension. The paper describes the principal ways in which the TCAS III collision-avoidance logic has been designed to enhance operational acceptability. This discussion covers three major areas of the TCAS III logic: threat detection, modeling of escape maneuvers, and threat resolution. Author

A89-18751
ARCHITECTURE OF AN OPTIMAL NAVIGATION SYSTEM INTEGRATING GPS [ARCHITECTURE D'UN SYSTEME OPTIMAL DE NAVIGATION INTEGRANT LE GPS]
E. TARNOWSKI (Airbus Industries, Blagnac, France) (Instituts de Navigation, Congres International, Sydney, Australia, Feb. 2-5, 1988) Navigation (Paris) (ISSN 0028-1530), vol. 36, Oct. 1988, p. 437-449. In French.

In the early 1990s, GPS shall be fully operational. The advantages and performance of this system are predicted to be outstanding; however, GPS will be one unit among an overall navigation system. Thus it must be properly integrated in order to take maximum benefit out of its qualities. Author

A89-18753
RADIONAVIGATION NEEDS FOR THE EUROPE OF THE FUTURE [BESOINS EN RADIONAVIGATION POUR L'EUROPE DE DEMAIN]
JEAN FOURNIER (Institut Francais de Navigation, Paris, France) Navigation (Paris) (ISSN 0028-1530), vol. 36, Oct. 1988, p. 508-516. In French.

Present and projected radionavigation systems are described, and the European radionavigation needs for the 1990s are discussed. Systems such as GPS, VOR, and DME aid in the optimization and guidance of commercial aircraft flights. It is predicted that in the future, Loran C will be used for coastal navigation, fishing monitoring, and merchant marine applications. A hybrid Navstar/GPS-Loran C system will be used for general and transport aviation, and ground based systems will be used for such applications as fire fighting and mobile position location. R.R.

A89-18754
SPECIAL COMMITTEE ON FUTURE AIR NAVIGATION SYSTEMS (FANS) [COMITE SPECIAL DES FUTURS SYSTEMES DE NAVIGATION AERIENNE /F.A.N.S./]
OLIVIER CAREL (Service Technique de la Navigation Aerienne, Paris, France) Navigation (Paris) (ISSN 0028-1530), vol. 36, Oct. 1988, p. 517-527. In French.

The recommendations of the ICAO committee on future navigation systems for the next 25 years are presented, emphasizing new satellite technology. The present insufficiency and future evolution of communications, navigation, and surveillance (CNS) systems are discussed in detail. It is suggested that future air traffic control needs can be fulfilled by improvement of data transmission between users, extension of existing surveillance coverage, and the use of advanced data treatment systems. Future CNS systems will include automatic dependent surveillance, secondary surveillance radar, and a satellite-based mobile aeronautical service. R.R.

A89-19867
OMEGA NAVIGATION SYSTEM - A STATUS REPORT
ROBERT J. WENZEL (USCG, Omega Navigation System Center, Alexandria, VA) Navigation (ISSN 0028-1522), vol. 35, Fall 1988, p. 309-315. refs

Plans to continue operating the Omega Navigation System until at least 2005 are discussed. The establishment of a 15-year period of transition to GPS and the resoltuion of international commitments are examined. Results from evaluations the Omega system elements are presented, including performance statistics, operational requirements, regional validations, propagation effects, and the recapitalization of the Omega infrastructure. Changes to extend the service life of the system are considered, such as redesigning or replacing transmitting station equipment, changes in system monitors and system control software, and system propagation corrections. R.B.

A89-20117
AERONAUTICAL SATELLITE NETWORKS
WALTER J. GRIBBIN (Aeronautical Radio, Inc., Annapolis, MD) IN: EASCON '88; Proceedings of the Twenty-first Annual Electronics and Aerospace Conference, Arlington, VA, Nov. 9-11, 1988. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 135-138.

The design and development of a satellite-based network that is to provide critical safety-of-life communications services to the air transport industry are described. The system uses a fully integrated digital transmission system for cockpit and passenger voice and data. The voice-transmission system provides for multiple channels of near-toll-quality communications using 8-9.6-kb/s voice-coding algorithms. Applications of this system are discussed, and attention is given to the number and locations of satellites, network capacity, avionics, the ground segment, and network interoperability. Also provided is a description of the near-term-service development plans for aviation satellite services. I.E.

A89-20122
AN OVERVIEW OF SPACE-BASED RADIONAVIGATION SYSTEMS
ALISON K. BROWN and JOHN W. LAVRAKAS (NAVSYS Corp., Monument, CO) IN: EASCON '88; Proceedings of the Twenty-first Annual Electronics and Aerospace Conference, Arlington, VA, Nov. 9-11, 1988. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 161-171. refs

A survey of the major space-based radio navigation systems currently operating or in development is presented, considering their design, capabilities, and current status. The basic principles of space-based radio navigation are described. Orbital characteristics, signal structure, accuracy, and coverage are examined for the following systems: Transmit, Navstar/GPS, Glonas, Starfix, Geostar, and ESA Navsat. I.E.

A89-20123#
AN OVERVIEW OF THE FEDERAL RADIONAVIGATION PLAN
LARRY V. GRANT (DOT, Research and Special Programs Administration, Washington, DC) IN: EASCON '88; Proceedings of the Twenty-first Annual Electronics and Aerospace Conference, Arlington, VA, Nov. 9-11, 1988. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 173-177. refs

A brief review of FRP (the U.S. Federal Radionavigation Plan) history is presented. Current and future federal requirements for radionavigation systems and the status of the GPS and its possible impact on existing systems are addressed. Issues such as the role of the private sector and uses other than navigation, that appeared for the first time in the 1986 FRP, are highlighted. The radionavigation users' conference held in Washington DC in March 1988 and other user-oriented actions are discussed. I.E.

A89-20239
FLIGHT GUIDANCE TECHNOLOGY [FLUGFUEHRUNGSTECHNIK]
G. SCHAENZER (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 738-761. In German. refs
(DGLR PAPER 87-119)

Technological developments and problems in the area of flight

guidance are discussed. Advances made in sensors and measurement technology, data processing, and communications as they relate to flight guidance are considered. Problems encountered in flight guidance in a high-wind environment, including takeoff and landing and safety-enhancement measures. are examined. C.D.

N89-14228*# Systems Technology, Inc., Hawthorne, CA.
AUTONOMOUS RPRV NAVIGATION, GUIDANCE AND CONTROL
DONALD E. JOHNSTON, THOMAS T. MYERS, and JOHN W. ZELLNER Mar. 1983 170 p
(Contract NAS4-2896)
(NASA-CR-179425; NAS 1.26:179425; TR-1180-1) Avail: NTIS HC A08/MF A01 CSCL 17G

Dryden Flight Research Center has the responsibility for flight testing of advanced remotely piloted research vehicles (RPRV) to explore highly maneuverable aircraft technology, and to test advanced structural concepts, and related aeronautical technologies which can yield important research results with significant cost benefits. The primary purpose is to provide the preliminary design of an upgraded automatic approach and landing control system and flight director display to improve landing performance and reduce pilot workload. A secondary purpose is to determine the feasibility of an onboard autonomous navigation, orbit, and landing capability for safe vehicle recovery in the event of loss of telemetry uplink communication with the vehicles. The current RPRV approach and landing method, the proposed automatic and manual approach and autoland system, and an autonomous navigation, orbit, and landing system concept which is based on existing operational technology are described.
Author

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A89-17624
DESIGNING HYDRAULIC SYSTEMS FOR SURVIVABILITY
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 8, Nov. 1988, p. 11-14.

An account is given of novel criteria in the design practices used for the armoring and subsystem-features design of military aircraft hydraulic systems, in order to improve aircraft survivability in combat scenarios without compromise of performance levels. Attention is given to the concept of 'proximity armoring', which protects only critical components. Proximity armoring is added in locations where the lines of independent hydraulic systems cross generally, and specifically in locations where a single hit could cause a catastrophic malfunction of the system. O.C.

A89-18346
SIZING UP THE 146-300
HARRY HOPKINS Flight International (ISSN 0015-3710), vol. 134, Oct. 22, 1988, p. 19-25.

A design features account and flight test report are presented for the BAe 146-300 four-turbofan commuter airliner, whose 8-foot fuselage stretch over older versions of the 146 family will expand passenger capacity to 112 in six-abreast configuration. The present assessment praises landing gear softness as well as the cockpit's roominess and the design layout of the instruments suite. In addition to a cut-away drawing, tabular comparative data are presented for the 146-300 and its current commercial competitors, the F100, MD-87, and B737-500 commuter airliners. O.C.

A89-18349
BOEING 747-400 - FLIGHT TEST
HARRY HOPKINS Flight International (ISSN 0015-3710), vol. 134, Nov. 12, 1988, p. 25-31.

Flight test impressions are presented for the third production B747-400 airliner, which is being used as the test platform for the candidate propulsion system RB.211-524G turbofans (CF6-80C2 or PW4000 turbofans are additional candidates). The B747-400 is the world's longest-range airliner; since a relief crew will often be needed, full crew rest facilities have been provided for both cockpit and cabin crewmembers. In addition, the cockpit is fitted for long hours of operation without a third crewmember. Comparative data are furnished for the performance of the three candidate engines, and a cut-away drawing is provided. O.C.

A89-18350
NEW DESIGN, PRODUCTION TOOLS WILL PLAY KEY ROLE IN B-2 COST
WILLIAM B. SCOTT Aviation Week and Space Technology (ISSN 0005-2175), vol. 129, Dec. 5, 1988, p. 18-22.

Novel CAD/CAM and CIM processes developed under USAF sponsorship for the B-2 program at a cost of about $1 billion feature a three-dimensional computer graphics system that links the primary contractor to both the USAF and all its subcontractors. This system is being credited with the substantial reduction of the time and cost involved in design, fabrication, assembly, inspection, and testing. Among the consequences of this system's use are the virtual elimination of master tooling, the use of the same data base by all concerned parties, near-perfect dimensioning of components, and direct generation of technical manuals by the data base. O.C.

A89-18752
THE UNUSED STRATEGIC TOOL - THE AIRSHIP [L'OUTIL STRATEGIQUE 'MANQUANT' - LE DIRIGEABLE]
JEROME SINET (Societe Dirigeables-Espace, France) Navigation (Paris) (ISSN 0028-1530), vol. 36, Oct. 1988, p. 471-483. In French.

The characteristics of the 10 existing gas-propelled airships, and possible applications beyond their current use for advertising, are discussed. The present airships range in volume from about 5500 to 7000 cu m, and they are currently limited to a maximum of 20 hours of flight. Airships can carry radar antennas of up to 18 m, and they can be used for the routine surveillance of regions of the order of 200 miles in diameter, the modeling of risk zones above industrial sites, and remote sensing. The characteristics of a projected airship of over 10,000 cu m volume, a maximum speed of 130 km/hr, a mission length of 100 hours (at an average speed of 70 km/hr), and a capacity for carrying over 12 passengers is described. R.R.

A89-18854
ROTOR/AIRFRAME INTERACTIONS ON TILTROTOR AIRCRAFT
MICHAEL A. MCVEIGH, WILLIAM K. GRAUER, and DAVID J. PAISLEY (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 45-55. refs

The aerodynamic interactions between the rotors and the airframe of tiltrotor aircraft are discussed. Data obtained from powered scale model tests are presented and compared with other test data and with analysis. It is shown that significant interactions exist between the rotor and the airframe in all modes of flight and that these interactions influence performance. The effects of the direction of rotor rotation on wing download in hover and on airplane lift and drag are described and explained. Author

A89-18863
AIRFRAME AND PROPULSION ASSESSMENT OF ALTERNATIVE LIGHT HELICOPTER TECHNOLOGIES (LHX)
KAYDON A. STANZIONE and RANDALL F. SMITH (Praxis Technologies Corp., Woodbury, NJ) IN: AHS, Annual Forum,

44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 159-188. refs

This paper describes the methodology and results of an independent assessment of the alternative airframes and propulsion systems which could be used to satisfy the U.S. Army's light helicopter mission requirements. This paper provides an assessment of technologies applicable for advanced vehicle design. The aircraft configurations assessed in this study included the helicopter and tilt rotor as part of the fundamental ground rules jointly agreed to by the Army Aviation Research and Technology Activity and the two LHX contractor teams. Author

A89-18870
CORROSION AND CORROSION CONTROL OF SELECTED FIELD PROBLEMS
HERBERT JACOBS and MARY J. LLOYD (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 237-242.

The present discussion of factors implicated in helicopter corrosion during field operations furnishes perspective on the resolution of those problems in the field, rather than through redesign. The provocative concept of a 'universal' corrosion prevention/correction compound is formulated and evaluated in light of speculative performance criteria for surface wetting and infiltration characteristics, mechanical application and lubricity characteristics, environmental response behavior, electrical and electronics system application consequences, and human tolerance characteristics. O.C.

A89-18874
EXPERIMENTAL VERIFICATION OF HELICOPTER BLADE DESIGNS OPTIMIZED FOR MINIMUM VIBRATION
WILLIAM H. WELLER and MARK W. DAVIS (United Technologies Research Center, East Hartford, CT) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 263-279. refs

An experimental program was conducted to demonstrate the capability of an automated modal-based design optimization analysis to predict helicopter blade structural properties leading to improved rotor vibratory characteristics. Nineteen articulated model rotor configurations were wind-tunnel tested, and the resulting vibratory responses were measured. Each configuration was based on a unique combination of mass distribution and structural stiffness, corresponding to designs developed to achieve alternative objectives. The experimental results show that the modal-based optimization analysis can be used to tailor blade structural properties to achieve low vibration rotor designs. Author

A89-18875
DEVELOPMENTS IN DYNAMICS METHODOLOGY AT BELL HELICOPTER TEXTRON
J. J. CORRIGAN, J. J. SCHILLINGS, S. K. YIN, and P. Y. HSIEH (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 281-292. refs

The second-generation global rotorcraft flight simulation program designated 'COPTER' incorporates the well-validated, first-generation 'C81' code through a process of restructuring and modularization to reduce development time and cost. Improvements made to the modal displacement methodology are noted to have dramatically improved the computation of steady blade loads; in addition, an updating of modal data as a function of cyclic pitch has yielded improvements in the computation of oscillatory loads. The free-wake module added to COPTER has produced encouraging results for the prediction of higher harmonic blade loads and vibrations. O.C.

A89-18876
BEARINGLESS ROTORS AND HIGHER HARMONIC CONTROL MODELING USING RACAP
KARAN B. SANGHA (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 293-304. refs

This paper addresses the formulation of a generalized rotor-fuselage coupling procedure using impedance matching in the frequency domain. The use of the transfer matrix approach to predict rotor loads and fuselage vibrations is described. The tool is extended to formulate a bearingless main rotor configuration and for the modeling and analysis of higher harmonic control (HHC). It is found that the approach can be used to model redundant load paths on a bearingless rotor, and that torsional loads induced in the flexbeam are primarily due to applied feathering rather than aerodynamically induced loads. HHC trends are found to be largely independent of the modal character of the rotor to which it is applied. Analysis of the mechanisms behind HHC indicates a primary role of the phase of the aerodynamic loads at the harmonics of interest rather than the magnitude of loads. The modes of the fuselage influence minimum vibrations for given hubloads and in the computation of hubloads. C.D.

A89-18877* California Univ., Los Angeles.
DESIGN OF A SIMPLE ACTIVE CONTROLLER TO SUPPRESS HELICOPTER AIR RESONANCE
M. D. TAKAHASHI and P. P. FRIEDMANN (California, University, Los Angeles) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 305-316. refs
(Contract NAG2-209; NAG2-477)

A coupled rotor/fuselage helicopter analysis with the important effects of blade torsional flexibility, unsteady aerodynamics, and forward flight is presented. Using this mathematical model, a nominal configuration is selected that experiences an air resonance instability throughout most of its flight envelope. A simple multivariable compensator using conventional swashplate inputs and a single body roll rate measurement is then designed. The controller design is based on a linear estimator in conjunction with optimal feedback gains, and the design is done in the frequency domain using the Loop Transfer Recovery method. The controller is shown to suppress the air resonance instability throughout wide range helicopter loading conditions and forward flight speeds. Author

A89-18878
STRUCTURAL DYNAMICS OF A HELICOPTER ROTOR BLADE SYSTEM
A. V. SRINIVASAN, D. G. CUTTS, H. T. SHU (United Technologies Research Center, East Hartford, CT), D. L. SHARPE (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and O. A. BAUCHAU (Rensselaer Polytechnic Institute, Troy, NY) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 317-329. refs

Structural dynamic characteristics of a 6.32-ft-diameter torsionally soft two-bladed composite rotor were measured in vacuum over a speed range of 0 to 1000 rpm. Measurements of vibratory strains for five modes of vibration were made on the blades for several combinations of precone, droop, and flexure stiffness. Theoretical predictions of the dynamic characteristics were made using a fully nonlinear FEM. This paper presents and compares the resonant frequencies and corresponding strain mode shapes obtained from the experimental and analytical efforts. Excellent agreement (within 0.5 percent) was found for all flapping and lead-lag modal frequencies. Correlation with torsional frequencies was within 2 percent with stiff flexure and within 7 percent for the soft flexure configuration. Author

A89-18879* Bell Helicopter Co., Fort Worth, TX.
INVESTIGATION OF DIFFICULT COMPONENT EFFECTS ON FEM VIBRATION PREDICTION FOR THE AH-1G HELICOPTER
ROBERT V. DOMPKA (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 331-343. NASA-sponsored research. refs

Under the NASA-sponsored Design Analysis Methods for Vibrations program, a series of ground vibration tests and NASTRAN finite element model correlations were conducted on the Bell AH-1G helicopter gunship to investigate the effects of difficult components on the vibration response of the airframe. Secondary structure and damping were found to have significant effects on the frequency response of the airframe above 15 Hz. The nonlinear effects of thrust stiffening and elastomeric mounts on the low-frequency pylon modes below the main rotor were also significant. C.D.

A89-18880
DESIGN AND FABRICATION OF AN ADVANCED LIGHT ROTOR
HARLAN W. FRIEDMAN (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 347-354.

The successful model 680 four-bladed composite bearingless rotor has been modified by incorporating new rotor blades designed and fabricated with advanced technology. This paper describes the aerodynamic design requirements and structural design practices used to create the simple blade structure, the dynamic tuning methods used to achieve low vibration, and the use of CAD to disseminate engineering and tooling information. Discussion of tooling and manufacturing approaches that yield the blades at a 33-percent time savings and a 40-percent cost savings over typical preproduction blades are included. Author

A89-18881
THE POINTER - A REVOLUTIONARY IDEA TO IMPROVE RPV CAPABILITIES
RODNEY S. TAYLOR (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 355-363.

The paper describes the 'Pointer', which is a small remotely piloted vehicle. It can operate routinely from unprepared and confined areas or from the decks of small vessels with no requirement for launch or recovery equipment. Pointer integrates the advantages of VTOL and low-speed flight with the speed and endurance associated with fixed-wing aircraft. Mission turn-around time is minimized and the high 'g' forces associated with launch and recovery are eliminated. A half-scale model of the developmental version of Pointer is presented. K.K.

A89-18882 Boeing Helicopter Co., Philadelphia, PA.
CIVIL TILTROTOR AIRCRAFT - A COMPARISON OF FIVE CANDIDATE DESIGNS
JOSEPH B. WILKERSON (Boeing Helicopters, Philadelphia, PA) and RODNEY S. TAYLOR (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 365-388. NASA-FAA-DOD-sponsored research. refs

The results of a NASA, FAA, and DOD funded study on civil tiltrotor missions and applications showed that a substantial share of the Northeast Corridor shorthaul market may be captured by civil tiltrotor aircraft with strategically located IFR-certified vertiports. A slightly enlarged version of the XV-15 and commercial versions of the basic V-22 were the baseline configurations for the study. Three totally new commercial tiltrotor concepts were developed as well. K.K.

A89-18885
DESIGN, ANALYSIS, AND TEST OF COMPOSITE FUEL TANK PODS FOR THE CH-46E HELICOPTER
JOHN P. KELLEHER and SIDNEY MOSZER (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 423-431.

The logistic effectiveness of the helicopter is limited by its mission radius capability. The U.S.Navy requested an increase in fuel capacity from 356 gallons to 600 gallons to improve the CH-46E helicopter mission radius capability. Various fuel tank pod design concepts were evaluated from state-of-the-art metal to advanced composite designs. The most efficient structural design based on weight, parts count, tooling count, material data base available and the resulting final cost, was selected. This paper summarizes the sequence of design events from initial design concepts up to and including full-scale structural tests. Author

A89-18888
ADVANCEMENTS IN EROSION TESTING OF ROTOR BLADE LEADING EDGES
DAVID A. HAYNIE (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 453-466. refs

Data that identify and quantify the parameters influencing helicopter rotor blade erosion are used to design a new erosion test stand that more accurately simulates the erosion environment encountered in flight. The parameters controlled by the test stand include airfoil shape, tip speed, angle of attack, sand cloud, and rain field. A comparison is made with actual rain erosion experiences in flight. C.D.

A89-18893
NOTAR HYBRID COMPOSITE/METAL FAN BLADE
R. A. LOFLAND and JIM NEMO (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 493-495.

For the past ten years McDonnell Douglas Helicopter Company has been developing the NOTAR (No Tail Rotor) helicopter. At the start of the NOTAR Program, a metal blade and hub assembly were selected to supply the air for both the tail boom and the thruster. Though adequate for proving the viability of the NOTAR concept, as the program matured it became clear that the performance of the blade was not suitable for continued use and improvement in directional control would have to be made. Towards this end, an outside company was contracted in 1984 to design and fabricate an all-composite fan blade that would be compatible with the existing hub. Though this was accomplished, the composite blades that were supplied failed. This paper will discuss the design changes of the all-composite blade that resulted in the evolution of a hybrid composite/metal fan blade. Author

A89-18896
SIX DEGREE OF FREEDOM CREW ISOLATION DESIGN, BENCH TEST AND FLIGHT TEST
R. DESJARDINS, R. GABEL, and V. SANKEWITSCH (Boeing Helicopters, Philadelphia, PA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 521-530. refs

A six-degree-of-freedom isolation system has been developed for the cockpit crew module of the Boeing Model 360 helicopter, an advanced technology demonstrator. Analyses, bench tuning tests, an aircraft shake test and flight test have demonstrated the effectiveness of the system. Flight vibration levels on the floor near the co-pilot seat at the dominant 4P frequency for 200 knots are + or - 0.06 g vertical, + or - 0.02 g lateral, and 0.02 g longitudinal. Author

A89-18898* Maryland Univ., College Park.
AEROELASTIC OPTIMIZATION OF A HELICOPTER ROTOR
JOON W. LIM and INDERJIT CHOPRA (Maryland, University, College Park) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 545-558. refs
(Contract NAG1-739; DAAG29-83-K-0002)

Structural optimization of a hingeless rotor is investigated to reduce oscillatory hub loads while maintaining aeroelastic stability in forward flight. Design variables include spanwise distribution of nonstructural mass, chordwise location of blade center of gravity and blade bending stiffnesses (flap, lag and torsion). A comprehensive aeroelastic analysis of rotors, based on a finite

element method in space and time, is linked with optimization algorithms to perform optimization of rotor blades. Sensitivity derivatives of blade response, hub loads, and eigenvalues with respect to the design variables are derived using a direct analytical approach, and constitute an integral part of the basic blade response and stability analyses. This approach reduces the computation time substantially; an 80 percent reduction of CPU time to achieve an optimum solution, as compared to the widely adopted finite difference approach. Through stiffness and nonstructural mass distributions, a 60-90 percent reduction in all six 4/rev hub loads is achieved for a four-bladed soft-inplane rotor. Author

A89-18899
DYNAMIC CHARACTERISTICS OF ADVANCED BEARINGLESS ROTORS AT MCDONNELL DOUGLAS HELICOPTER COMPANY
JEFFREY L. SORENSEN, LOUIS J. SILVERTHORN, and THOMAS H. MAIER (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 559-570.

Two bearingless main rotor systems consisting of advanced composite blades and composite flexbeams were designed, fabricated, and tested. This paper addresses dynamic and aeroelastic stability issues affecting the design of both rotor systems. First, the paper presents analytical results on the effects of dynamic requirements on damper sizing, pitch-flap-lag stability, blade frequency placement, whirl-mode stability, and vibration. Next, the document confirms the assumptions made in the design and analysis of the rotor system using test results. Finally, the paper compares the dynamic characteristics of the two flexbeam designs. Author

A89-18901
TIP LOSS AND BLADE STRIKE SIMULATIONS USING DYSCO
B. A. GUSTAVSON (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 581-585. refs
(Contract DAAJ02-85-C-0033; DAAJ02-86-C-0027)

A modeling technology has been developed to evaluate the damage tolerance of rotorcraft dynamic systems and has been incorporated into an interactive computer program called DYSCO (Dynamic System Coupler). The motion of a rotorcraft can be simulated with changes in control inputs, physical and geometric properties, and applied loads imposed at any instant. Changes to single or multiple blades of an aeroelastic rotor representation due to ballistic damage or other anomalies can be made. The feasibility of a strike-tolerant main rotor blade was investigated; a blade striking an obstacle would cause a frangible blade tip to separate from the blade, preventing impact loads from being transmitted to the blade root and hub. The loss of one blade tip from a teetering rotor and a blade strike were modeled. The effects on the system dynamic response, corresponding blade loads, and control inputs were demonstrated. Using the coupling procedure unique to DYSCO, forcing functions can be applied at any point or points along a blade, allowing precise definitions of the impact function associated with a strike to be implemented. Author

A89-18911
ANALYTICAL PREDICTION AND FLIGHT TEST EVALUATION OF BELL ACAP HELICOPTER CABIN NOISE
GOPAL P. MATHUR (Bell Helicopter Textron, Inc., Fort Worth, TX), JEROME E. MANNING, and LOUIS R. QUARTARARO (Cambridge Collaborative, Inc., MA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 719-729. Army-supported research.

The application of Statistical Energy Analysis (SEA) approach to Bell ACAP (Advanced Composite Airframe Program) helicopter for cabin noise modeling and prediction is discussed. The SEA model of the composite airframe is based on the following major structural sections of the helicopter: roof, bulkheads and frames, side panels, internal acoustic spaces, floor, and external acoustic spaces. Each of these sections is substructured into smaller parts, and the degree of resolution required is defined by its proximity to the transmission gearbox attachment points. The substructures are further subdivided into subsystems which represent mode group types, such as bending or in-plane modes. Ground and flight tests conducted to obtain acoustic and vibration data for validating the SEA prediction model are described. Good agreement between the predicted and flight test data showed that the SEA technique can be used to model and predict cabin noise of an all-composite airframe. The flight test noise data showed that the ACAP helicopter cabin noise is dominated by the main transmission gear-box. There is no local amplification of noise observed in the ACAP cockpit. Author

A89-18920
BELL ACAP FULL-SCALE AIRCRAFT CRASH TEST AND KRASH CORRELATION
JAMES D. CRONKHITE (Bell Helicopter Textron, Inc., Fort Worth, TX) and L. T. MAZZA (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 849-863.

A full-scale ACAP aircraft crast test was carried out to verify that the aircraft met the specified crash requirements and that all of the important components functioned properly as a system. Adequate crash protection involved providing a protective shell or livable volume around the occupied areas and containing fuel to prevent postcrash fire. ACAP worthiness requirements are discussed as well as drop test preparations, and the correlation of the KRASH analysis with the test. K.K.

A89-18921
APPLICATION OF DAMAGE TOLERANCE METHODOLOGY TO HELICOPTER DYNAMIC COMPONENTS USING THE EXAMPLE OF A MAIN ROTOR PITCH LINK FOR THE AH-1S HELICOPTER
B. R. KRASNOWSKI, W. W. SPENCE (Bell Helicopter Textron, Inc., Fort Worth, TX), and K. M. ROTENBERGER (U.S. Army, Aviation Systems Command, Saint Louis, MO) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 865-878. refs

A simplified engineering approach to damage tolerance analysis of typical helicopter components is presented. The equivalent method of stress intensity factor determination and crack growth was found to be effective in the analysis of helicopter components. The results of the analysis and testing of the crack growth in the thread root showed that, in this case, high stresses in a small portion of the crack front did not influence crack growth. K.K.

A89-18923
EVOLUTION OF THE ACAP CRASH ENERGY MANAGEMENT SYSTEM
CHARLES W. CLARKE (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 887-897. refs

A full-scale drop test of the S75 ACAP was carried out in an attempt to establish an effective crash management system for meeting the Army survivability and crashworthiness requirements. A dynamic simulation software program, KRASH, was used to evaluate the system performance and to predict the effects of alternate design concepts. KRASH was also used to provide guidance in selecting the drop test condition and to predict the results. K.K.

A89-18924
METHODOLOGY FOR FATIGUE SUBSTANTIATION OF ALTERNATE SOURCES AND DEGRADED MODES ON HELICOPTER DYNAMIC COMPONENTS
D. O. ADAMS (United Technologies Corp., Sikorsky Aircraft Div.,

Stratford, CT), C. ALBRECHT (Boeing Helicopters, Philadelphia, PA), and W. D. HARRIS (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 899-910.

It is shown that the qualification of alternate sources and degraded modes on new helicopter dynamic components can reduce fatigue-related problems in the field and improve safety margins. The alternate process evaluation of a main rotor pitch horn is discussed as well as the alternate supplier evaluation of stainless steel sheet. Degraded mode qualifications are considered as well. K.K.

A89-18928
DEVELOPMENT AND QUALIFICATION TESTING, TEAMING FOR THE V-22 MULTI-SERVICE AIRCRAFT SYSTEM
K. LUNN, P. DUNFORD (Boeing Helicopters, Philadelphia, PA), R. MAGNUSON (Bell Helicopter Textron, Inc., Fort Worth, TX), and S. PORTER (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 941-954.

The design phase of the V-22 tiltrotor aircraft program has been concluded, the required preflight qualification testing is well underway, and the first flight of the Full Scale Development test aircraft will take place soon. This paper will discuss the teaming required between major subcontractors and the engine manufacturer and Government test teams to prepare for the flight test program. The paper will also present a progress report. Author

A89-18929
AIR-TO-AIR COMBAT HELICOPTER DEVELOPMENT
JAMES M. MCCOLLOUGH, CHRISTOPHER J. STRONCEK, and HUGH W. WARD (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 955-963.

The purpose of this paper is to illustrate how the air-to-air combat environment can affect helicopter designs. To accomplish this, a case study of the Bell 406CS helicopter in an air-to-air combat role is presented. The preparations for testing, flight envelope expansion and simulated air combat against other helicopters during Air-to-Air Combat Tests IV are discussed from both an engineer's and a pilot's point of view. Finally, requirements for a superior air combat helicopter are discussed. Author

A89-18931#
AN ANALYTICAL MODEL FOR THE PREDICTION OF MR/TR INTERACTION NOISE
HORMOZ TADGHIGHI (McDonnell Douglas Helicopter Co., Mesa, AZ) AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Paper. 14 p. refs

A detailed analytical study of helicopter tail rotor noise due to interaction with the main rotor tip vortices was carried out. The airloads due to MR/TR (main rotor/tail rotor) vortex interaction were modeled assuming an airfoil of infinite span cutting through a moving vortex. A comparison with experimental data showed that, overall, acoustic pressure time histories for multiple rotor revolutions and interactions were found to be reasonably predicted. B.J.

A89-18933*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPARISONS OF PREDICTED AND MEASURED ROTOR PERFORMANCE IN HOVER USING A NEW FREE WAKE ANALYSIS
FORT F. FELKER, JEFFREY S. LIGHT (NASA, Ames Research Center, Moffett Field, CA), TODD R. QUACKENBUSH (Continuum Dynamics, Inc., Princeton, NJ), and DONALD B. BLISS (Duke University, Durham, NC) AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Paper. 22 p. refs

A new free-wake analysis has been developed to predict the performance of rotors in hover and axial flight. The analysis finds the rotor wake geometry using a novel influence coefficient/relaxation scheme. In this paper, the features of the analysis are reviewed, and the accuracy of the analysis is assessed for a wide range of rotor configurations in hover and vertical climb. The effects of variations in the analysis parameters are addressed, and recommendations for future development are presented. Generally good results were obtained for the predicted performance of a wide range of rotor geometries and operating conditions without any special 'tuning' of the analysis. The analysis also provides predictions of rotor performance in vertical climb that are substantially more accurate than momentum theory. Author

A89-18934*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DEVELOPMENT AND FLIGHT TEST OF A PRECISION AUTOHOVER CAPABILITY FOR TACTICAL ROTORCRAFT
W. S. HINDSON and G. E. TUCKER (NASA, Ames Research Center, Moffett Field, CA) AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Paper. 27 p. refs

This paper describes the implementation of an automatic position-hold system in the NASA/Army CH47B variable-stability research helicopter. The test helicopter is briefly described, and a detailed documentation is given of the position-measurement system. The control system design model and the design procedure are described, and flight-test data describing overall system performance in strong winds are presented. C.D.

A89-18935#
BOEING MODEL 360 ADVANCED TECHNOLOGY HELICOPTER - DESIGN FEATURES AND FLIGHT TEST UPDATE
LAWRENCE J. HARTMAN, RON MECKLIN, and ROBERT WIESNER AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Paper. 8 p.

This paper describes the design feature and fabrication methods involved in the Boeing Model 360 Advanced Technology Helicopter. The high-performance rotor, dry composite hub, composite upper controls, composite drive shafts, low-drag composite fuselage, vibration isolation system, integrated avionics system, and automatic flight control system are addressed. The flight test program is discussed, including the airborne instrumentation, aeromechanical stability, drive system verification, envelope expansion, performance, acoustics, and vibration are examined. C.D.

A89-18938#
THREE-DIMENSIONAL INTERACTIVE SYSTEM IDENTIFICATION OF HELICOPTER ROTOR/BODY DYNAMICS
ROBERT M. MCKILLIP, JR. (Princeton University, NJ) AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Paper. 11 p. refs

System identification results on UH-60 Blackhawk flight test data in hover are described. Simple quasi-static models of the helicopter's flight dynamics characteristics were generated using a two-pass estimation approach. The method incorporates Kinematic Observer theory for the initial state estimation phase, and a factorized Kalman Filter for the stability derivative extraction. The study also employs the novel use of a graphics workstation in order to aid the identification process, through superposition of both flight test data and identified responses in real time. This approach allows the identification engineer to visualize and understand significantly larger amounts of data than would be possible through examination of purely numerical data alone, providing an interactive environment for modeling of flight dynamics. Author

A89-19427
CARBON/CARBON COMPOSITE MATERIALS FOR AIRCRAFT BRAKES
S. AWASTHI and J. L. WOOD (Allied-Signal Aerospace Co., Bendix Wheels and Brakes Div., South Bend, IN) Ceramic Engineering and Science Proceedings (ISSN 0196-6219), vol. 9, July-Aug. 1988, p. 553-559.

Aircraft brake manufacturers are meeting the challenge of reducing the weight of the braking system by using carbon/carbon (C/C) composite materials which serve as the friction material, heat sink, and structural components. Different types of C/C composite materials, their processing and properties are discussed. Author

A89-19559
MODELLING OF GROUND EFFECTS ON AIRCRAFT
ALEXANDER DJORDJEVICH (New Brunswick, University, Fredericton, Canada) IN: Aerospace simulation III; Proceedings of the SCS Multiconference, San Diego, CA, Feb. 3-5, 1988. San Diego, CA, Society for Computer Simulation International, 1988, p. 102-116.

For the purpose of mathematical modeling and computer simulation of all the phases of an aircraft's flight, there is a necessity for a better description of the dynamic interaction between an aircraft's landing gear and its connecting surface. Landing and take-off are certainly the most delicate phases of the flight regime; yet, these phases are the least mathematically developed. This paper mathematically describes the problem, defining the dynamic influence of a surface to an aircraft, as an additional module for numerous aircraft mathematical models. This influence is determined for every individual component of the aircraft's landing gear, as a function of the aircraft's and surface's parameters, and the majority of the dynamic state variables. Results can be generalized to all other wheeled vehicles. Mathematical modeling of the entire object (aircraft) is not considered. Author

A89-19675
B-2 BOMBER ROLLS OUT
Aviation Week and Space Technology (ISSN 0005-2175), vol. 129, Nov. 28, 1988, p. 20-27.

USAF officials have stated during the unveiling ceremonies for the B-2 'stealth' bomber that this aircraft combines all the best attributes of a penetrating bomber: long range, efficient cruise, heavy payload, all-altitude penetration capability, accurate delivery, and reliability and maintainability. The aircraft will fly only at subsonic speeds to ranges of 6000 n.mi. at 50,000 ft., and is speculated to be capable of eliminating contrails at high altitude by using a fuel additive that minimizes the size of exhaust particles. Armament consists of SRAMs, advanced cruise missiles, and gravity-drop bombs. A multiyear procurement approach may be employed to allow contractors to save on contract costs by buying long-lead items. Attention is given to the computational power and sophistication required aboard the B-2 for effective operations. O.C.

A89-19790#
NONLINEAR STABILITY ANALYSIS FOR HELICOPTER GROUND RESONANCE
DEMAN TANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, July 1988, p. A319-A325. In Chinese, with abstract in English. refs

A simplified analytical method for calculating the limit-cycle behavior of a helicopter model with nonlinear dampers in both the landing gear and blades is presented. It has provided a new way to protect effectively against the ground resonance instability for helicopter designers. The chaotic oscillations induced by both the geometrical nonlinearities of the blade lag motion and the nonlinear dampers and the effect of initial disturbances on the instability response are also discussed. An experiment has been carried out using a helicopter scale model. The experimental results agree with those of the theoretical analysis. Author

A89-19809#
SELECTION OF THE OPTIMAL LIGHTER-THAN-AIR GAS FOR AIRSHIP AND A SCHEME OF DOUBLE-LAYER STRUCTURAL DESIGN
YOUFU WANG and DAYONG CHANG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Aug. 1988, p. B381, B382. In Chinese, with abstract in English.

The background of airship development in China is reviewed, and the main difficulty involved, the lack of helium, is discussed. A new scheme for structural design of a hydrogen airship is considered. This scheme's advantages over the helium airship are described, and ways to avoid explosions and/or burning are addressed. C.D.

A89-19981
COCOMAT, A CAE SYSTEM FOR COMPOSITE STRUCTURES DESIGN
H. J. W. M. KOELMAN and H. W. VEERBEEK (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Computer aided design in composite material technology; Proceedings of the International Conference, Southampton, England, Apr. 13-15, 1988. Southampton, England/Berlin and New York, Computational Mechanics Publications/Springer-Verlag, 1988, p. 75-88.

The proliferation of aircraft structural design variables that is a consequence of the introduction of composite materials calls for the use of CAE as a design aid. Controlling specialized composite structural analysis programs imposes severe generality and flexibility requirements on such CAE tools; attention is presently given to a CAE system, COCOMAT, which meets such criteria during the preliminary design phase of a structure. Illustrative applications of COCOMAT in hat-stiffener structures are presented. O.C.

A89-19982
PROCESSING COMPOSITE FINITE ELEMENT MODEL WITH CADCOMP
A. MORAN, B. HOFFMAN, A. KLUNOVER, and A. NEER (Israel Aircraft Industries, Ltd., Lod) IN: Computer aided design in composite material technology; Proceedings of the International Conference, Southampton, England, Apr. 13-15, 1988. Southampton, England/Berlin and New York, Computational Mechanics Publications/Springer-Verlag, 1988, p. 105-120.

The CADCOMP computer modeling system displays FEM models of both composite and noncomposite material structures, accompanying design engineers through the structure preanalysis phase in order to evaluate structural model properties, and then through the postanalysis phase, for the processing and implementation of results. System development has focused on user control over the engineering data to be displayed; color graphics are employed in order to more clearly define the distribution of engineering data, both at the level of the whole model and at that of the single element. O.C.

A89-20020
NOTAR - AN ALTERNATIVE TO THE HELICOPTER TAIL ROTOR
JAMES VAN HORN (McDonnell Douglas Helicopter Co., Mesa, AZ) ICAO Bulletin (ISSN 0018-8778), vol. 43, Aug. 1988, p. 10-13.

The 'NOTAR' rotorless helicopter tail boom system incorporates a circulation-control tailboom, a direct-jet thruster, and a variable-pitch fan; the main rotor wake interacts with the circulation-control slot's airstream to generate a powerful Coanda effect that constitutes lift-antitorque moment. Water-tank flow-visualization tests have been conducted on a 9.5-percent scale model of the NOTAR demonstrator helicopter. Development efforts to date have solved fan-efficiency and premature tailboom flow-separation problems. O.C.

A89-20135*# Purdue Univ., West Lafayette, IN.
INFLUENCE OF A FLOOR ON SOUND TRANSMISSION INTO AN AIRCRAFT FUSELAGE MODEL
J. D. JONES (Purdue University, West Lafayette, IN) and C. R FULLER (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 882-889. Previously cited in issue 22, p. 3223, Accession

no. A86-45426. refs
(Contract NAG1-390)

A89-20138#
NEW DESIGN PROCEDURES APPLIED TO LANDING GEAR DEVELOPMENT
JACQUES VEAUX (Messier-Hispano-Bugatti, Montrouge, France) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 1361-1371) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 904-910. Previously cited in issue 24, p. 3542, Accession no. A86-49117.

A89-20144#
STATIC AEROELASTIC CHARACTERISTICS OF CIRCULATION CONTROL WINGS
DAVID J. HAAS (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) and INDERJIT CHOPRA (Maryland, University, College Park) (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. 717-729) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 948-954. Previously cited in issue 14, p. 2105, Accession no. A87-33724. refs

A89-20150#
COMMENT ON 'AEROELASTIC OSCILLATIONS CAUSED BY TRANSITIONAL BOUNDARY LAYERS AND THEIR ATTENUATION'
L. E. ERICSSON (Lockheed Missiles and Space Co., Sunnyvale, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 975, 976; Authors' Reply, p. 976. refs

A89-20236
PROJECT FOR AN ADVANCED REGIONAL TRANSPORT AIRCRAFT [PROJEKT EINES FORTSCHRITTLICHEN REGIONALVERKEHRSFLUGZEUGES]
H.-G. KLUG and B. FISCHER (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, Federal Republic of Germany) IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 709-722. In German.
(DGLR PAPER 87-079)

The MPC regional transport aircraft, scheduled to go into service in the mid-1990s, is discussed. The market for the aircraft and the aircraft requirements are examined, and the design of the aircraft is described, including the configuration, the tail and the cabin, and the weight and performance. The application of new technologies to the MPC, including natural laminates, reinforced fiber composites, and engines with very high secondary flow ratio, is addressed. C.D.

A89-20237
PROGRESS TOWARDS A COMMERCIAL AIRCRAFT DESIGN EXPERT SYSTEM
J. ALSINA, J. P. FIELDING, A. J. MORRIS (Cranfield Institute of Technology, Bedford, England), A. ANINOS, and N. EROL (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 723-730. refs
(DGLR PAPER 87-120)

The current status of an aircraft design expert system based on a two-pass implementation approach is described. The first pass, which involved the creation of a wing design program, is outlined, and attempts made in the second pass at an aircraft configuration are addressed, reporting the main details of the resulting output in terms of the knowledge base. The basic differences with the wing design program are enumerated and the current status of the configuration program is described. C.D.

A89-20318#
DESIGN STUDIES OF PRIMARY AIRCRAFT STRUCTURES IN ARALL LAMINATES
JAN WILLEM GUNNINK (Delft, Technische Hogeschool, Netherlands) (International Conference on Composite Materials, 6th, and European Conference on Composite Materials, 2nd, London, England, July 20-24, 1987) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 1023-1032. Previously announced in STAR as N88-22888. refs

Use of ARALL for fatigue dominated structural parts, like the lower wing and the pressure cabin of an aircraft, was assessed. To investigate the potential of the material, preliminary design studies were carried out on these components. The studies result in a weight reduction of more than 25 percent for the lower wing and the pressure cabin. Author

A89-20637#
A NOTE ON THE OPTIMAL HYPERSONIC FLIGHT PATH
YOSHINORI WARIISHI and KANICHIRO KATO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 416, 1988, p. 427-432. In Japanese, with abstract in English.

Flight paths of a hypersonic plane are formulated as optimal control problems. Minimum-time, minimum-fuel and maximum-range solutions are shown with varying fuel-to-weight and thrust-to-weight ratios. One of the findings is that an initial path with a slight upward angle is usually advantageous because of the smaller drag (in higher altitude) when in high speed. Author

A89-20745
THE V-22 - 'AM I GONNA LIKE IT?'
WILLIAM S. LAWRENCE (U.S. Navy, Naval Air Systems Command, Washington, DC) Vertiflite (ISSN 0042-4455), vol. 34, Nov.-Dec. 1988, p. 51-55.

Full flight testing of the V-22 tilt-rotor VTOL aircraft will require about four years; this developmental testing will encompass performance and flying qualities, systems operability in combat and other hazardous conditions, structural durability, and propulsion reliability and maintainability. In order to accomplish this test program, six instrumented aircraft are undergoing preparation and will be assigned to geographically and climatologically appropriate test sites throughout the U.S. Attention is presently given to flight control and cockpit instrumentation features that will be important to the success of developmental flight testing. O.C.

N89-13422*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
STUDIES OF THE DYNAMICS OF THE TWIN-LIFT SYSTEM
Interim Report, Jul. 1983 - Sep. 1987
H. C. CURTISS, JR. Oct. 1988 63 p
(Contract NAG2-244)
(NASA-CR-183273; NAS 1.26:183273; MAE-TR-1840) Avail: NTIS HC A04/MF A01 CSCL 01C

A full set of equations of motion for the twin lift system, linearized about a hover trim condition were derived and presented. It is shown that this full set of equations of motion decouples into simpler sets of equations of motion if the aerodynamic coupling derivatives of the helicopters are neglected. One of these decoupled sets of equations of motion (referred to as the planar set) was studied at length. The other decoupled set (referred to as the nonplanar set) is examined here. It is shown that when the geometric configuration of the twin-lift is symmetric that a further decoupling is possible into antisymmetric and symmetric sets of equations. One set of these reduced equations of motion referred to as the antisymmetric set is directly equivalent to the longitudinal motion of a single helicopeter with a sling load. The second set, referred to as the symmetric set corresponds to the rotation of the entire system without load motion. As in the case of the planar symmetric motion, the location of the tether attachment point influences the stability of the nonplanar symmetric mode. The trend is opposite however in the nonplanar case in that an attachment point below the helicopter center of gravity

gives a favorable effect on the stability. The effect is not as strong however as the unfavorable effect on the planar symmetric mode. Author

N89-13424*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
REAL-TIME FLIGHT TEST ANALYSIS AND DISPLAY TECHNIQUES FOR THE X-29A AIRCRAFT
JOHN W. HICKS and KEVIN L. PETERSEN Nov. 1988 20 p Presented at the 73rd Flight Test Techniques Symposium Flight Mechanics Panel, Edwards AFB, Calif., 17-20 Oct. 1988
(NASA-TM-101692; H-1520; NAS 1.15:101692; AGARD-PAPER-6) Avail: NTIS HC A03/MF A01 CSCL 01C

The X-29A advanced technology demonstrator flight envelope expansion program and the subsequent flight research phase gave impetus to the development of several innovative real-time analysis and display techniques. These new techniques produced significant improvements in flight test productivity, flight research capabilities, and flight safety. These techniques include real-time measurement and display of in-flight structural loads, dynamic structural mode frequency and damping, flight control system dynamic stability and control response, aeroperformance drag polars, and aircraft specific excess power. Several of these analysis techniques also provided for direct comparisons of flight-measured results with analytical predictions. The aeroperformance technique was made possible by the concurrent development of a new simplified in-flight net thrust computation method. To achieve these levels of on-line flight test analysis, integration of ground and airborne systems was required. The capability of NASA Ames Research Center, Dryden Flight Research Facility's Western Aeronautical Test Range was a key factor in enabling implementation of these methods. Author

N89-13425# Army Aviation Engineering Flight Activity, Edwards AFB, CA.
ROTOR SYSTEM EVALUATION, PHASE 1 Final Report, 1 Sep. - 2 Feb. 1987
ROBERT M. BUCKANIN, WARREN GOULD, PAUL W. LOSIER, DAVID A. DOWNEY, and ROY LOCKWOOD Mar. 1988 207 p
(AD-A198794; USAAEFA-85-15) Avail: NTIS HC A10/MF A01 CSCL 01C

Flight testing was conducted on a UH-60A Black Hawk helicopter in support of the NASA-Ames Modern Technology Rotors program to provide and validate the technology, acoustics, handling qualities and cost of civil and military rotorcraft. In cooperation with the Rotorcraft Flight Investigations Branch of NASA-Ames Research Center and the U.S. Army Aviation Research and Technology Activity, the U.S. Army Aviation Engineering Flight Activity (AEFA) conducted flight tests totalling 31 productive flight hours between 9 January and 2 June 1987. This report summarizes the flight tests accomplished, test conditions, data, and techniques used to obtain the data. Data measurements included: atmospheric and aircraft state parameters; main rotor blade structural loads, positions and accelerations; flight control positions and structural loads; main rotor hub accelerations and various vibration measurements for the aircraft cabin floor. The handling qualities data in this report, although not representative of a UH-60A in typical operating conditions, were similar to previous AEFA test results in similar configurations. The power required for level flight and hovering out-of-ground effect also agreed with previous results. GRA

N89-13426# Rensselaer Polytechnic Inst., Troy, NY.
THE CENTER OF EXCELLENCE IN ROTARY TECHNOLOGY AT RENSSELAER POLYTECHNIC INSTITUTE Final Report
R. G. LOEWY, ed., O. BAUCHAU, R. BIELAWA, M. DARLOW, R. J. DIEFENDORF, R. DUFFY, R. MAYLE, H. NAGAMATSU, M. SHEPHARD, and S. WINCKLER 15 Apr. 1988 327 p
(Contract DAAG29-82-K-0093)
(AD-A198964; CERL-TR-E-88/08; ARO-19431.23-EG-RW) Avail: NTIS HC A15/MF A01 CSCL 01C

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

N89-13427# Boeing Advanced Systems Co., Seattle, WA.
OPTICAL FIRE DETECTOR TESTING IN THE AIRCRAFT ENGINE NACELLE FIRE TEST SIMULATOR Final Report, Jul. 1985 - Oct. 1986
ALAN M. JOHNSON Mar. 1988 85 p
(Contract F33615-84-C-2431)
(AD-A197974; D180-30348-1; AFWAL-TR-87-2089) Avail: NTIS HC A05/MF A01 CSCL 01C

Optical fire detector systems for aircraft engine compartments provided by fire vendors were evaluated in the Aircraft Engine Compartment Fire Test Simulator (AENFTS). Their ability to sense JP-4 fires of two sizes and provide fire warnings in a variety of simulated flight environments was monitored along with their freedom from false fire warnings. One systems was identified which provided fire warnings for every test fire and was completely free of false alarms. GRA

N89-14231 Texas A&M Univ., College Station.
A UNIFIED APPROACH TO VEHICLE DESIGN, CONTROL, AND FLIGHT PATH OPTIMIZATION Ph.D. Thesis
RUSH DALETH ROBINETT, III 1987 205 p
Avail: Univ. Microfilms Order No. DA8808822

A set of vehicle design and control optimization methods is presented that minimizes the difference between the desired and actual dynamical flight paths. The approach taken seeks the optimum, physically admissible mass properties and/or the thrust history of the vehicle to minimize a quadratic measure of departure from the desired path. The minimization process developed belongs to a family of problems which are commonly referred to as constrained parameter optimization. A recursive quadratic programming algorithm is used to implement the analytical formulation as a numerical algorithm. The derivations are presented of the equations of motion for fixed and variable mass bodies which include the unification of the control volume and particle dynamics analyses of the variable mass body problem. Analytical and numerical optimization procedures are discussed in detail. Basic concepts are defined along with measures of stability and robustness of motion matching in terms of the uniform boundedness of the deviation from the desired flight path. The theoretical results are illustrated with a set of test cases. Dissert. Abstr.

N89-14232*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PASSIVE VENTING TECHNIQUE FOR SHALLOW CAVITIES Patent Application
ROBERT L. STALLINGS, JR., inventor (to NASA) and FLOYD J. WILCOX, JR., inventor (to NASA) 30 Sep. 1988 9 p
(NASA-CASE-LAR-14031-1; NAS 1.71:LAR-14031-1; US-PATENT-APPL-SN-252081) Avail: NTIS HC A02/MF A01 CSCL 01C

A device is introduced for reducing drag and store separation difficulties caused by shallow cavities on aircraft in supersonic flight consisting of a group of hollow pipes the same length as the cavity. The pipes are attached to the cavity floor so as to allow air to flow through the pipes. This device allows air to flow through the pipes opposite to the direction of flow outside the pipes. This results in reduced drag and improved store separation characteristics. NASA

N89-14233*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PASSIVE VENTING TECHNIQUE FOR SHALLOW CAVITIES Patent Application
ROBERT L. STALLINGS, JR. and FLOYD J. WILCOX, JR. 28 Sep. 1988 11 p
(NASA-CASE-LAR-13875-1; NAS 1.71:LAR-13875-1; US-PATENT-APPL-SN-250468) Avail: NTIS HC A03/MF A01 CSCL 01C

A device is disclosed for reducing drag and store separation difficulties caused by shallow cavities on aircraft in supersonic flight consisting of a slab of porous material cut to fit precisely inside the cavity. This slab is mounted inside the cavity such that a plenum chamber is formed between the slab and the floor of the cavity. This device allows air to flow through the chamber opposite to the direction of flow outside the chamber. This results in reduced drag and improved store separation characteristics. NASA

N89-14234# *Logistics Management Inst., Bethesda, MD.*
THE NATURE OF THE AIRCRAFT COMPONENT FAILURE PROCESS: A WORKING NOTE
F. M. SLAY and CRAIG C. SHERBROOKE Feb. 1988 28 p
(Contract MDA903-85-C-0139)
(AD-A197979; LMI-IR701R1) Avail: NTIS HC A03/MF A01 CSCL 01C

The physics of component failures is normally assumed to follow a Poisson process. However, many studies have shown that the component demands in the U.S. Air Force supply system have a variance-to-mean ratio (VMR) much higher than 1.0, the VMR of a Poisson process. This apparent contradiction is resolved by modeling component failures as a Poisson process whose demand rate is not fixed, but rather is itself a stochastic process, wandering over time as a result of various causes such as weather, flying intensity, reliability growth, and, presumably, other unknown factors. Component and program data for the F-16 and A-10 aircraft show that demand over short time periods is Poisson. This is even more apparent when demands per flying hours are used instead of demands per day. However, when demands are aggregated over longer periods of time or more flying hours, the VMR increases. A gamma-Poisson model for future demands as a function of past observations fits the measured data. We call this process planetary Poisson to distinguish it from the general class of nonstationary Poisson models. GRA

N89-14922*# Oklahoma Univ., Norman. Dept. of Aerospace and Mechanical Engineering.
THE POSTSTALL NONLINEAR DYNAMICS AND CONTROL OF AN F-18: A PRELIMINARY INVESTIGATION Abstract Only
WILLIAM N. PATTEN *In* Hampton Inst., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program 1988 p 90-92 Sep. 1988
Avail: NTIS HC A07/MF A01 CSCL 01C

The successful high angle of attack (HAOA) operation of fighter aircraft will necessarily require the introduction of a new onboard control methodology that address the nonlinearity of the system when flown at the stall/poststall limits of the craft's flight envelope. As a precursor to this task, a researcher endeavored to familarize himself with the dynamics of one specific aircraft, the F-18, when it is flown at HAOA. This was accomplished by conducting a number of real time flight sorties using the NASA-Langley Research Center's F-18 simulator, which was operated with a pilot in the loop. In addition to developing a first hand familarity with the aircraft's dynamic characteristic at HAOA, work was also performed to identify the input/output operational footprint of the F-18's control surfaces. This investigator proposes to employ the nonlinear models of the plant identified this summer in a subsequent research effort that will make it possible to fly the F-18 effectively at poststall angles of attack. The controller design used there will rely on a new technique proposed by this investigator that provides for the automatic generation of online optimal control solutions for nonlinear dynamic systems. Author

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AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A89-18051
AIAA/IEEE DIGITAL AVIONICS SYSTEMS CONFERENCE, 8TH, SAN JOSE, CA, OCT. 17-20, 1988, TECHNICAL PAPERS. PARTS 1 & 2
Conference sponsored by AIAA and IEEE. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. Pt. 1, 461 p.; pt. 2, 467 p. For individual items see A89-18052 to A89-18113, A89-18115 to A89-18188.

Various papers on avionics systems are presented. The general topics discussed include: modular avionics, design for testability, systems engineering methods and tools, vehicle management systems, Japanese avionics, pilot-vehicle interface, advanced aviation for next generation aircraft, fault-tolerant avionics, Ada applications, commercial avionics, rotorcraft avionics, optical technology and systems, advanced architecture and processing, and management techniques for software development. Also addressed are: European avionics, general aviation avionics, crew station technology, space systems, sensor signal processing, software verification and quality assurance, data link, data bus, embedded processors and operating systems, communication/navigation/identification systems, artificial intelligence and expert systems, application-specific integrated circuits, and 32-bit microprocessors. C.D.

A89-18052#
MODULAR AVIONICS SYSTEMS STUDIES
LARRY D. BROCK and JOHN J. DEYST, JR. (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1-7.
(Contract F04606-87-D-0051)
(AIAA PAPER 88-3850)

Engineering analyses of modular avionics for military aircraft will be discussed. A data base of avionics requirements for both future and existing military aircraft forms the basis for these studies. Avionics modules, consistent with both projected new aircraft and retrofits, are being defined. Avionics architectures for a few of the vehicles in the data base have been configured from the modules. Quantitative evaluations of these architectures have been carried out to determine their relative performance, mission availability, probabilities of mission success, and life cycle costs. The architectures will be discussed, strengths and weaknesses examined, and general recommendations put forward on the feasibility and merits of modular avionics. Author

A89-18054#
FAULTS WITH NONSTATIONARY OBSERVABILITY ARE LIMITING AVIONICS R&M
JEAN GEBMAN, DOUGLAS MCIVER, and HY SHULMAN (Rand Corp., Santa Monica, CA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 16-23.
(AIAA PAPER 88-3852)

This paper addresses of avionics faults that have nonstationary observability. This class of faults threatens to cause erosion in needed levels of avionics performance and unacceptable growth in the avionics support burden. The challenges posed by such faults and weaknesses in correcting the faults are considered. A data collection and analysis conducted to improve deficiencies in the support process for the F-15 avionics is discussed. It is concluded that traditional measures of R&M are completely inadequate to measure the frequency and duration of performance degradation caused predominantly by faults with nonstationary

observability. Current weaknesses in the ability to correct such faults are the dominant R&M limitation for contemporary avionics. C.D.

A89-18055#
ADVANCED AVIONICS INTERCONNECTION
R. AL MORRISON and JON SIMMONS (Lockheed Aeronautical Systems Co., Marietta, GA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 24-31.
(AIAA PAPER 88-3856)

Recent and ongoing improvements in avionics interconnection are discussed. Increases in system reliability being achieved by these advances are examined. The improvements in mission availability which are to be achieved using Pave Pillar avionics architecture are addressed. Advances being made in basic connector research are discussed. C.D.

A89-18057#
A METHODOLOGY FOR THE DESIGN OF HIERARCHICALLY TESTABLE AND MAINTAINABLE DIGITAL SYSTEMS
M. A. BREUER and J. C. LIEN (Southern California, University, Los Angeles, CA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 40-47. DARPA-supported research. refs
(Contract N00014-87-K-0861)
(AIAA PAPER 88-3859)

A methodology for the design of hierarchical testable and maintainable (HTM) systems is proposed. Typical major building blocks and bus structures for such a system are shown. Functional requirements and related design issues are presented, as well as procedures for testing such a system. The proposed HTM system is able to support correct fault detection and isolation in a timely and cost-effective manner; reduce, eliminate or explain discrepancies in test results; support a uniform design for test methodology; reduce problems in maintenance, such as false alarms, CND, and RTOK; and support a two-level maintenance scheme. Author

A89-18058#
FAULT DETECTION AND ISOLATION FOR RECONFIGURABLE FLIGHT CONTROL SYSTEMS
ELLEN R. MAYHEW and DANIEL GLEASON (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 48-55. refs
(AIAA PAPER 88-3860)

Reconfigurable flight control systems can maintain aircraft mission effectiveness even after control surface failure occurs. Quick and accurate fault detection and isolation (FDI) are essential for implementing reconfiguration. This paper presents an analytic redundancy FDI methodology and integrates it with a pseudoinverse reconfiguration scheme. Minimum effort control theory is used to develop the control mixing strategies. Simulation results for a highly maneuverable, multiple control surfaced aircraft demonstrate the viability of the techniques described. Author

A89-18060*# Allied Signal Corp., Teterboro, NJ.
A METHOD OF MEASURING FAULT LATENCY IN A DIGITAL FLIGHT CONTROL SYSTEM
JOHN MCGOUGH (Allied-Signal, Inc., Bendix Flight Systems Div., Teterboro, NJ), DENNIS MULCARE (Lockheed-Georgia Co., Atlanta, GA), and WILLIAM E. LARSEN (NASA, Ames Research Center; FAA, Moffett Field, CA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 64-72. refs
(AIAA PAPER 88-3863)

This paper 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 Facility. Fault detection was correlated with hardware and software fault monitoring and, in limited cases, with sensitivity to flight program execution modes. The results are statistically assessed to ascertain system-level reliability implications based on a single-fault model. Extension to multiple-fault models is addressed. The overall methodology/facility itself is judged to be a promising enhancement to current practice. C.D.

A89-18072#
OPTIMAL INTEGRATION OF INERTIAL SENSOR FUNCTIONS FOR FLIGHT-CONTROL AND AVIONICS
UWE K. KROGMANN (Bodenseewerk Geraetetechnik GmbH, Ueberlingen, Federal Republic of Germany) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 148-155.
(AIAA PAPER 88-3878)

The development of an integrated, strapdown inertial sensor system is discussed. The integration steps are outlined, and the development of the basic integrated redundant reference system (IRRS) which represents a first step toward the final system is addressed. Failure detection, isolation, and dynamic reconfiguration are examined, and integration of the IRRS with the flight control system is considered. C.D.

A89-18080#
STEREOSCOPIC 3-D DISPLAYS FOR COCKPITS
RONALD E. OPP, II, JOHN M. REISING, and JOHN P. ZENYUH (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 203-206.
(AIAA PAPER 88-3887)

The crewstations of future military aircraft will rely upon computer generated displays to present information to the pilot. The increased availability of information due to greater sensor and data link capability will greatly challenge the ability of displays to present the information to the pilot in a clear manner. More capable types of displays will be required to give the pilot the information he needs. One possible display type is the stereoscopic three-dimensional display. The focus of this paper is to discuss the three-dimensional technologies currently being used by the Flight Dynamics Lab to evaluate the advantages, if any, of using stereoscopic three-dimensional displays in cockpits. Results show a significant performance advantage for a visual search task when performed on a three-dimensional display versus the same format presented on a two-dimensional display. Three-dimensional performance is also superior to two-dimensional as a function of complexity of the format. Additional research efforts have shown that the inclusion of multi-color symbology in a three-dimensional format reduces the amount of response time required on the part of the subject. Author

A89-18085#
DESIGN AND VALIDATION OF THE IFTAS FAULT-TOLERANT CLOCK
DAVID FURA, TODD HILL, and MICHAEL RAFTERY (Boeing Aerospace Co., Seattle, WA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 235-242.
(AIAA PAPER 88-3899)

A fault-tolerant distributed clock was designed and validated for use in an integrated fault-tolerant avionics systems (IFTAS) computer. The clock synchronization algorithm and its functional implementation are described. The synchronization error and resynchronization overhead are characterized on the basis of the assumptions used in the validation. Both meet IFTAS requirements. K.K.

A89-18090#
A CASE STUDY - F-16 ADA DIGITAL FLIGHT CONTROL SYSTEM
KEN GARLINGTON and AMY TYRRELL (General Dynamics Corp., Data Systems Div., Fort Worth, TX) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 267-272.
(AIAA PAPER 88-3911)

The F-16 Ada Digital Flight Control System (FLCS) project, which started in May 1985, is one of several Ada technology programs at General Dynamics. The project's goal was to develop the necessary software tools and in-house expertise to support future Ada software development for digital flight control systems. The F-16 Ada FLCS was built using a language-independent design baseline from an earlier JOVIAL implementation of the production FLCS. After completing rigorous low-level tests using A VAX-base MIL-STD-1750A simulator/debugger, laboratory testing was performed to validate the system in a realistic hardware environment. The project was successful; the Ada system did perform as expected, and several lessons were learned concerning the application of the Ada language to embedded flight systems.
Author

A89-18092#
RESULTS OF THE IN-SERVICE EVALUATION OF THE TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM INDUSTRY PROTOTYPE
DANIEL H. TILLOTSON (ARINC Research Corp., Annapolis, MD) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 277-282.
(AIAA PAPER 88-3915)

This paper provides a summary of the operational findings and anomalies detected during a 10-month in-service evaluation of the Traffic Alert and Collision Avoidance System (TCAS) on board a Piedmont Airlines Boeing 727 aircraft. The objectives of the in-service evaluation were to assess the utility of TCAS to the flight crews and to determine how well TCAS performed in its intended operational environment. The evaluation was successful in meeting these objectives, and the use of the system was easily incorporated with the crewmembers' other tasks. However, several minor operational anomalies were noted, resulting in recommendations for improving the system. The observed anomalies did not significantly affect pilot acceptance of TCAS, and corrections for the anomalies have been incorporated into changes to the TCAS logic.
Author

A89-18095#
AN AIR DATA INERTIAL REFERENCE SYSTEM FOR FUTURE COMMERCIAL AIRPLANES
DAVID L. SEBRING and MELVILLE D. MCINTYRE (Boeing Commercial Airplanes, Seattle, WA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 308-313.
(AIAA PAPER 88-3918)

An air data, inertial reference system architecture featuring skewed axis inertial sensors, fault-tolerant electronics, and remote air data modules has been developed. An efficient means of design verification and certification using flight test data and flight code hosted on execution vehicles has also been developed. The new architecture surpasses the functional integrity of classic architectures, using about half as many parts. Its modular fault-tolerance also allows the system to be configured with additional redundancy providing the airline the option to defer maintenance to a convenient time and place. While developed specifically for commercial transports, this approach could offer substantial benefits to military transports and fighters and aerospace applications requiring robust air data and /or inertial reference systems.
Author

A89-18096#
DESIGN OF A CERTIFIABLE PRIMARY ON-BOARD AIRCRAFT WEIGHT AND BALANCE SYSTEM
LEE E. VETSCH and LARRY L. BURGENER (Honeywell, Inc., Phoenix, AZ) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 314-323.
(AIAA PAPER 88-3919)

The load sensor of an on-board aircraft weight and balance system is described as well as its weight and balance computer, its calibration module, pitch attitude sensor, in-axle mounts, cockpit display, and remote dedicated display unit. Gear load measurement is examined with attention given to shear deflection, gear types, and the deflection range requirement. Consideration is also given to load sensor design, measuring shear and rejecting nonvertical strain, system calibration, system architecture and bite, cross channel fault detection, and cross gear sensor fault isolation.
K.K.

A89-18097#
CENTRAL MAINTENANCE COMPUTER SYSTEM - A BOLD STEP FORWARD ON THE 747-400
MATT ASLIN (Boeing Co., Seattle, WA) and LYNN COLE (Rockwell International Corp., Collins Air Transport Div., Cedar Rapids, IA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 324-331.
(AIAA PAPER 88-4039)

The 747-400 features longer range, a two-crew flight deck, new passenger accommodations, a fuel-efficient power plant, digital Avionics, and a Centralized Maintenance Computer System (CMCS). Currently, the CMCS consolidates the maintenance activity from nearly 70 aircraft systems. Most everything with a wire out of it is monitored by the CMCS. One of the primary design goals was to provide a consistent man-machine maintenance interface for all maintenance activity. The 747-400 takes a bold step forward in aircraft maintenance. This paper will overview the CMCS system design, highlighting the capabilities of the system and how the user operates the system under a common set of operations.
Author

A89-18102#
STRAPDOWN ISSUES FOR AIRBORNE EO SENSORS
JOSEPH E. CARROLL and PETER SYMOSEK (Honeywell Systems and Research Center, Minneapolis, MN) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 367-375.
(AIAA PAPER 88-3927)

The access of airborne EO sensors to large FORs is discussed as well as what to do about image motions. Field of view/field of regard issues are addressed as well as vehicle motion issues. Particular attention is given to image smearing causes and effects, random vibration, sinusoidal vibration, and desmearing approaches.
K.K.

A89-18109#
FAULT TOLERANT AVIONICS
ANDY D. HILLS and NISAR A. MIRZA (GEC Avionics, Ltd., Flight Controls Div., Rochester, England) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 407-414. Research supported by Boeing Commercial Airplanes. refs
(AIAA PAPER 88-3901)

This paper discusses the design issues relating to a novel fault-tolerant reconfigurable architecture targetted for real-time embedded flight-control applications. The architecture can absorb multiple random failures and thus enables the realization of systems which exhibit ultrahigh reliability and require little maintenance

action. The architecture is based on replication of the computing hardware which is partitioned into elements or links. Author

A89-18112*# Illinois Univ., Urbana.
IMPACT OF DEVICE LEVEL FAULTS IN A DIGITAL AVIONIC PROCESSOR
S. KIM and R. K. IYER (Illinois, University, Urbana) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 428-435. refs
(Contract NAG1-602)
(AIAA PAPER 88-3904)

This paper describes an experimental analysis of the impact of gate and device-level faults in the processor of a flight control system. Via mixed mode simulation faults were injected both at the gate (stuck-at) and at the transistor levels, and their propagation through the chip to the output pins was measured. The results show that there is little correspondence between a stuck-at and a device-level fault model insofar as error activity or detection within a functional unit is concerned. Insofar as error activity outside the injected unit and at the output pins are concerned, the stuck-at and device models track each other, although the stuck-at model overestimates, by over one hundred percent, the probability of fault propagation to the output pins. The stuck-at model significantly underestimates the impact of an internal chip fault on the output pins. Author

A89-18119#
MODERN DIGITAL PRESSURE CONTROL SYSTEM
HANNS-ULRICH ETTL (Nord-Micro Elektronik Feinmechanik AG, Frankfurt am Main, Federal Republic of Germany) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 478-483.
(AIAA PAPER 88-3948)

This paper describes the system concept, system design, and system performance of an overall digital cabin pressure control system (CPCS). It has been developed and already flight-test proven on the Airbus A-320. The following major system features are presented: (1) digital implementation of all control loops to guarantee high accuracy and reliability; (2) fully microprocessor-controlled actuation system provides fast response; (3) all system interconnections in the aircraft like ADIRS, FMS, CFDS; and (4) use of flight management system data for optimum pressure schedules and rate control. Flight Test results for typical flight profiles and the response to flow changes demonstrate the excellent performance of this modern design concept. Author

A89-18120#
AN ICE DETECTION SYSTEM FOR HELICOPTERS
T. JOHN SPRIGGS (Plessey Avionics, Ltd., Havant, England) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 484-488. Research supported by the Ministry of Defence and Royal Aircraft Establishment. refs
(AIAA PAPER 88-3949)

A probe has been designed and developed which will permit accurate measurement of the liquid water content of air. This is achieved by measuring the power dissipation of a thermally self-stabilizing cylinder fabricated from a semiconducting ferro-electric perovskite ceramic exhibiting a positive temperature coefficient of resistance. Measurements from the probe can be used with other air data to predict the onset of icing. A novel icing detection system based on the probe is being developed for all current and future helicopters requiring an all-weather 24-hour capability. Author

A89-18121#
REFLECTIONS ON AVIONIC INTEGRATION
ALBERT JANEX (LMT Radio Professionnelle, Boulogne-Billancourt, France) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 489-492.
(AIAA PAPER 88-3950)

The increasing quantity and complexity of the electronic equipments onboard an aircraft soon require research on integration. The first attempts were limited by the available technology. The last and supposedly optimal concept progressively took form: general-purpose black boxes (transmitter/receivers, sensors, computers, indicators, controls, etc.) adaptively interconnected to perform the required missions. This paper considers the drawbacks of this concept. An alternative is presented, taking account of the technology limitations. Author

A89-18122#
DIGITAL CONTROL OF A QUADRUPLEX DIRECT DRIVE ACTUATOR
REINHARD W. REICHEL (Bodenseewerk Geraetetechnik GmbH, Ueberlingen, Federal Republic of Germany) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 493-500.
(AIAA PAPER 88-3951)

Digital fly-by-wire aircraft are fitted with a redundant Flight Control Computer (FCC). Some of its functions are input of analogue and discrete signals, demodulation of LVDT/RVDT inputs, voting/monitoring of inputs, control/monitoring of the actuators. The module within a lane of the FCC performing all these functions is called Analog-I/O. The realization of such an Analog-I/O based on analogue techniques is hardware-intensive. This paper deals with an Analog-I/O built in purely digital technology, thus saving hardware. Author

A89-18123#
DEVELOPMENT AND APPLICATIONS OF AN AVIONICS RESEARCH TESTBED
JOB BRUEGGEN (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 501-507.
(AIAA PAPER 88-3952)

The Avionics Research Testbed (ART) was started in 1986 with the aim to develop an airborne facility for inflight research on the optimal use of advanced avionics systems. The main components of the system are described and it is explained how the specific qualities of the ART enables research applications in the field of human engineering and in the field of flight procedures. Author

A89-18125#
THUNDERSTORM AVOIDANCE FOR GENERAL AVIATION AIRCRAFT
ERNEST W. COLEMAN (Honeywell, Inc., Phoenix, AZ) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 515-519. refs
(AIAA PAPER 88-3955)

This paper presents the design and summary of test results of a new Wideband Lightning Sensor System (LSS). The LSS senses electrostatic and electromagnetic disturbances caused by lightning discharge activity. When a discharge occurs, the system analyzes the lightning discharge and creates the proper symbol for display on a radar, an EFIS/MFD or a stand-alone indicator. The system determines the rate of lightning in a fixed geographical area and displays the centroid of that area with the unique lightning rate symbol. The system has a 700 KHz bandwidth and a maximum range of 100 nm radius. Tests on a number of lightning storms at distances to 100 nm indicate the angular resolution is better than + or - 10 deg and may be in the range of less than 3 deg with no dependence on the number of active thunderstorm cells which are at different angles. Author

A89-18126#
COCKPIT MANAGEMENT FOR REGIONAL AIRLINES AND BUSINESS AIRCRAFT AS APPLIED IN THE BEECH STARSHIP
R. BRUCE RAY and PAUL D. HEYSSE (Rockwell International Corp., Pittsburgh, PA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 520-527.
(AIAA PAPER 88-3957)

The development of an all-digital aircraft affords a rare opportunity in the design of avionics systems. Top-down design of new digital systems allows avionics engineers to create operationally consistent systems throughout the cabin. This new generation of electronic systems provides an opportunity to conceive concepts for simpler and more direct access to highly-used avionics features, while insisting on cockpit operational consistency in an attempt to enhance safety and reduce training. Flight Management Systems will continue to play a growing role in these new-generation systems. Author

A89-18128#
A SIMPLIFIED AIRCRAFT COLLISION AVOIDANCE SYSTEM
DALE POLLACK (Northern Illinois University, De Kalb, IL) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 535-537.
(AIAA PAPER 88-3961)

This simple aircraft collision avoidance system is based on the principle that two aircraft cannot collide unless they are at the same altitude. In this system all aircraft transmit on a common radio-frequency, which is frequency modulated by a tone proportional to the altitude of that aircraft. Since frequency-modulated signals exhibit the capture effect, each receiver will respond only to the strongest intruder signal. In all likelihood, the strongest signal would be that from the nearest airplane, which is, of course, the only one of concern to the pilot. An instrument on the panel tells the pilot the difference in altitude between his airplane and that of the nearest intruder. A second instrument indicates the signal strength of the intruder, and tells the pilot whether the intruder is approaching or departing.
Author

A89-18129#
COMMERCIAL AVIONICS APPLICATIONS OF FLAT PANEL DISPLAYS
SCOTT RAUSCH (Honeywell, Inc., Phoenix, AZ) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 538-541. refs
(AIAA PAPER 88-3962)

Recent advances in liquid crystal active matrix color flat panel displays will allow for utilization in the next generation of commercial avionics equipment. Four aspects of flat panel display utilization in the cockpit to be reviewed are flat panel technical challenges, display system architecture considerations, cost, and schedule. The primary question in deciding whether flat panels are applicable to the cockpit is whether or not flat panels look as good as a cathode ray tube (CRT). Comparisons to color shadow mask CRTs currently in operation in today's aircraft are made throughout this paper. The next generation cockpit display systems will provide new opportunities and advantages in the areas of systems and architecture. Speculation is offered as to what a new display system will be like. Author

A89-18132*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STEREO 3-D AND NON-STEREO PRESENTATIONS OF A COMPUTER-GENERATED PICTORIAL PRIMARY FLIGHT DISPLAY WITH PATHWAY AUGMENTATION
MARK NATAUPSKY (NASA, Langley Research Center, Hampton, VA) and LUCILLE CRITTENDEN (Research Triangle Institute, Research Triangle Park, NC) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 552-557. refs
(AIAA PAPER 88-3965)

Stereo 3-D was researched as a means to present cockpit displays which enhance a pilot's situational awareness while maintaining a desirable level of mental workload. The initial study at the NASA Langley Research Center used two different pathways-in-the-sky to augment a computer-generated pictorial primary flight display. One pathway resembled the outline of signposts, while the other pathway resembled a monorail. That display was configured for a curved approach to a landing such as could be used in a Microwave Landing System (MLS) approach. It could also be used for military transports which would have to fly a precision curved pathway. Each trial was initialized with the pilot on the desired flight path. After 2 seconds, he suddenly was shifted to one of eight flight path offsets. The pilot was then required to make the initial pitch and/or roll input to correct back to the nominal flight path. As soon as the input was made, the trial was over. No input was required for control trials with no flight path offset. Pilots responded statistically significantly faster when the display was presented in the stereo version than when it was presented in the nonstereo version. Author

A89-18134#
ONE MILLION PIXEL FULL COLOR LIQUID CRYSTAL DISPLAY FOR AVIONICS APPLICATIONS
ELIAS HAIM, FANG-CHEN LUO, GARY BIERMANN, and MICHAEL CUSHING (General Electric Co., Infrared Systems and Displays Dept., Wilmington, MA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 564-570. refs
(AIAA PAPER 88-3967)

A 6.25 x 6.25 in. active matrix liquid crystal display (LCD) unit with optical display characteristics sufficient for avionics use has been designed and fabricated. Major components development included the display panel, lighting and associated dimming electronics, optical components, and display driver electronics. Emphasis was placed on meeting the needs of military applications while improving display optical characteristics. In this paper, display manufacturing methods, fluorescent backlighting, polarizer and diffuser optical elements, display drivers, and associated electronics are described. Typical display performance is presented and compared to requirements for avionics use. Author

A89-18165#
A FAULT TOLERANT INTEGRATED AVIONICS COMPUTER SYSTEM
JOHN R. FRANZEL (Boeing Electronics, Seattle, WA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 756-760.
(AIAA PAPER 88-4041)

A fault-tolerant Integrated Avionics Computer System (IACS) is proposed which would provide central processing for multiple avionics functions in the same cabinet. Through this approach a single IACS cabinet could replace many individual airplane systems, and multiple cabinets could replace the majority of the avionics on a commercial airplane. A significant reduction in development cost could be achieved using this approach. Author

A89-18174#
MODELING MISSION RELIABILITY OF ADVANCED INTEGRATED COMMUNICATION, NAVIGATION, IDENTIFICATION AVIONICS SYSTEMS
ROBERT L. HARRIS and DANA L. HOWELL (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p.

815-820. refs
(AIAA PAPER 88-4023)

The combination of new technologies, changing mission requirements, increased electronic warface, increasingly complicated logistics support, and escalating costs have forced a move toward modular, integrated Communication, Navigation, Identification (CNI) systems for solutions of these problems in future generation avionics. During early development of integrated CNI concepts, an analytical tool known as the Mission Reliability Model (Mirem) was concurrently created to aid in system design. Mirem allows system designers to model any specific configuration of integrated CNI and obtain a preliminary indication of several figures of merit. This paper will describe the modeling of a 'generic' integrated CNI architecture using Mirem and show the usefulness of such a tool in the early development of integrated avionics architectures. Author

A89-18188#
ADVANCED APACHE ARCHITECTURE
FRANK BOOTH (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 905-911.
(AIAA PAPER 88-3928)

The computer architecture being developed for the advanced version of the U.S. Army Apache helicopter is described and illustrated with block diagrams. Consideration is given to avionics-system partitioning; system mechanization; the multiplex data bus; aircraft-survivability equipment; and subsystems for aircraft management, communication, control and display functions, navigation, sight management, weapons management, and maintenance management. T.K.

A89-18189#
VEHICLE MANAGEMENT SYSTEM ARCHITECTURAL CONSIDERATIONS
WON-ZON CHEN, LEO J. STEIN, and KARL R. HAIGES (Northrop Corp., Aircraft Div., Hawthorne, CA) AIAA and IEEE, Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988. 7 p.
(AIAA PAPER 88-3875)

The vehicle Management System (VMS) concept provides significant performance benefits via functional and physical integration of all the flight-critical subsystems aboard an aircraft. The key to realizing these benefits is the design of a VMS architecture that not only satisfies overall functional requirements, but also achieves a good balance between minimizing the technology risks and optimizing various performance metrics such as weight, cost and supportability. In the Air Force's Integrqted Control Law Evaluation (ICLE) program, the VMS requirements for an advanced fighter aircraft were identified and translated to a set of architectural design issues. This paper discusses these architectural design issues along with a description of four VMS configurations that were developed by Northrop to study several of the issues through laboratory evaluation. Author

A89-18190#
APPLICATION OF AI TECHNOLOGY TO TIME-CRITICAL FUNCTIONS
IRA GLICKSTEIN and PETER STILES (IBM, Systems Integration Div., Owego, NY) AIAA and IEEE, Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988. 7 p.
(AIAA PAPER 88-4030)

Applicability of AI technology in the development of automated time-critical functions for tactical rotorcraft is a subject of great interest. (A time-critical function requires response in at most a few seconds to tens of seconds.) A number of researchers have developed laboratory demonstration versions of knowledge-based 'expert' systems (KBS) that may provide acceptable solutions to tactical problems, but which run too slowly for time-critical tactical applications and require excessive and nonstandard processor resources. Using an ongoing IR&D project as a case study, this paper discusses the transition of a tactical routing KBS from rapid prototype versions on a Symbolics computer to a time-efficient version on IBM PC AT and PS/2 computers. Author

A89-18401
OPTIMIZATION OF ALGORITHMS FOR DATA PROCESSING IN RADAR ALTIMETERS WITH ELECTRONIC STABILIZATION OF THE RADIATION PATTERN [OPTIMIZATSIIA ALGORITMOV OBRABOTKI INFORMATSII V RADIOVYSOTOMERAKH S ELEKTRONNOI STABILIZATSIEI DIAGRAMMY NAPRAVLENNOSTI]
A. S. BOGACHEV Radiotekhnika (ISSN 0033-8486), Sept. 1988, p. 9-12. In Russian. refs

The method of conditional Markov processes is used to obtain quasi-optimal algorithms for the complex processing of data in low-altitude radar altimeter with array receiving antennas. It is shown that optimization of the processing algorithms in altimeters with sufficiently narrow electronically stabilizable array radiation patterns leads to highly accurate measurements of flight altitude and altimeter noise immunity. B.J.

A89-18865
HUMAN FACTORS IMPACT ON THE V-22 OSPREY COCKPIT DEVELOPMENT - AN OVERVIEW
VIRGIL A. GRAF and CHARLES D. HOLLEY (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 201-212. refs

The V-22 is a multimission, multiservice tiltrotor aircraft that will make its first flight this year. The crewstation configuration, with its advanced cockpit management system, represents the culmination of the human engineering (HE) program from predesign through full-scale development. To illustrate the HE impact on the development program, three representative cockpit domains are described: control and display architecture, display design, and cockpit visibility. The HE process, including associated tools, is emphasized throughout the discussion. Implementation of this process has resulted in a cockpit that is designed with the user as a prime consideration. Author

A89-18867* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DYNAMIC PERSPECTIVE DISPLAYS AND THE CONTROL OF TILT-ROTOR AIRCRAFT IN SIMULATED FLIGHT
C. T. BENNETT, W. W. JOHNSON (NASA, Ames Research Center, Moffett Field, CA), and K. A. O'DONNELL (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 219-226. refs

Two simulations were conducted to study the effect of dynamic perspective displays on performance measures collected during simulated flight. The first study was a pure altitude regulation task with simple first order plant dynamics. In the second simulation, pilots performed two basic rotary-wing flight tasks with dynamic perspective displays projected out-the-window (panoramic head up display) or on a panel mounted simulation of a sensor display. The data from the two studies, taken together, show that when such displays are used during flight, they will not degrade performance; and, under certain display configurations, they will minimize flight control errors. Author

A89-18868
AIRBORNE INTEGRATED MONITORING SYSTEM
ALBERT H. NEUBAUER, JR. (Teledyne Controls, Los Angeles, CA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 227-232.

Goals and tasks of the onboard monitoring techniques to be implemented in the V-22 tiltrotor aircraft are discussed with a view to input and output signal interface goals and the microprocessor and memory technology required for successful implementation. Memory and recording call for solid-state

nonvolatile devices able to furnish error-free, long-lasting data storage while withstanding hostile environments. Aircraft sensors will furnish the basic data analyzed and formatted by the monitoring system processor; the display of pertinent information for review by the flight crew is usually controlled by the primary flight computer via the system bus. O.C.

A89-18932#
STANDARDIZED ADVANCED INFRARED SENSOR - A PROGRAM STATUS
CHERYL G. HOWARD and DENNIS VAN DERLASKE (U.S. Army, Center for Night Vision and Electro-Optics, Fort Belvoir, VA) AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Paper. 5 p.

SAIRS is a concept feasibility prototype for a second generation thermal imager. Two sensors are currently being developed, one by Texas Instruments Incorporated and one by Martin Marietta Corporation. The near-term program goal of SAIRS is to provide target acquisition system technology to minimize risks in time to impact the LHX system design review and ensuing technical decisions under the LHX DEM/VAL program. SAIRS will incorporate many design improvements over first generation thermal imagers. These improvements will provide a higher fidelity image to automatic target recognizers, and will also improve target acquisition performance for human observers. Extensive testing will be performed using the two SAIRS sensors in both ground and airborne environments. The results of these tests will allow the Center for Night Vision and Electro-Optics to provide the LHX program with a technology benchmark for second generation thermal imager and automatic target recognizer technology. Author

A89-19186* Mesoscale Environmental Simulations, Inc., Hampton, VA.
NUMERICAL SIMULATION OF THE 2 AUGUST 1985 DFW MICROBURST WITH THE THREE-DIMENSIONAL TERMINAL AREA SIMULATION SYSTEM
FRED H. PROCTOR (MESO, Inc., Hampton, VA) IN: Conference on Numerical Weather Prediction, 8th, Baltimore, MD, Feb. 22-26, 1988, Preprints. Boston, MA, American Meteorological Society, 1988, p. J99-J102. refs
(Contract NAS1-18336)

A model simulation is performed for a small, intense thunderstorm which occurred at the Dallas-Fort Worth airport on August 2, 1985, leading to the crash of a commercial jetliner. The simulation is conducted with the three-dimensional Terminal Area Simulation System, a nonhydrostatic cloud model. The simulation is in good agreement with observations of the storm. It is found that for similar events, very little warning time may be possible as warning is based only on the surface level winds. R.B.

N89-13429*# Toledo Univ., OH. Dept. of Chemical Engineering.
A COMPARISON OF NUMERICAL METHODS FOR THE PREDICTION OF TWO-DIMENSIONAL HEAT TRANSFER IN AN ELECTROTHERMAL DEICER PAD M.S. Thesis. Final Contractor Report
WILLIAM B. WRIGHT Washington NASA Dec. 1988 138 p
(Contract NAG3-72)
(NASA-CR-4202; E-4380; NAS 1.26:4202) Avail: NTIS HC A07/MF A01 CSCL 01D

Transient, numerical simulations of the deicing of composite aircraft components by electrothermal heating have been performed in a 2-D rectangular geometry. Seven numerical schemes and four solution methods were used to find the most efficient numerical procedure for this problem. The phase change in the ice was simulated using the Enthalpy method along with the Method for Assumed States. Numerical solutions illustrating deicer performance for various conditions are presented. Comparisons are made with previous numerical models and with experimental data. The simulation can also be used to solve a variety of other heat conduction problems involving composite bodies. 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.

A89-17742#
VARIABLE-CYCLE ENGINES FOR BOOSTING-CRUISING VEHICLES
N. IU. ROTMISTROV and M. M. TSKHOVREBOV (AN SSSR, Sovet Interkosmos, Moscow, USSR) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 15 p. refs
(IAF PAPER 88-249)

The present consideration of variable-cycle airbreathing booster vehicle engines for operation at Mach 5-6 gives attention to a variable-cycle engine with ramjet duct whose optimum energy transfer value into the duct is optimized. The thermodynamic and kinematic parameters of powerplant configurations of this type are presented; the boosting instantaneous overall efficiency is used to estimate these configurations' efficiencies at representative flight regimes. O.C.

A89-17941*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL INVESTIGATION OF PROPFAN AEROELASTIC RESPONSE IN OFF-AXIS FLOW WITH MISTUNING
ORAL MEHMED (NASA, Lewis Research Center, Cleveland, OH) and DURBHA V. MURTHY (Toledo University, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 28 p. Previously announced in STAR as N88-28344. refs
(AIAA PAPER 88-3153)

Measured vibratory strain amplitudes from off-axis flow are compared for the blades of two, 8-bladed propfan model rotors with mistuning. One rotor had inherent mistuning. The other was intentionally mistuned by replacing every other blade of the first rotor with a blade of same geometry but different frequencies and mode shapes. The data shows that the intentional mistuning had a beneficial effect on the aeroelastic response of the propfan motors for a wide range of off-axis flow angles, blade pitch angles, and rotational speeds. Statistical trends of blade strain amplitudes are compared for both the rotors in terms of the ratio of the maximum to the mean and the coefficient of variation. Author

A89-17942*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AEROELASTIC RESPONSE OF METALLIC AND COMPOSITE PROPFAN MODELS IN YAWED FLOW
KRISHNA RAO KAZA, ORAL MEHMED, G. V. NARAYANAN (NASA, Lewis Research Center, Cleveland, OH), and MARC H. WILLIAMS (Purdue University, West Lafayette, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 26 p. Previously announced in STAR as N88-29807. refs
(AIAA PAPER 88-3154)

An analytical investigation of aeroelastic response of metallic and composite propfan models in yawed flow was performed. The analytical model is based on the normal modes of a rotating blade and the three-dimensional unsteady lifting surface aerodynamic theory including blade mistuning. The calculated blade stresses or strains are compared with published wind tunnel data on two metallic and three composite propfan wind tunnel models. The comparison shows a good agreement between theory and experiment. Additional parametric results indicate that blade response is very sensitive to the blade stiffness and also to blade frequency and mode shape mistuning. From these findings, it is concluded that both frequency and mode shape mistuning should be included in aeroelastic response analysis. Furthermore, both

calculated and measured strains show that combined blade frequency and mode shape mistuning has beneficial effects on response due to yawed flow. Author

A89-17943*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
VIBRATION, PERFORMANCE, FLUTTER AND FORCED RESPONSE CHARACTERISTICS OF A LARGE-SCALE PROPFAN AND ITS AEROELASTIC MODEL
RICHARD AUGUST (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) and KRISHNA RAO V. KAZA (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 28 p. Previously announced in STAR as N89-10043. refs
(AIAA PAPER 88-3155)

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

A89-18124#
FUNCTIONAL AUGMENTATION OF DIGITAL ENGINE CONTROLLERS TO IMPLEMENT AN INTEGRATED TESTABILITY CONCEPT
GRAHAM F. TANNER (Rolls-Royce, PLC, Bristol, England) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 508-514.
(AIAA PAPER 88-3953)

Some techniques proposed for an integrated aircraft engine test concept and their evolution from previous system designs are considered. Suggestions are given on how greater use of existing on-board engine electronics can be made in order to achieve a higher testability factor. Necessary areas of interface with the airframe manufacturer are discussed. C.D.

A89-18908
DUAL CENTRIFUGAL COMPRESSORS - THE HELICOPTER SOLUTION TO SAND AND ICE INGESTION
JOHN PUGNALE (Allied-Signal Aerospace Co., Garrett Engine Div., Phoenix, AZ) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 673-681. refs

The engine design characteristics that result in engines with reduced susceptibility to foreign object damage (FOD) are discussed, with particular attention given to helicopter engines. It is demonstrated that, for the helicopter engines, which are especially vulnerable to damage in hostile environments, the dual centrifugal compressor is superior to the axial and axial/centrifugal compressors by offering competitive performance; reduced acquisition and maintenance cost; and superior reliability, availability, and maintainability, FOD, survivability and vulnerability, and sand erosion features. Design diagrams are included. I.S.

A89-19793#
OPTIMIZATION OF MISTUNED BLADE ROTOR FOR CONTROLLING FLUTTER
TAO SONG, MEI MA, and ZHAOHONG SONG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, July 1988, p. A342-A349. In Chinese, with abstract in English. refs

In order to get the most stable mistuned blade system, a new design procedure has been developed. The damping factor of the most unstable mode shape of the mistuned blade system is chosen as the cost function of optimization. The results of the computation show that the mistuning pattern with which the system is the most stable will vary as the aerodynamic condition changes, but all these optimum mistuning patterns have the same characteristic, that the amounts of mistuning between neighboring blades are large. The results also show that the mistuning pattern which is being used in engines for the Chinese air force is effective in controlling flutter. Author

A89-19803#
EFFECT OF BLADE MISTUNING AND BLADE-DISK ON CASCADE FLUTTER BOUNDARIES
JINGBO CHEN, QUN CHEN, DAKUAN SHEN, and FEIDA FAN (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Aug. 1988, p. B330-B337. In Chinese, with abstract in English. refs

The eigenvalue method is presented for determining the effects of blade mistuning and blade-disk on cascade flutter boundaries in incompressible flow. Results presented illustrate that mistuning has a beneficial effect on the cascade flutter. With the mistuning amplitude increasing, the flutter boundaries move more backward and different mistuning orders have different effects on flutter boundaries, depending on the order of the modal cascade flutter. Addition of bladed-disk makes mistuned cascade flutter boundaries move forward. Author

A89-20240
DEVELOPMENT OF RAM PROPULSION FOR FLIGHT VEHICLES [ENTWICKLUNG EINES STAUANTRIEBS FUER DEN FLUGKOERPEREINSATZ]
W.-D. POHL (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 806-820. In German. refs
(DGLR PAPER 87-101)

The use of ram propulsion in flight vehicles is reviewed, and recent technological advances in this area are discussed in detail. Progress made toward developing a ram propulsion engine for flight vehicles is discussed. Experimental test results are reported. C.D.

A89-20241
DESIGN AND INTEGRATION OF AIR-BREATHING PROPULSION SYSTEMS OF SPACE TRANSPORTS AND HYPERSONIC AIRCRAFT [AUSLEGUNG UND INTEGRATION LUFTATMENDER ANTRIEBSSYSTEME VON RAUMTRANSPORTER-HYPERSCHALLFLUGZEUGEN]
O. HERRMANN (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) and H. RICK (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 853-866. In German. refs
(DGLR PAPER 87-103)

The usefulness of propulsion concepts for hypersonic flight vehicles based on contemporary high-performance turbopropulsion devices with afterburners are investigated. The usefulness of the concepts for spaceflight vehicles is also addressed. The design and operational behavior of turbo-ram propulsion combinations are considered, and the operational behavior of individual components of such propulsions is examined. C.D.

A89-20625
SELECTED PAPERS ON FUNDAMENTAL ASPECTS OF GAS TURBINE COMBUSTION
ARTHUR H. LEFEBVRE (Purdue University, West Lafayette, IN) Beijing, Chinese Astronautic Publishing House, 1987, 706 p. refs

Theoretical, experimental, and applications aspects of gas-turbine combustion are examined in a collection of the author's previously published papers. The main topics addressed are ignition, flame stabilization, flame propagation, atomization, fuel evaporation, and flame radiation. Extensive diagrams, drawings, and graphs are provided. T.K.

N89-13430# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
EARLY JET ENGINES AND THE TRANSITION FROM CENTRIFUGAL TO AXIAL COMPRESSORS: A CASE STUDY IN TECHNOLOGICAL CHANGE Ph.D. Thesis
BRIAN J. NICHELSON 1988 257 p
(AD-A198775; AFIT/CI/NR-88-192) Avail: NTIS HC A12/MF A01 CSCL 21E

The transition from centrifugal-flow compressors to axial-flow compressors in the jet engines of the late 1940's and early 1950's provides an illuminating case study of the evolutionary nature of technological change. A look at the development of the turbojet in light of engineering design reveals that incremental changes came about in response to changing needs. The iterative nature of engineering design, whereby a designer repeats a step until he arrives at an acceptable solution, allows the designer to take into account new needs and new information. The first two turbojets, invented independently in England and Germany in the mid-1930's, both used centrifugal compressors. The inventors built upon the two hundred year-old tradition of centrifugal-flow turbomachinery to design a successful turbojet compressor. In contrast, all attempts at designing and building an axial-flow compressor prior to the twentieth century failed. Yet, researchers in four different countries persisted in their efforts because of their faith in the potential of the axial compressor to produce a higher pressure ratio at a better efficiency than the centrifugal compressor. GRA

N89-13431# Avco Lycoming Div., Stratford, CT.
T55-L-714 ENGINE DEVELOPMENT AND QUALIFICATION: TIP CLEARANCE ANALYSIS Final Report
S. SAWDYE 31 May 1988 23 p
(Contract DAAJ09-87-C-A072)
(AD-A198849; LYC-T55-88-04) Avail: NTIS HC A03/MF A01 CSCL 21E

The performance of the T55-L-714 engine has shown to be strongly influenced by gas turbine running tip clearance. In order to ensure both optimum steady state performance and to prevent rubs of the gas producer turbine upon rapid deceleration and acceleration, a steady state and transient tip clearance analysis has been conducted. GRA

N89-13432*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SENSOR FAILURE DETECTION FOR JET ENGINES
WALTER C. MERRILL Nov. 1988 43 p Submitted for publication
(NASA-TM-101396; E-4402; NAS 1.15:101396) Avail: NTIS HC A03/MF A01 CSCL 21E

The use of analytical redundancy to improve gas turbine engine control system reliability through sensor failure detection, isolation, and accommodation is surveyed. Both the theoretical and application papers that form the technology base of turbine engine analytical redundancy research are discussed. Also, several important application efforts are reviewed. An assessment of the state-of-the-art in analytical redundancy technology is given. Author

N89-13434# Coordinating Research Council, Inc., Atlanta, GA.
AVIATION FUEL LUBRICITY EVALUATION
Jul. 1988 212 p
(Contract DAAK70-86-C-0011)
(AD-A198197; CRC-560) Avail: NTIS HC A10/MF A01 CSCL 21D

Fuel system components have experienced problems with the slipperiness or lubricity of the fuel back to the early 1960's. As a consequence of the level of refinement necessary for the PWA 523 fuel (now designated Mil-T-38219 grade JP-7) to obtain its high-temperature stability, many of the polar compounds contributing to lubricity had been removed, resulting in abnormal hydraulic fuel pump wear. A lubricity-enhancing compound was developed (PWA 536) to eliminate the wear problem. High-pressure piston-type fuel pumps were one of the first parts of the engine fuel system to exhibit problems related to fuel properties. One early problem manifested itself as corrosion of silver-plated slipper pads and was related to carryover of residual chlorides fuel. Fuel controls were another part of the engine fuel system susceptible to fuel properties. Lack of lubricity agents caused fuel control sliding servo valves to stick. GRA

N89-13435*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
FLIGHT MEASURED AND CALCULATED EXHAUST JET CONDITIONS FOR AN F100 ENGINE IN AN F-15 AIRPLANE
FRANCISCO J. HERNANDEZ and FRANK W. BURCHAM, JR. Oct. 1988 17 p
(NASA-TM-100419; H-1449; NAS 1.15:100419) Avail: NTIS HC A03/MF A01 CSCL 20E

The exhaust jet conditions, in terms of temperature and Mach number, were determined for a nozzle-aft end acoustic study flown on an F-15 aircraft. Jet properties for the F100 EMD engines were calculated using the engine manufacturer's specification deck. The effects of atmospheric temperature on jet Mach number, M10, were calculated. Values of turbine discharge pressure, PT6M, jet Mach number, and jet temperature were calculated as a function of aircraft Mach number, altitude, and power lever angle for the test day conditions. At a typical test point with a Mach number of 0.9, intermediate power setting, and an altitude of 20,000 ft, M10 was equal to 1.63. Flight measured and calculated values of PT6M were compared for intermediate power at altitudes of 15500, 20500, and 31000 ft. It was found that at 31000 ft, there was excellent agreement between both, but for lower altitudes the specification deck overpredicted the flight data. The calculated jet Mach numbers were believed to be accurate to within 2 percent. Author

N89-13436*# General Electric Co., Cincinnati, OH. Aircraft Engine Business Group.
CONSTITUTIVE MODELING FOR ISOTROPIC MATERIALS Annual Report, May 1983 - Apr. 1984
V. G. RAMASWAMY, R. H. VANSTONE, L. T. DAME, and J. H. LAFLEN 15 Apr. 1985 86 p
(Contract NAS3-23927)
(NASA-CR-174805; NAS 1.26:174805) Avail: NTIS HC A05/MF A01 CSCL 21E

The first year of progress on a NASA-Lewis contract with the General Electric Co is documented. The purpose of this contract (NAS3-23927) is to develop and evaluate unified constitutive equations for applications to hot-path components of aircraft gas turbine engines such as high pressure turbine blades and vanes. To accomplish this goal, uniaxial, notched, and multiaxial specimens made of conventionally cast Rene 80 are being tested under conditions that simulate engine operating conditions. To reduce the raw data, automated data reduction techniques are being developed that produce computer files containing the information needed to analyze proposed constitutive theories. Described are the analytical methods being developed to determine the parameters for these nonlinear unified theories by using the reduced data files. In another activity, a dedicated finite-element computer code is being developed to use unified theories in the structural analysis of hot-section components. This code was extensively verified for one such theory by successfully predicting the strain histories measured experimentally at the notch root of complex specimens taken from complex laboratory specimens. Author

N89-13437*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ISOLATED TESTING OF HIGHLY MANEUVERABLE INLET CON CEPTS
W. P. NORBY, B. A. HAEFFELE (McDonnell Aircraft Co., St. Louis, Mo.), and R. R. BURLEY Dec. 1986 167 p
(NASA-CR-179544; NAS 1.26:179544) Avail: NTIS HC A08/MF A01 CSCL 21E

Ten percent scale models of a Mach 2.2 two dimensional inlet and a Mach 2.0 axisymmetric inlet were tested in the NASA Lewis Research Center 8'x6' Supersonic Wind Tunnel as part of a cooperative effort with the McDonnell Aircraft Company. The objective of this effort was to test methods designed to increase the maneuvering performance of fighter aircraft inlets. Maneuvering improvement concepts were tested up to 40-deg angle of attack for Mach numbers of 0.6 and 0.9, and up to 25 deg for Mach numbers 1.2 and 1.4. Maneuvering improvement concepts included a rotating cowl lip, auxiliary inlets aft of the inlet throat, and a retracting centerbody for the axisymmetric inlet. Test results show that the rotating cowl design was effective in improving subsonic maneuvering performance for both inlets. Auxiliary inlets did not produce significant performance increases for either model. The retracted centerbody resulted in some performance benefits at high angles of attack. None of the maneuvering improvement concepts were effective at Mach 1.2 and 1.4. Author

N89-14236# Weapons Systems Research Lab., Adelaide (Australia).
ENGINES FOR MINI-RPV XM-1A
E. H. BARNARD-BROWN Jan. 1988 110 p
(AD-A198336; WSRL-0566-TM; DODA-AR-005-348) Avail: NTIS HC A06/MF A01 CSCL 21G

There were very few light-weight reciprocating engines in the five to ten horsepower range existing in Australia or overseas when a program of research and exploratory development of the techniques required to operate unmanned airborne vehicles from a remote base station started in 1975. Those that did were generally single cylinder engines which are difficult to balance over the speed range necessary for mini remotely piloted vehicle (RPV) operation. A twin cylinder Kolbo D238 engine and a larger Herbrandson Dyad 160 engine were flown. When fitted with a locally developed capacitor discharge ignition system, both these engines performed reliably in flight trials of the mini-RPV XM-1A. However, the Kolbo engine had insufficient power for aircraft with a take-off mass of more than about 35 kg. This memorandum records the experience and test results gained at Weapons Systems Research Laboratory (WSRL) on small engines from its mini-RPV program conducted during 1975 to 1981. GRA

N89-14237*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED CORE TECHNOLOGY: KEY TO SUBSONIC PROPULSION BENEFITS
ARTHUR J. GLASSMAN, CHRISTOPHER A. SNYDER, and GERALD KNIP, JR. 1989 13 p Prepared for presentation at the 34th International Gas Turbine and Aeroengine Congress and Exposition, Toronto (Ontario), 4-8 Jun. 1989; sponsored in part by ASME
(NASA-TM-101420; E-4519; NAS 1.15:101420) Avail: NTIS HC A03/MF A01 CSCL 21E

A study was conducted to identify the potential performance benefits and key technology drivers associated with advanced cores for subsonic high bypass turbofan engines. Investigated first were the individual sensitivities of varying compressor efficiency, pressure ratio and bleed (turbine cooling); combustor pressure recovery; and turbine efficiency and inlet temperature on thermal efficiency and core specific power output. Then, engine cycle and mission performance benefits were determined for systems incorporating all potentially achievable technology advancements. The individual thermodynamic sensitivities are shown over a range of turbine temperatures (at cruise) from 2900 to 3500 R and for both constant (current technology) and optimum (maximum thermal efficiency) overall pressure ratios. It is seen that no single parameter alone will provide a large increase in core thermal efficiency, which is the thermodynamic parameter of most concern for transport propulsion. However, when all potentially achievable advancements are considered, there occurs a synergism that produces significant cycle and mission performance benefits. The nature of these benefits are presented along with the technology challenges. Author

N89-14238*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SIMULATION OF 3-D VISCOUS FLOW WITHIN A MULTI-STAGE TURBINE
JOHN J. ADAMCZYK, MARK L. CELESTINA, TIM A. BEACH, and MARK BARNETT (United Technologies Research Center, East Hartford, Conn.) 1989 14 p Proposed for presentation at the 34th International Gas Turbine and Aeroengine Congress and Exposition, Toronto, Ontario, 4-8 Jun. 1989; sponsored by ASME
(NASA-TM-101376; E-4430; NAS 1.15:101376) Avail: NTIS HC A03/MF A01 CSCL 21E

This work outlines a procedure for simulating the flow field within multistage turbomachinery which includes the effects of unsteadiness, compressibility, and viscosity. The associated modeling equations are the average passage equation system which governs the time-averaged flow field within a typical passage of a blade row embedded within a multistage configuration. The results from a simulation of a low aspect ratio stage and a one-half turbine will be presented and compared with experimental measurements. It will be shown that the secondary flow field generated by the rotor causes the aerodynamic performance of the downstream vane to be significantly different from that of an isolated blade row. Author

N89-14239*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PLOTTING COMPONENT MAPS IN THE NAVY/NASA ENGINE PROGRAM (NNEP): A METHOD AND ITS USAGE
ROBERT M. PLENCNER Jan. 1989 20 p
(NASA-TM-101433; E-4539; NAS 1.15:101433) Avail: NTIS HC A03/MF A01 CSCL 21E

The Navy/NASA Engine Program (NNEP) and the new extended version which handles chemical equilibrium (NNEPEQ) are very general cycle analysis codes that have been used extensively to calculate design and off-design performance of a wide range of turbine engine cycles and configurations. Component maps are used to obtain the off-design engine performance and a matched engine cycle. This paper describes a method of plotting the scaled NNEP compressor and turbine maps as the user runs the NNEP code as well as plotting the operating line defined by all the cases that were computed in that particular NNEP run. Afterwards, an example demonstrates the use of this capability to help analyze an engine cycle model and then make improvements to that cycle. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A89-18068#
ENERGY MANAGEMENT FOR INTEGRATED FLIGHT AND PROPULSION CONTROL SYSTEMS
KEITH W. ROSENBERG (GEC Avionics, Ltd., Combat Aircraft Controls Div., Rochester, England) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 120-127. refs
(AIAA PAPER 88-3873)

The use of energy state approximations for aircraft performance

optimization is extended to tactical energy management. Until now it has primarily been applied to minimum time, minimum fuel and maximum range types of problems. This study is extended to provide propulsion management by throttle modulation, utilizing the full dry thrust and afterburner range while taking account of the variation in fuel conversion efficiency throughout the range. To provide tactical maneuvering the analysis takes account not only of current and terminal aircraft state requirements but also en-route threats and prohibited volumes of airspace. As an example the air interception of a noncooperative target is developed to demonstrate the concept. Emphasis has been placed on the development of real time algorithms which exhibit Baysian behavior rather than the more rigorous approaches which involve the solution of classic two point boundary value problems. Author

A89-18070#
VEHICLE MANAGEMENT SYSTEM REQUIREMENTS
D. R. KATT (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 136-141.
(Contract F33615-86-C-2630)
(AIAA PAPER 88-3876)

This paper presents the results obtained from a study of the design objectives, design requirements, performance specifications, and a design approach for a vehicle management system (VMS). The approach seeks to maximize the benefits of the VMS concept for a given integrated system definition while ensuring that the functional control requirements are satisfied by the implementation. The approach is applied to a baseline system including STOL and Maneuver Technology Demonstrator and Performance-Seeking Control laws as well as utility integration concepts such as thermal management, engine start scheduling, and adaptive CG control. The baseline also includes a number of mission-related design issues which drive the VMS implementation to an architecture configuration. Several configurations are examined to show the impact of different design issues of the VMS implementation. C.D.

A89-18071#
VEHICLE MANAGEMENT SYSTEM FOR A MANNED HYPERSONIC VEHICLE
JACK M. HERRLIN (Honeywell Systems and Research Center, Minneapolis, MN) and HENDRIK GELDERLOOS (Honeywell, Inc., Space and Strategic Avionics Div., Clearwater, FL) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 142-147.
(AIAA PAPER 88-3877)

A study was performed to determine the advantages of using advanced technology in the design of a Vehicle Management System for a Manned Hypersonic Vehicle (MHV). An integrated system architecture was derived from the Pave Pillar model, and the functional architecture was mapped onto the system architecture. Size, weight, and power dissipation estimates were made for a modular mechanization of the proposed system. Software size and performance estimates were made along with comparisons with Space Shuttle Orbiter (SSO) data. The results showed that an increase in throughput of an order of magnitude was required for the flight management portion of the computations relative to the equivalent functions for the SSO. An order of magnitude more memory is required for the MHV compared to the SSO. C.D.

A89-18076#
THE T-2 CONTROL CONFIGURED VEHICLE DEVELOPMENT, INTEGRATION AND FLIGHT TEST
KATSUHEI SHIBATA (Japan Defense Agency, Technical Research and Development Institute, Tokyo, Japan) and HIDEAKI OHMIYA (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 177-184.
(AIAA PAPER 88-3882)

The research program of the T-2 control configured vehicle (CCV) with a triplex digital flight control system and CCV modes is described. Results showed that the automatic tracking control law can provide increased tracking performance and survivability with reduced pilot workload. The simulated target projected on the HUD for the automatic tracking and HQDT flight tests proved to be highly effective and economical. K.K.

A89-18077#
TRIPLEX DIGITAL FLIGHT CONTROL SYSTEM FOR THE STOL RESEARCH AIRCRAFT 'ASKA'
TADAO UCHIDA, AKIRA WATANABE, NORIAKI OKADA (National Aerospace Laboratory, Tokyo, Japan), YUKIO SHIMIZU, KOJI IWASAKI (Kawasaki Heavy Industries, Ltd., Japan) et al. IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 185-192.
(AIAA PAPER 88-3883)

A research aircraft, Aska, designed to demonstrate the feasibility of STOL at low airspeed is described. The Aska uses a stability and control augmentation system (SCAS) to improve flying qualities at low airspeed. The SCAS is composed of triplex SCAS computers, triplex interface units, triplex electronic control units, sensors, actuators, a mode control panel, and maintenance units. K.K.

A89-18098#
GUIDANCE AND FLIGHT DIRECTOR SYSTEM FOR THE V-22 TILTROTOR
ROBERT L. KILMER, JR. (IBM, Systems Integration Div., Owego, NY) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 332-339.
(AIAA PAPER 88-3921)

The V-22 Tiltrotor has the unique capability to operate in the airplane mode, the helicopter mode, or throughout the conversion region between the two modes. The thrust vectoring provided by rotating the nacelles causes the aircraft to transition from conventional fixed wing (frontside) operation in the airplane mode to 'backside' operation in the helicopter mode. The technique used to accommodate the transition from frontside to backside operation and the resulting Flight Director control laws are discussed in this paper. The paper concludes with a summary of piloted simulation results using a group of industry and military test pilots. Author

A89-18099#
DIGITAL FLY-BY-WIRE SYSTEM FOR ADVANCED AH-64 HELICOPTERS
STEPHEN S. OSDER (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 340-346. refs
(AIAA PAPER 88-3922)

This paper describes the Fly-By-Wire Flight Control System being developed for Advanced AH-64 (Apache) aircraft. It emphasizes the system architecture and control mode concepts. It is a double fail-operative configuration featuring triplex computers which drive dual-dual actuator interfaces for main rotor and tail rotor control. The paper describes the sensor requirements needed to implement control laws that provide flight path management directly from the sidestick controllers and it reviews the redundancy management techniques used for sensors, computers and actuators. Author

A89-18100#
X-WING FLY-BY-WIRE VEHICLE MANAGEMENT SYSTEM
WILLIAM C. FISCHER (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AIAA/IEEE Digital Avionics Systems

Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 347-355.
(AIAA PAPER 88-3923)

The paper discusses the Rotor System Research Aircraft (RSRA)/X-Wing Program, which combines a circulation control rotor with the NASA RSRA to demonstrate an inflight flight conversion to and from a stopped rotor state. The development of the vehicle management system, which controls many subsystems and provides functions beyond the classical flight control system, is considered. Redundancy is addressed as well as hardware, development testing, productionization, and system status. K.K.

A89-18101*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SIMULATION EVALUATION OF HELICOPTER TERRAIN FOLLOWING/TERRAIN AVOIDANCE CONCEPTS
HERRY N. SWENSON, GORDON H. HARDY (NASA, Ames Research Center, Moffett Field, CA), and PAT M. MORRIS (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 356-366. refs
(AIAA PAPER 88-3924)

A helicopter Terrain-Following/Terrain-Avoidance (TF/TA) system was developed and evaluated using a real-time piloted simulation. The TF/TA system included a guidance algorithm based upon dynamic programming and a head-up display (HUD) concept which incorporates a pathway in the sky, a phantom aircraft, and flightpath vector/predictor symbology. The simulation was conducted at the NASA Ames Research Center Interchangeable Cab (ICAB) Laboratory using NASA test pilots. The pilots performed the TF/TA task by manually tracking the HUD symbology. The pilots were able to satisfactorily perform the TF/TA tasks with an acceptable level of pilot workload. Author

A89-18108#
COMMERCIAL JET TRANSPORT FLY-BY-WIRE ARCHITECTURE CONSIDERATIONS
ROBERT J. BLEEG (Boeing Commercial Airplanes, Seattle, WA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 399-406.
(AIAA PAPER 88-3900)

Fly-by-wire (FBW) for jet transports has come of age with the introduction to service of the first pitch and roll axes system this year. There are tangible advantages to FBW and the Boeing Company has committed to a development program, with the objective of validating system architecture and a prototype Primary Flight Computer System (PFCS). The program includes performance and safety analyses of a specific architecture, and PFCS laboratory testing with special emphasis on fault tolerance investigation. The rationale behind architecture selection and a review of safety requirements are presented, in addition to discussion of the analysis and test program. Author

A89-18110#
MAFT - AN ARCHITECTURE FOR RELIABLE FLY-BY-WIRE FLIGHT CONTROL
CHRIS J. WALTER (Allied-Signal Aerospace Technology Center, Columbia, MD) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 415-421. refs
(AIAA PAPER 88-3902)

MAFT, a multilane architecture suitable for real-time control applications requiring high reliabilty, is described. The MAFT architecture was applied to the design of a digital flight control system in a fly-by-wire (FBW) aircraft which has a failure probability requirement of 10 to the -10 failures/hr for a 10 hr mission time. Central issues influencing the design of a fault tolerant computer for a FBW application are addressed. K.K.

A89-18114#
APPLICATION OF DIGITAL TECHNOLOGY TO AIRCRAFT UTILITY SYSTEMS
I. MOIR (Smiths Industries Aerospace and Defence Systems, Ltd., Cheltenham, England) AIAA and IEEE, Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988. 7 p. refs
(AIAA PAPER 88-3872)

The integrated Utilities Management System (UMS) developed for the UK Experimental Aircraft Program (EAP) is described and illustrated with diagrams and photographs. The UMS employs a MIL-STD-1553B data bus, 16-bit microprocessors, and state-of-the-art memory devices to control or monitor about 600 aircraft-system signals and provide relevant information to the pilot on three multicolor multifunction displays; the EAP prototype with UMS was successfully test flown in August 1986. T.K.

A89-18903
THE IMPACT OF YAW AXIS CONTROL MODES, FLIGHT DIRECTORS AND AUTOMATIC CONTROL COUPLING ON DECELERATING IFR APPROACHES FOR ROTORCRAFT
STEWART BAILLIE, STAN KERELIUK (National Aeronautical Establishment, Flight Research Laboratory, Ottawa, Canada), and ROGER HOH (Systems Technology, Inc., Hawthorne, CA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 613-623. refs

The handling qualities and certification impacts of various issues on low minima decelerating flight directed IFR approaches for rotorcraft are studied on the basis of an in-flight simulation experiment. Particular attention is given to the use of crab versus sideslip techniques to maintain lateral tracking under crosswind conditions, the effects of various methods of vertical axis display, guidance and control, and the benefits of coupling flight director control signals directly to the rotorcraft control actuators. It was found that coupling any axis of control to the flight director provided slight workload relief benefits. The collective axis is expected to be the most likely axis for this implementation. K.K.

A89-18904
DETERMINATION OF CONTROL LAWS FOR A SINGLE PILOT, ATTACK HELICOPTER
PATRICK J. HOLLIFIELD and ANNE M. OETTING (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 625-634.

A piloted simulation recently conducted at the Bell Helicopter Textron Inc. (BHT) flight simulation facility defined the flight control laws for the AH-4BW. This four-bladed, single pilot, attack helicopter will enter flight testing in mid-1988. This paper describes the control system and control law evolution and the role played by simulation in their development. A discussion of the computer simulation programs and their use during the development of the AH-4BW control laws is presented. The SCAS (Stability and Control Augmentation System) evaluation process used is also discussed. Flight test data from a demonstration four-bladed helicopter that was used to help define the goals for aircraft response are shown. Comparisons between simulation results and current and proposed handling qualities specifications are made. The proposed handling qualities specifications are found in ADS-33 (Reference 1). Author

A89-18905
A COMPARISON BETWEEN VARIOUS SIDE-ARM CONTROLLER CONFIGURATIONS IN A FLY-BY-WIRE HELICOPTER
J. M. MORGAN (National Research Council of Canada, Flight Research Laboratory, Ottawa) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 635-648. DND-supported research. refs

A piloted experiment was flown in the National Aeronautical Establishment variable stability Bell 205A-1 to examine the effects on both handling qualities and pilot performance of varying control configurations when using multi-axis sidestick controllers. Two types of controller were used in fully and partially integrated configurations, conventional controls were also evaluated in the same study to provide direct comparisons between the inceptor types. The flight control systems comprised rate command in pitch and roll, rate command heading hold in yaw and simple direct drive for collective. In general the data suggest that there was no clear or obvious preference for any particular inceptor or configuration. The performance analyses indicate that there was no significant change in the pilot's control capabilities as controllers or configurations were changed. Author

A89-19557
X-29 VALIDATION METHODOLOGY FOR SIMULATION AND FLIGHT CONTROL SYSTEM
D. WALLER and M. SOLAN (Grumman Aerospace Corp., Bethpage, NY) IN: Aerospace simulation III; Proceedings of the SCS Multiconference, San Diego, CA, Feb. 3-5, 1988. San Diego, CA, Society for Computer Simulation International, 1988, p. 68-88. refs

Lessons learned and important results of the X-29 verification and validation testing program over the past three years are discussed. Particular attention is given to the contribution of real-time simulation to the overall success of the program. It is found that significant nonlinearities and high-order dynamic effects must be included in the math-model simulation early in order to accelerate control law development for specification of flight hardware/software. K.K.

A89-19558
RECONFIGURABLE FLIGHT CONTROL SYSTEM SIMULATION
JOSEPH ANDERSON, CURT CLARK, PAUL MADSEN, and FREDERICK UNFRIED (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Aerospace simulation III; Proceedings of the SCS Multiconference, San Diego, CA, Feb. 3-5, 1988. San Diego, CA, Society for Computer Simulation International, 1988, p. 89-101. refs

A man-in-the-loop simulation was carried out for the self-repairing flight control system program to demonstrate the system's ability to detect and correct for control surface or actuator failures. A reconfiguration strategy, developed for the AFTI/F-16 aircraft, was employed to minimize the effects of battle damage or actuator failure. This was done by: (1) detecting and isolating the failure, (2) estimating the remaining control effectiveness, and (3) reapportioning the control power among the remaining surfaces to restore the best possible aircraft handling qualities. K.K.

A89-19661
IDENTIFICATION OF UNSTABLE FLIGHT-MECHANICAL SYSTEMS USING AN OUTPUT ERROR METHOD [IDENTIFIZIERUNG INSTABILER FLUGMECHANISCHER SYSTEME MIT EINEM AUSGANGSFEHLERVERFAHREN]
E. PLAETSCHKE (DFVLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 12, July-Aug. 1988, p. 233-240. In German. refs

The identification of unstable systems by using an output error method leads to severe numerical difficulties. In this paper, the modification of a maximum-likelihood-output error method to circumvent these difficulties is addressed. The testing of the method on a simple unstable system simulation is shown, and the use of the modified method to identify the lateral movement of the U.S. research aircraft XV-15 in hover flight is reported. C.D.

A89-19800#
COUNTERACTING SIDEWIND CONTROL SYSTEM FOR AIRCRAFT LANDING
YIDONG YANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, July 1988, p. A393-A397. In Chinese, with abstract in English. refs

The most obvious use of direct sideforce control (DSC) is for counteracting sidewind during takeoff and landing of aircraft. Based on the review of the two conventional methods (crabbed and sideslipping) for coping with a crosswind on approach, this paper presents a feasible scheme which applies DSC to facilitate correction of lateral offsets to runway. An open-loop control and closed-loop correction strategy has been employed in this scheme. The results of the digital simulation of this system show that the effect on the counteracting sidewind is obvious. Author

A89-19813#
DESIGN OF MULTI-LEVEL FLIGHT CONTROL SYSTEMS
GANG FENG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Aug. 1988, p. B407-B412. In Chinese, with abstract in English.

This paper discusses the design principle of hierarchical controllers and its application to flight control systems. A new way to the real-time realization of optimal flight control systems is explored, giving an example. Simulation results are reported which show that the achieved performance of the hierarchical optimal flight control system is almost equivalent to that of a conventional optimal flight controller. C.D.

A89-20170
AN EXAMPLE OF THE BEHAVIOR OF AN AIRCRAFT WITH ACCUMULATED ICE - LATENT INSTABILITY
JAMES W. TELFORD (Nevada, University, Reno) Journal of Applied Meteorology (ISSN 0894-8763), vol. 27, Oct. 1988, p. 1093-1108. refs

Performance details related to the unstable behavior of a research aircraft after ice accumulation which caused the aircraft to crash are examined. The data system remained fully operational during the flight and the final spiraling dive. The observations show a reduced lift effect, involving transition to partial stall on the inboard wing. The data suggest that the anomalous behavior produced an equivalent to control reversal in pitch, in which forward pressure on the control column could have induced increased lift and a nose up response. It is suggested that the effects of ice accumulation should be studied in more detail. R.B.

A89-20238
CONCEPT AND FLIGHT TESTING OF A MODERN LONGITUDINAL MOTION REGULATOR USING AN INVERSE MODEL [KONZEPT UND FLUGERPROBUNG EINES MODERNEN LAENGSBEWEGUNGSREGLERS MIT INVERSEM MODELL]
A. REDEKER (Aerodata Flugmesstechnik GmbH, Brunswick, Federal Republic of Germany) IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 731-737. In German. refs
(DGLR PAPER 87-121)

It is demonstrated that a nonlinear precontrol for longitudinal flight regulation is possible with limited identification costs, and leads to excellent results in flight accuracy. The precontrol is diagrammed and described, and the longitudinal flight and controller design are analyzed. Flight test results using the precontrol are reported. C.D.

A89-20322*# Old Dominion Univ., Norfolk, VA.
COUPLED FLOW, THERMAL, AND STRUCTURAL ANALYSIS OF AERODYNAMICALLY HEATED PANELS
EARL A. THORNTON (Old Dominion University, Norfolk, VA) and PRAMOTE DECHAUMPHAI (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987, Technical Papers. Part 1, p. 1-9) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 1052-1059. Previously cited in issue 14, p. 2164, Accession no. A87-33552. refs

A89-20323#
APPLICATION OF TRANSIENT AERODYNAMICS TO THE STRUCTURAL NONLINEAR FLUTTER PROBLEM
L. O. BRASE (McDonnell Aircraft Co., Saint Louis, MO) and W. EVERSMAN (Missouri-Rolla, University, Rolla) (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. 648-656) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 1060-1068. Previously cited in issue 14, p. 2110, Accession no. A87-33717. refs

A89-20638#
A NOTE ON THE AIRCRAFT MINIMUM-TIME TURNS
KAZUHIRO OBAYASHI and KANICHIRO KATO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 416, 1988, p. 433-439. In Japanese, with abstract in English.

Three-dimensional minimum-time turns are formulated and solved numerically as optimal control problems. The formulation covers the drag increase and the lift decrease due to sideslip. Inequality constraints are used to simulate the upper and lower bounds of thrust, angle of attack, sideslip and load factor. A state-variable constraint is included to treat the flight sustaining the corner velocity. Numerical results explain the effect of thrust, sideslip and initial velocity in optimal maneuvers. Author

N89-13438*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CONTROL OF A HUMAN-POWERED HELICOPTER IN HOVER
JOSEPH J. TOTAH and WILLIAM PATTERSON (California Polytechnic State Univ., San Luis Obispo.) Nov. 1988 65 p (NASA-TM-101029; A-88280; NAS 1.15:101029) Avail: NTIS HC A04/MF A01 CSCL 01C

The study of a control system for the Da Vinci 2 human-powered helicopter in hovering flight is documented. This helicopter has two very large, slowly rotating rotor blades and is considered to be unstable in hover. The control system is designed to introduce stability in hover by maintaining level rotors through the use of rotor tip mounted control surfaces. A five degree of freedom kinematic model was developed to study this control system and is documented. Results of this study show that the unaugmented configuration is unstable due to the large Lock Number, and the augmented configuration is stable. The role of NASA in this study included the development and analysis of the kinematic model and control laws. Both analytical and numerical techniques were used. Author

N89-14240 Maryland Univ., College Park.
CALCULATION OF THE STEADILY PERIODIC AND GUST RESPONSES OF A HINGELESS ROTOR HELICOPTER USING TWO-DIMENSIONAL TIME DOMAIN UNSTEADY AERODYNAMICS Ph.D. Thesis
ANDREW SETH ELLIOTT 1987 194 p
Avail: Univ. Microfilms Order No. DA8808542

The deterministic and random gust response of a helicopter in forward flight is examined analytically, using a state space formulation in the time domain. The gust response is considered to be a perturbation about the steadily periodic solution. The hingeless rotor blades are modelled structurally as rotating elastic beams undergoing out-of-plane bending. The blades are discretized using the finite element method and the equation of motion are transformed into a modal space using the first few normal models. The rotor hub and fuselage are considered as a rigid body with a single degree of freedom along the shaft axis. The aerodynamic forcing is developed from a two-dimensional unsteady time domain model based on an exponential series approximation for the response to an indicial change in the downwash. Compressibility effects are included. This model is converted to an equivalent state space representation at radial stations along each blade and these states are appended to the state vector. For computation of the steadily periodic rotor responses, the aerodynamic model is extended to include separation effects and dynamic stall. Results are presented for a representative helicopter flying at various combinations of advance ratio, turbulence intensity, and scale length typical of low altitude and nap-of-the-earth flight environments. These include deterministic and statistical blade loads, deflections, and hub motions. Inclusion of an appropriate unsteady model for the aerodynamic forcing is shown to be essential to accurate response prediction at high advanced ratios. Dissert. Abstr.

N89-14744# Aeronautical Systems Div., Wright-Patterson AFB, OH.
RECONFIGURABLE FLIGHT CONTROL: AN OPPORTUNITY FOR INTEGRATED DIAGNOSTICS
E. RACHOVITSKY, J. W. DAVISON, and R. E. GUTH *In* Colorado Univ., Proceedings of the Air Force Workshop on Artificial Intelligence Applications for Integrated Diagnostics p 138-161 Jul. 1987 Prepared in cooperation with Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH
Avail: NTIS HC A23/MF A01 CSCL 01C

Modern flight control technology is a key for achieving flight safety and enhanced performance for future high performance military aircraft where mission complexities and multiple subsystem integration are dominant characteristics. Integrated flight/weapon control and systems have already demonstrated dramatic improvements in aircraft lethality. Now, the Flight Dynamics Laboratory (FI) examine revolutionary integration schemes involving reconfigurable flight control techniques and fault detection and isolation (FDI) methods which will dramatically enhance aircraft survivability, yield increased lethality and provide improvements in reliability and maintainability. This paper presents an overview of key flight control R and D programs which contribute to the Flight Dynamics Laboratory's pursuit of safer, more enduring military aircraft and highlights the potential role of expert systems for diagnosis, isolation and correction of system faults. Author

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A89-18133#
AN ADVANCED FACILITY FOR COCKPIT STUDIES
P. A. LYPACZEWSKI (CAE Electronics, Ltd., Montreal, Canada) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 558-563.
(AIAA PAPER 88-3966)

As modern aircraft become appreciably more complex, a great deal of study is being done on how best to interface the pilot/operator to the equipment. In response to the U.S. Army's needs in this area a Crew Station Research and Development Facility (CSRDF) has been constructed for NASA Ames. This facility simulates a wide range of new aircraft technologies. The facility's advanced cockpit includes a wide-field-of-view fiber-optic helmet-mounted display, which is used to provide both sensor and out-the-window views of the outside world to the pilot. Interactive voice recognition and voice synthesis systems allow hands-off control of the aircraft systems. High-resolution touch-sensitive displays provide reconfigurable graphics for studies on how best to present information to the crew members. Author

A89-18900
TESTING AND CORRELATION ON AN ADVANCED TECHNOLOGY, BEARINGLESS ROTOR
KAREN PERRY and JIM WHITE (Bell Helicopter Textron, Inc.,

Fort Worth, TX) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 571-579. refs

This paper describes a wind tunnel test of a one-sixth Froude scale model of an optimized design, advanced technology, soft-inplane, bearingless rotor. The model was designed to match not only the first out-of-plane and first inplane frequencies of the full-scale optimized rotor, but also the rotor torsional and second order out-of-plane and inplane modes. The rotor support system was designed to simulate the flexibilities of the full-scale helicopter, including pylon mount flexibility, mast-bending flexibility, and control system stiffness. The model was tested for pylon stability in hover and for rotor lead-lag stability in forward flight. The effects of various aeromechanical couplings on aeroelastic stability was investigated by testing four pitch-horn/pitch-link locations. The paper presents the results of these tests and correlation with the COPTER computer analysis. Author

A89-19565
EVALUATION OF SIMULATOR MOTION CHARACTERISTICS BASED ON AGARD-AR-144 PROCEDURES
WILLIAM CHUNG and WILLIAM Y. WANG (SYRE, Moffett Field, CA) IN: Aerospace simulation III; Proceedings of the SCS Multiconference, San Diego, CA, Feb. 3-5, 1988. San Diego, CA, Society for Computer Simulation International, 1988, p. 177-188.

This paper presents the results of applying a set of motion evaluation procedures based on performance criteria developed by the North Atlantic Treaty Organization Advisory Group for Aerospace Research and Development on the Vertical Motion Simulator at Ames Research Center. The criteria being evaluated include the describing function, operational limits and acceleration noise. The procedures include the development of a real-time operating system to generate the motion system drive commands and collect the response. The data analysis reveals the describing function and operational envelopes of the six motion axes, and the cross coupling between the motion axes. Author

A89-19808#
AN INVESTIGATION OF WALL INTERFERENCE CORRECTION TO THE PRESSURE MEASUREMENT IN LOW SPEED WIND TUNNEL WITH SOLID WALLS
GUIQING JIANG (China Aerodynamics Research and Development Centre, Sichuan, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Aug. 1988, p. B375-B380. In Chinese, with abstract in English.

Pressure measurements were made on a group of cuboids and cylinders with streamlined nose in a low-speed wind tunnel. Each group consists of models of different sizes with blockage ratio of 4.4, 6, 12, and 17.5 percent, respectively. During testing the pressure on the wall of the tunnel was measured, and the pressure results corrected by wall pressure signature matrix method are presented. The results show that although the flow characteristics around the two groups of models are completely different, the pressure coefficients of different models corrected by the method tend to agree with each other. It has been proved that pressure at the stagnation point on the model is not affected by the wall and the wall blockage interference cannot be eliminated by applying dynamic pressure correction for the pressure measurement. Author

A89-19876#
INTRODUCTION OF PILOT'S OPERATIONAL WORKLOAD EVALUATION RESEARCH SIMULATOR, POWERS, IN AEROMEDICAL LABORATORY, JASDF
ZOJIRO KATOH Japan Air Self Defence Force, Aeromedical Laboratory, Reports (ISSN 0023-2858), vol. 28, Dec. 1987, p. 91-110. In Japanese, with abstract in English. refs

The design, performance, and applications of the POWERS workload-evaluation simulator, developed to reproduce the flight characteristics of a T-2 twin-engine jet trainer aircraft, are reviewed. POWERS is a fixed-base single-seat simulator with two wide-FOV computer-generated-image multipurpose displays; it permits simultaneous acquisition of pilot performance and physiological data on 140 channels and is controlled by two digital computers. Reserve ability, strain, and fatigue can be measured in order to evaluate workloads, display concepts, and cockpit configurations. Diagrams, drawings, graphs of typical data, and flow charts (all in English) are provided. T.K.

A89-19884#
METHOD FOR SIMULATING TURBULENCE CHARACTERISTICS FOR WIND ENVIRONMENT IN WIND TUNNEL
SHUZO MURAKAMI and YASUSHIGE MORIKAWA Tokyo, University, Institute of Industrial Science, Report (ISSN 0040-9006), vol. 34, no. 4, Aug. 1988, p. 177-237. In Japanese, with abstract in English. refs

Methods of analyzing problems associated with wind in urban areas and around buildings are studied from an environmental engineering point of view. Research carried out on correlations and reproductions in wind tunnels of the atmospheric boundary layer is considered. A comparison is made between numerical and experimental data on mean wind speed, pressure, turbulence intensity, power spectra, and frequency distributions. K.K.

A89-19950#
FAN ACOUSTIC MODES MEASURING SYSTEM
KOUSUKE ISOMURA, YOSHIYA NAKAMURA, and ICHIRO ISHIKAWA Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 28, July 1988, p. 244-250. In Japanese, with abstract in English. refs

The fan acoustic modes detecting system has been developed to separate fan rotor-stator and rotor-struts interaction noise to evaluate the low-noise fan design method. To measure the data, two devices were developed. One is the Induct Acoustic Modes Measuring Device to detect acoustic modes in the intake duct. The other is the Radiated Acoustic Modes Measuring Device which detects acoustic modes radiated from the duct lip to free field. To analyze the data, the Noise Data Automatic Analyzer has been developed. This can analyze multple points of noise data automatically by utilizing the multiplexer system while the measuring device is rotating slowly with some microphones on it. The system with all these devices enables detection of dominant acoustic modes within 5 dB of accuracy. Author

A89-20234
IMPROVING THE HALF-MODEL TECHNOLOGY IN THE GOETTINGEN TRANSONIC WIND TUNNEL [VERBESSERUNG DER HALBMODELLTECHNIK IM TRANSSONISCHEN WINDKANAL GOETTINGEN]
G. HEFER, H. SOBIECZKY, and S. TUSCHE (DFVLR, Goettingen, Federal Republic of Germany) IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 686-690. In German.
(DGLR PAPER 87-083)

A half-model with a boundary layer separation plate is described whose inflow is calculated using pressure measurements in the nose area and is controlled using a flap at the separation plate and a suction in the secondary flow channel. The device is suitable now only for making pressure distribution measurements, but force measurements will be made in the future. Pressure distribution test results are presented. C.D.

A89-20245
THE OETZTAL WIND TUNNEL AS BASIC IDEA AND INCENTIVE FOR PLANNING THE USAF RESEARCH CENTER AEDC TULLAHOMA [WINDKANAL OETZTAL ALS GRUNDIDEE UND ANREGUNG FUER DIE PLANUNG DES US-LUFTWAFFENFORSCHUNGSZENTRUMS AEDC TULLAHOMA]
ERNSTFRIED THIEL IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 956-963. In German. refs

The history of the Oetztal wind tunnel, in its time the largest

and most important wind tunnel in the world, is retold. The relationship of the tunnel to the USAF Tullahoma research center is examined. The role played by the Oetztal wind tunnel in aerodynamical advances is pointed out. C.D.

N89-14241* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE 13-INCH MAGNETIC SUSPENSION AND BALANCE SYSTEM WIND TUNNEL
WILLIAM G. JOHNSON, JR. and DAVID A. DRESS Jan. 1989 48 p
(NASA-TM-4090; L-16515; NAS 1.15:4090) Avail: NTIS HC A03/MF A01 CSCL 14B

NASA Langley has a small, subsonic wind tunnel in use with the 13-inch Magnetic Suspension and Balance System (MSBS). The tunnel is capable of speeds up to Mach 0.5. This report presents tunnel design and construction details. It includes flow uniformity, angularity, and velocity fluctuation data. It also compares experimental Mach number distribution data with computed results for the General Electric Streamtube Curvature Program. Author

N89-14242# Illinois Inst. of Tech., Chicago. Fluid Dynamics Research Center.
EQUIPMENT TO UPGRADE THE FACILITIES OF THE IIT (ILLINOIS INSTITUTE OF TECHNOLOGY) FLUID DYNAMICS RESEARCH CENTER Final Technical Report
JOHN L. WAY, DAVID WILLIAMS, THOMAS CORKE, HASSAN NAGIB, and MUKUND ACHARYA Jun. 1988 3 p
(Contract AF-AFOSR-0038-87)
(AD-A198084; AFOSR-88-0742TR) Avail: NTIS HC A02/MF A01 CSCL 14B

We are currently approaching the completion of the National Diagnostic Facility at IIT. The facility is based on a computer-controlled wind tunnel with a test section 4 ft. high, 5 ft. wide and 36 ft. long exhibiting very high quality flow conditions under both constant and oscillating free-stream velocity conditions. The funding of this facility was initiated under a 1983 DOD University Research Instrumentation Program (AFOSR-Grant-83-0339). A key aspect of the wind tunnel design is the manner in which heat energy produced by fan inefficiencies, is removed from the recirculating tunnel air. This involves the first use of turning vanes which also act as heat transfer elements. The system is sized to allow continuous operation of the wind tunnel at speeds of 250 fps, which is 2.5 times those of common university wind tunnels, and two hours of operation at the maximum tunnel velocity of 550 fps. This new and unique facility will be dedicated to basic research at near-flight Reynolds numbers, thereby, aiding in the design of the next generation of aircraft. The equipment acquired under this Grant has made many of these objectives become realities. GRA

N89-14243# Rockwell International Corp., Columbus, OH. Aircraft Operations.
FABRICATION AND TESTING OF LIGHTWEIGHT HYDRAULIC SYSTEM SIMULATOR HARDWARE. PHASE 2: ADDENDUM Report, 15 Nov. 1985 - 15 Jul. 1988
WILLIAM N. BICKEL and ROBERT K. HANING Jul. 1988 107 p
(Contract N62269-80-C-0261)
(AD-A198524; NA-88-0011; NADC-79024-60-1) Avail: NTIS HC A06/MF A01 CSCL 20D

Follow-on work was conducted in a development program to design, fabricate, and test a full scale 8000 psi Lightweight Hydraulic System simulator. The principal task was the performance of an additional 600 hours of mission/profile cycling (1200 hours total). Three flight control actuators completed approximately 5 million cycles under simulated aircraft loading. All minor hydraulic components performed satisfactorily. The results demonstrated that 8000 psi hydraulic systems pose no technological problems for aircraft applications. Other tasks completed were ground support equipment re-work, piston seal evaluation test, coil tube design guidelines, black residue investigation, hybrid pump development, and tube fitting re-design. GRA

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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.

A89-17745#
CONCEPTUAL STUDY OF TURBO-ENGINES FOR HORIZONTAL TAKEOFF AND LANDING SPACE PLANE
HIROYUKI NOUSE, MITSUHIRO MINODA, RYOOJI YANAGI (National Aerospace Laboratory, Chofu, Japan), TEIICHI TAMAKI, and TETSUJI FUJIMURA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p.
(IAF PAPER 88-253)

A Hotol SSTO vehicle that employs an airbreathing powerplant for acceleration from takeoff to Mach 6, whereupon scramjet, and then rocket, powerplants supply thrust for acceleration to orbital velocity, is presently evaluated in light of the capabilities of air turboramjet or turboramjet airbreathing propulsion systems. Higher specific thrust scramjets and lower weight airbreathing engines generally are identified as prerequisites for successful SSTO vehicles of this type. O.C.

A89-17929
HYPERVELOCITY TECHNOLOGY ESCAPE SYSTEM CONCEPTS PROGRAM
ARUN K. TRIKHA (Boeing Co., Seattle, WA) and LANNY A. JINES (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) SAFE Journal, vol. 18, Fall 1988, p. 6-15. refs

Hypervelocity technology escape system design requirements are addressed. A preliminary evaluation of sixteen candidate escape system concepts showed that only three of these concepts can satisfy the established crew escape and crew protection requirements over the whole flight envelopes of the study vehicles. The results showed that an encapsulated seat with thermal protection was overall superior to an escape capsule with thermal protection for both study vehicles. Author

A89-19870
LOW-ORBIT NAVIGATION CONCEPTS
H. JAMES ROME (Lowell, University, MA) Navigation (ISSN 0028-1522), vol. 35, Fall 1988, p. 371-390. DOT-supported research.

Low-orbit, inexpensive navigation satellite concepts applicable to civil aviation are developed as an alternative to GPS. Details are provided on orbits, signal structure, positioning software, power budget, and estimated costs and risks. Comprehensive error analysis indicates that a 2 dRMS accuracy of approxiamtely 85 m is achievable, and that the system is fault-tolerant. Rough estimates indicate that the satellite configuration will cost about $300 million. Author

A89-20233
NEW APPLICATION POSSIBILITIES FOR BALLOON-BORNE CASE STUDIES - MIKROBA (MICROGRAVITY BY BALLOONS) [NEUE ANWENDUNGSMOEGLICHKEITEN VON BALLONGESTUETZTEN FALLVERSUCHEN - MIKROBA /MIKRO-GRAVITATION MIT BALLONEN/]
E. OVERESCH, K. KRETSCHMAR, and H. STOCKFLETH (OHB-System GmbH, Bremen, Federal Republic of Germany) IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 662-669. In German.
(DGLR PAPER 87-069)

The MIKROBA (Microgravity by Balloons) project for achieving microgravity conditions aboard balloons is discussed. The usefulness of microgravity for certain industrial processes and

systems for producing microgravity are reviewed, and the rationale for MIKROBA is described. The structure of the MIKROBA system is addressed, including the attitude control, propulsion, salvage system, and flight control. C.D.

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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.

A89-17619
DWELL TIME EFFECTS ON THE FATIGUE BEHAVIOUR OF TITANIUM ALLOYS
Z. SONG and D. W. HOEPPNER (Utah, University, Salt Lake City) International Journal of Fatigue (ISSN 0142-1123), vol. 10, Oct. 1988, p. 211-218. refs

Dwell effects on titanium alloys have drawn much attention since the in-service failure of RB 211 fan disks in the early 1970s. Different test methods and specimens have been used by different investigators, and there is wide discrepancy and even contradiction in the results. This study attempts to correlate findings from different researchers to draw some conclusions and to rationalize the existing discrepancies in the results. Suggestions are presented for future work to achieve better understanding of dwell effects on the behavior of titanium alloys and other materials. Author

A89-17622
PM AL ALLOYS - HOT PROSPECTS FOR AEROSPACE APPLICATIONS
W. E. FRAZIER (U.S. Navy, Naval Air Development Center, Warminster, PA) Advanced Materials and Processes (ISSN 0882-7958), vol. 134, Nov. 1988, p. 42-46. refs

A development status report is presented for dispersion-strengthened P/M Al alloys, whose resistance to creep deformation and fatigue at service temperatures in excess of 375 C recommends them as lower-density replacements for more expensive Ti alloys in supersonic aircraft primary airframe structures and moderate-temperature turbine engine sections. The most highly developed P/M Al alloys for such elevated-temperature applications are those produced via rapid solidification processing in the Al-Fe-X system, where X is Ce, Mo, Cr, or V; their strength and thermal stability is attributable to fine dispersions of incoherent intermetallic phases, oxides, and carbides. O.C.

A89-18650
PERFORMANCE OF COATED MATERIALS IN HIGH-ENTHALPY OXIDIZING GAS FLOWS [RABOTOSPOSOBNOST' MATERIALOV S POKRYTIIAMI V VYSOKOENTAL'PIINYKH OKISLITEL'NYKH GAZOVYKH POTOKAKH]
P. D. LEBEDEV, A. G. SMOLIN, V. S. TERENT'EVA, and N. V. KHOLODKOV Akademiia Nauk SSSR, Izvestiia, Metally (ISSN 0568-5303), Sept.-Oct. 1988, p. 157-164. In Russian.

Methods of the analysis of the oxidizing capacity of gas flow are examined with reference to conditions typically encountered in the operation of high-speed flight vehicles. In particular, it is demonstrated that testing in stationary or low-velocity gas media is unacceptable for coatings used under conditions of high heat transfer coefficients and pressure gradients. Performance testing of such coatings must include laboratory testing under conditions of multiparametric modeling. The heating temperature of the material should be calculated with allowance for the possibility of local superheating due to oxidation in the defect zone. V.L.

A89-18925
ENVIRONMENTALLY INDUCED CRACKING IN ALUMINUM
LUIS R. RODRIGUEZ (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 911-923. refs

Normal storage conditions can result in spontaneous body fractures in some Al alloys. Forged 7049T73 appears to be highly susceptible to this failure mechanism and is the primary subject of this paper. The very unusual failure mode is characterized by critical crack formation and resultant static fracture in the parting plane of the forging. This environmentally induced cracking region is intergranular and resembles stress-corrosion cracking, except that there are no corrosion products. The failure mode was reproduced by extended exposure to conditions up to 180 F and 90 percent RH, with the resulting data used to predict real life-to-failure. Author

A89-19481
CHEMICAL VAPOR DEPOSITION OF OXIDATION RESISTANT HFB2 + SIC COMPOSITE COATINGS
W. J. LACKEY, ARLYNN W. SMITH, and DOUGLAS J. TWAIT (Georgia Institute of Technology, Atlanta) Ceramic Engineering and Science Proceedings (ISSN 0196-6219), vol. 9, Sept.-Oct. 1988, p. 1223-1231. refs
(Contract N00014-87-K-0036; N60921-86-C-0035)

Prior testing has repeatedly shown an HfB2 + SiC composite to have oxidation resistance superior to that of HfB2 or SiC. The majority of the prior work has relied on hot pressing or hipping for fabrication. Attempts to prepare the material by chemical vapor deposition have been unsuccessful. Computerized thermodynamic free energy minimization calculations have been performed that predict reagent concentrations for the HfCl4-CH3-SiCl3-BCl3-H2 system which should result in the codeposition of the HfB2 + SiC composite at 1200-1500 K. Coatings of HfB2 + SiC offer potential for oxidation protection of graphite and carbon-carbon composites. Author

A89-20243
STRENGTH OF DYNAMICALLY LOADED FORCE INTRODUCTION FOR FIBER-REINFORCED ROTORS [FESTIGKEIT VON DYNAMISCH BEANSPRUCHTEN KRAFTEINLEITUNGEN FUER FASERVERBUNDROTOREN]
H. BANSEMIR (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 873-898. In German. refs
(DGLR PAPER 87-108)

Research results on retaining and bolt elements as well as glues whose function is to retard erosion in fiber-reinforced composite helicopter rotor blades are discussed. Force introduction requirements for such rotors are reviewed. The dynamic strength of bolts, retaining bonds, and erosion protection glues is addressed. C.D.

A89-20244
CARBON FIBER COMPOSITES FOR SUPERSONIC TECHNOLOGY [CFC-VERBUNDWERKSTOFFE FUER DEN UEBERSCHALLFLUG]
H. LEIS (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) IN: Yearbook 1987 II; DGLR, Annual Meeting, Berlin, Federal Republic of Germany, Oct. 5-7, 1987, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1987, p. 899-921. In German.
(DGLR PAPER 87-124)

The production of carbon fiber composites for the supersonic high-temperature environment is discussed. The fabrication of the fiber network, protection against oxidation, and the joining technology are addressed. The requisite characteristics of the finished product are examined, and the use of the composite in aircraft applications is considered. C.D.

N89-13642*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THERMAL BARRIER COATINGS. ABSTRACTS AND FIGURES

1985 220 p Workshop held in Cleveland, Ohio, 21-22 May 1985
(NASA-CP-10019; E-4425; NAS 1.55:10019) Avail: NTIS HC A10/MF A01 CSCL 11C

The Thermal Barrier Coatings Workshop was held May 21 and 22, 1985, at the NASA Lewis Research Center in Cleveland, Ohio. Six sessions covered Failure Mechanisms and Life Modeling, Effects of Oxidation and Creep, Phase Stability and Microstructural Aspects, Nondestructive and Analytical Assessment, Coating Development, and Alternative Applications.

N89-13643*# Garrett Turbine Engine Co., Phoenix, AZ.
DEVELOPMENT OF THERMOMECHANICAL LIFE PREDICTION MODELS FOR THERMAL BARRIER COATINGS
T. E. STRANGMAN *In* NASA, Lewis Research Center, Thermal Barrier Coatings. Abstracts and Figures p 1-7 1985
Avail: NTIS HC A10/MF A01 CSCL 11C

Thermal barrier coatings (TBCs) for turbine airfoils in high-performance engines represent an advanced materials technology with both performance and durability benefits. The foremost TBC benefit is the reduction of heat transferred into air-cooled components. To achieve these benefits, however, the TBC system must be reliable. Mechanistic thermomechanical and thermochemical life models and statistically significant design data are therefore required for the reliable exploitation of TBC benefits on gas turbine airfoils. Garrett's NASA-HOST Program (NAS3-23945) is designed to fulfill these requirements. This program focuses on predicting the lives of two types of strain-tolerant and oxidation-resistant TBC systems that are produced by commercial coating suppliers to the gas turbine industry. The plasma-sprayed TBC system, composed of a low-pressure plasma-spray (LPPS) applied oxidation resistant NiCrAlY bond coating, and an air-plasma-sprayed yttria partially stabilized zirconia insulated layer is applied by both Chromalloy and Klock. The second type of TBC is applied by the electron beam-physical vapor deposition process by Temescal. Thermomechanical life models are being tailored to predict TBC strain tolerance in terms of materials, engine, and mission parameters. Continuum and fracture mechanics approaches and statistical methods are being evaluated to develop tensile and compressive strain functions required to drive a mission analysis capable thermomechanical life model for TBCs. Results of initial testing to calibrate these life models will be presented. Author

N89-13648*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN INVESTIGATION OF ENVIRONMENTAL INFLUENCE ON THE CREEP BEHAVIOR OF A LOW PRESSURE PLASMA SPRAYED NICOCRALY ALLOY
M. G. HEBSUR and R. V. MINER *In its* Thermal Barrier Coatings. Abstracts and Figures p 53-58 1985
Avail: NTIS HC A10/MF A01 CSCL 11C

Low pressure sprayed MCrAlY overlay coatings are currently being used on advanced single crystal superalloy blades for gas turbine engines. Many studies were made on the influence of coatings on the mechanical properties of superalloys in oxidizing or hot-corroding environments, but very few on the properties of the bulk coating alloy itself. The creep behavior of a typical NiCoCrAlY alloyd (PWA 276) was studied in air and vacuum. The as-received low pressure plasma sprayed NiCoCrAlY plates were heat treated for 4 h at 1080 C followed by 32 h at 870 C, the heat treatment applied to coated superalloy parts. Standard creep specimens 12.7 mm long and 3.2 mm in diameter were then machined. Constant load creep-rupture tests were performed in air and vacuum at 650, 850, and 1050 C and various initial stresses. In addition, some specimens were preoxidized at 1050 C for 100 h prior to testing. Results are briefly discussed. Author

N89-13660*# Rolls-Royce, Inc., Atlanta, GA.
HIGH TIME SERVICE EVALUATION OF THERMAL BARRIER COATINGS ON THE ROLLS-ROYCE RB211 ENGINE
F. CHRIS TORIZ *In* NASA, Lewis Research Center, Thermal Barrier Coatings. Abstracts and Figures p 187-196 1985
Avail: NTIS HC A10/MF A01 CSCL 11C

One of the main concerns of airline operators for the use of thermal barrier coatings (TBC) in the turbine is that the coating will spall and cause a premature engine removal. Even though much cyclic data is available on TBCs, high time data is much harder and expensive to come by. The typical 150 h type test used to qualify hardware, or modifications, falls far short of the 5 to 10,000 hour experience desired. One way to obtain data demonstrating the longevity of TBCs is through a service evaluation program on a commercial engine. For a meaningful evaluation of the TBC system it must be applied to a component which operates in a typical hot end environment. In addition the component performance should not suffer if the coating is lost. For these reasons Rolls-Royce chose to coat the IP turbine nozzle guide vanes, and run these in an RB211 engine. Two ceramic top coats and several different bond coats were tested in a rainbow fashion on several engines. Three layer magnesium zirconate was used as a base line. Various yttria stabilized zirconia ceramics were used. Top MCrAlY bond coats were applied by various techniques. Some of the coated vanes have now accumulated ofer 5000 hours. The results are presented from the first sets with 2500 and 4200 hours of service respectively. Author

N89-14264*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MATERIALS AND STRUCTURES FOR HYPERSONIC VEHICLES
DARREL R. TENNEY, W. BARRY LISAGOR, and SIDNEY C. DIXON Oct. 1988 46 p Presented at the 16th Congress of the International Council of Aeronautical Sciences (ICAS), Jerusalem, Israel, 28 Aug. - 2 Sep. 1988 Previously announced in IAA as A89-13542
(NASA-TM-101501; NAS 1.15:101501) Avail: NTIS HC A03/MF A01 CSCL 11D

Hypersonic vehicles are envisioned to require, in addition to carbon-carbon and ceramic-matrix composities for leading edges heated to above 2000 F, such 600 to 1800 F operating temperature materials as advanced Ti alloys, nickel aluminides, and metal-matrix composited; These possess the necessary low density and high strength and stiffness. The primary design drivers are maximum vehicle heating rate, total heat load, flight envelope, propulsion system type, mission life requirements and liquid hydrogen containment systems. Attention is presently given to aspects of these materials and structures requiring more intensive development. Author

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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.

A89-17401* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MECHANICS OF FATIGUE CRACK CLOSURE
J. C. NEWMAN, JR., ED. (NASA, Langley Research Center, Hampton, VA) and WOLF ELBER, ED. (U.S. Army, Army Aerostructures Directorate, Hampton, VA) Philadelphia, PA, American Society for Testing and Materials, 1988, 675 p. For individual items see A89-17402 to A89-17435.

Papers are presented on plasticity induced crack closure, crack closure in fatigue crack growth, the dependence of crack closure on fatigue loading variables, and a procedure for standardizing crack closure levels. Also considered are a statistical approach to crack closure determination, the crack closure behavior of surface

cracks under pure bending, closure measurements on short fatigue cracks, and crack closure under plane strain conditions. Other topics include fatigue crack closure behavior at high stress ratios, the use of acoustic waves for the characterization of closed fatigue cracks, and the influence of fatigue crack wake length and state of stress on crack closure. R.R.

A89-17448
STRESS INTENSITY FACTORS FOR PERIODIC RADIAL CRACKS IN A ROTATING DISC
D. P. ROOKE (Royal Aircraft Establishment, Farnborough, England) and J. TWEED (Old Dominion University, Norfolk, VA) International Journal of Engineering Science (ISSN 0020-7225), vol. 26, no. 10, 1988, p. 1059-1069. refs

Stress intensity factors have been derived for periodically distributed radial cracks in rotating disks; both internal and edge cracks have been studied. It is shown that in general as the number of cracks increases, there is a shielding effect which lowers the stress intensity factors. Author

A89-17979
INTERFACING SENSOR ASSEMBLIES WITH WINDOWLESS COCKPIT DISPLAYS
JOHN J. DEVORE (Kansas State University, Manhattan) IEEE Transactions on Instrumentation and Measurement (ISSN 0018-9456), vol. 37, Dec. 1988, p. 501-505. Research sponsored by the Boeing Military Airplane Co.

An interface for converting aircraft instrument information into a video display was created. Due to the limited development time available, the interface was divided into two subsystems. The goal of the division was to allow concurrent work on two major system components. The division used greatly aided the development, test, and calibration tasks. The key to being able to develop and test them simultaneously was attributable to two factors. Both subsystems had local intelligence in the form of microprocessors, and their interconection was kept physically simple. Testing of each subsystem was accomplished by simulating the other subsystem on a general-purpose computer. It is concluded that the testing went as expected. The only suprise when the instrument interface was eventually connected to the PC was the lock-up problem. The system specifications and design, the instrument-to-PC interface, the PC-resident software, and subsystem test and calibration are described. I.E.

A89-18094#
SHARING THE PROTECTION OF AIRCRAFT ELECTRONIC SYSTEMS AGAINST THE EFFECTS OF HIGH-LEVEL ELECTROMAGNETIC ENVIRONMENTS BETWEEN TRADITIONAL PROTECTION AND SYSTEM ARCHITECTURE
RICHARD F. HESS, LARRY J. YOUNT (Honeywell, Inc., Phoenix, AZ), HENRY KNOLLER (Lockheed Aeronautical Systems Co., Burbank, CA), GERALD M. MASSON (Johns Hopkins University, Baltimore, MD), and WILLIAM E. LARSEN (FAA, Moffett Field, CA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 294-307. refs
(AIAA PAPER 88-3917)

It is shown how architectural techniques can be used as a complement to traditional protection techniques to provide additional protection of sensitive avionics against high-level electromagnetic fields. Consideration is given to potential threats, the data processor susceptibility response, protection from the threat, system architecture, and transparent recovery. The wave shape of engineering waveforms that reproduce important lightning waveform parameters (amplitude, rise time, and action integral) is presented. K.K.

A89-18104#
FIBER OPTIC APPLICATIONS TO THE HIGH ALTITUDE RECONNAISSANCE VEHICLE
C. E. POLCZYNSKI (Lockheed Aeronautical Systems Co., Burbank, CA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 382, 383.
(AIAA PAPER 88-3930)

Some fiber optic systems for the high-altitude reconnaissance vehicle are described. These are: (1) a single-fiber full duplex transmission system for multiple signals, and (2) a very-high-speed data distribution network incorporating a crosspoint switch. The electronic switch network will use an off-the-shelf GaAs switch. K.K.

A89-18105#
RELIABILITY IN FIBER OPTIC CABLE HARNESS MANUFACTURING
BRUCE M. MCCOY (Boeing Military Airplanes, Wichita, KS) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 384-389.
(AIAA PAPER 88-3931)

Key aspects of manufacturing cable harnesses for aircraft and spacecraft that incorporate optical fiber/cables along with traditional wiring are discussed. Issues regarding feasibility of automation of assembly processes, manual assembly, testing, installation, quality assurance, reliability and maintainability are addressed. Training procedures, formal training programs, and their results are reviewed. Author

A89-18158#
THE HIGH SPEED BUS TECHNOLOGY DEVELOPMENT PROGRAM
M. T. LUDVIGSON, M. B. MODROW (Rockwell International Corp., Cedar Rapids, IA), and P. C. GOLDMAN (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 714-718.
(AIAA PAPER 88-4005)

The current development status of a high-speed data bus to link MIL-STD-1750A computers in avionics applications is reviewed and illustrated with diagrams and photographs. The bus requirements include data rate 50 Mb/s, a linear token-passing scheme permitting both electronic and fiber-optic implementation, up to 64-terminal capacity, maximum terminal separation 300 ft, latency control via token-rotation-timer priority, self-test and bus-loop test capability, and automatic clock synchronization. The design concept and performance of a breadboard wire bus tested in July 1986 are discussed in detail, with particular attention to the redundancy manager, the output controller, the input controller, the ringmaster topology manager, and typical initial-placement problems. T.K.

A89-18159#
AN SAE HIGH SPEED RING BUS OVERVIEW
BRIAN W. KROEGER and HUBERT SHIH (Westinghouse Electric Corp., Electronic Systems Group, Baltimore, MD) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 719-723. refs
(AIAA PAPER 88-4008)

An overview of the protocols and important features of the SAE high-speed ring bus (HSRB) standard is presented here, along with the functional design of a typical ring interface unit architecture. The counterrotating ring topology, with both loopback and bypass mechanisms, provides the high degree of fault tolerance desirable in many military and avionic systems. The error-detection, fault-detection, and recovery mechanisms are briefly described to illustrate the robustness of the HSRB system. The reserved-priority token-passing protocol is shown to provide efficient and deterministic performance, uselful in real-time applications where messages must be transmitted predictably, quickly, and reliably. Author

A89-18161#
THE FIBER OPTIC DATA DISTRIBUTION NETWORK - A NETWORK FOR NEXT-GENERATION AVIONICS SYSTEMS
MARC D. COHN (Northrop Corp., Advanced Systems Div., Pico Rivera, CA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 731-737. refs
(AIAA PAPER 88-4011)

A fault-tolerant, high-performance interprocess communications mechanism is required to support next-generation avionic platforms. The fiber-optic data distribution network (FDDN) provides the high degree of availability and real-time performance necessary for distributed avionic systems. State-of-the-art communication protocols, network management, and VLSI technology have been incorporated into the FDDN approach to offer avionic designers a powerful tool. Avionics communication requirements are briefly examined, and the FDDN architecture is presented. Author

A89-18185#
COMPUTER-AIDED ENGINEERING METHODS FOR SUCCESSFUL VHSIC APPLICATION
R. GARY WOOD (Boeing Electronics Co., Seattle, WA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 887-894. refs
(AIAA PAPER 88-4035)

Through the example of a VHSIC implementation of a MIL-STD-1750A avionic processor subsystem, an effective approach has applied CAE methods tailored to the job of VHSIC integration. Structured hierarchical design organization combined with rigorous mixed-mode digital simulation permitted an entire VHSIC-based subsystem and its integral application-specific IC design to be verified with a high degree of confidence. Accurate performance data were obtained well in advance of fabrication. Author

A89-18644
A STUDY OF CONTACT INTERACTION IN AIRCRAFT STRUCTURAL ELEMENTS [ISSLEDOVANIE KONTAKTNOGO VZAIMODEISTVIIA V ELEMENTAKH AVIATSIONNYKH KONSTRUKTSII]
V. I. GRISHIN and T. K. BEGEEV Problemy Prochnosti (ISSN 0556-171X), Sept. 1988, p. 84-87. In Russian. refs

A procedure for calculating contact interaction between the structural elements of aircraft is proposed which employs the method of finite elements in displacements. The method has been implemented in a specialized software pack. The convergence and reliability of the method are evaluated, and solutions are presented for two-dimensional, axisymmetric, and three-dimensional problems involving riveted and bolted joints. V.L.

A89-18741
GROUND SIMULATION FOR AIRBORNE EQUIPMENT
D. SIMS (British Aerospace, PLC, Air Weapons Div., Hatfield, England) Environmental Engineering (ISSN 0954-5824), vol. 1, Sept. 1988, p. 31-33, 36. refs

This paper discusses the application of acoustic techniques for realistic representation of the service environment for airborne equipment and for the reproduction of the various stresses of operational life in the correct combinations, sequences, and levels. It is shown that vibrations of the type similar to that seen in service can be induced by applying high-intensity noise to the outer skin; it is possible to provide the required distributed input to the store's surface in all axes at once. The U.S. and the U.K. programs set up to develop acoustic techniques have demonstrated that the acoustic method of testing yields superior results, as compared to methods that use mechanical vibrators, in representing the aircraft carriage flight vibrational environment. I.S.

A89-18757
GAAS MMICS SATISFY EW REQUIREMENTS
JAIME G. TENEDORIO (Harris Corp., Microwave Semiconductor Div., Milpitas, CA) and JAMES J. KOMIAK (General Electric Co., Fairfield, CT) Microwaves & RF (ISSN 0745-2993), vol. 27, Nov. 1988, p. 51, 52, 54, 56. refs

The characteristics of GaAs MMICs are discussed with emphasis placed on the features required for their application to electronic warfare. Several examples of GaAs MMICs developed for phased-array application are described. Attention is also given to an X-band MMIC-based module designed for the multifunction active-array radar for fighter aircraft and to a C-band T/R module designed for a ground-based tactical radar. Two examples of GaAs MMIC applications to electronic countermeasure technology are presented. I.S.

A89-18766
MODAL ANALYSIS OF CONTINUOUS ROTOR-BEARING SYSTEMS
C.-W. LEE and Y.-G. JEI (Korea Advanced Institute of Science and Technology, Seoul, Republic of Korea) Journal of Sound and Vibration (ISSN 0022-460X), vol. 126, Oct. 22, 1988, p. 345-361. refs

Modal analysis is applied to continuous rotor systems with various boundary conditions, including isotropic and anisotropic natural boundary conditions. The rotor includes the effects of rotary inertia and gyroscopic moment. In particular, the whirl speeds and mode shapes, backward and forward, of a rotating shaft are obtained as spin speed and boundary conditions vary, and the unbalanced responses are calculated by using modal analysis. The effects of asymmetry in boundary conditions on the system dynamic characteristics are also investigated. Author

A89-18801
A GUIDE TO CLASSICAL FLUTTER
L. T. NIBLETT Aeronautical Journal (ISSN 0001-9240), vol. 92, Nov. 1988, p. 339-354. refs

First essentials of classical flutter are demonstrated by a comprehensive study of the behavior of a lifting surface with two degrees of freedom under the action of airforces limited to those in phase with displacement. Structural coupling between the coordinates is eliminated by taking the normal modes to be the deflection coordinates, and this results in conditions for stability with particularly concise forms. It is shown that the flutter stability can be seen to be very much a matter of the relative amplitudes of heave and pitch in the normal modes. In-quadrature airforces are then introduced and it is shown that they have little effect when the flutter is severe. They are of more importance in the milder forms of flutter, the extreme of which are shown to be little different from instabilities in a single degree of freedom. Author

A89-18852
A 'NEW' PHILOSOPHY OF STRUCTURAL RELIABILITY, FAIL SAFE VERSUS SAFE LIFE
KENNETH B. AMER (Rand Corp., Santa Monica, CA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 3-16. refs

The draft RFP for the U.S. Army's LHX requires a factor of reliability against catastrophic failure of 0.999999 in a 10,000-hour service life; any attempt to meet this requirement through a safe-life design approach will impose major weight and cost penalties relative to current stress-analysis procedures. An account and comparative evaluation is presently given for the alternative, 'fail-safe' redundant design approach, and to the possibility of combining fail-safe and safe-life design practices where required. The combination of the two approaches eliminates both weight and cost penalties while reducing the probability of catastrophic failure. O.C.

A89-18871
HELICOPTER VIBRATION ANALYSIS AND CONTROL
DALE CLAY (McDonnell Douglas Helicopter Co., Mesa, AZ) and

JIM CHADWICK (Chadwick-Helmuth Co., Inc., El Monte, CA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 243-250. refs

The present evaluation of available methods for helicopter vibration characteristics' determination-and-control projects prospective, Higher Harmonic Control (HHC) systems in light of both observed technology-performance trends and the features and capabilities of the recently implemented OH-6A helicopter HHC system. In the OH-6A, the HHC hydraulic actuators have been placed in parallel with the existing control system to allow fail-safe reversion in the event of hydraulic failure. Attention is given to the effects of HHC on blade and pitch-link loads, tail boom vibrations, and transient maeuvers. O.C.

A89-18884
OPTIMAL DESIGN OF AN ADVANCED COMPOSITE ROTATING FLEXBEAM
BRIAN HAMILTON, JAMES PETERS, and CYNTHIA CALLAHAN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 409-421.

This paper presents an automated procedure for the design analysis of composite flexbeams for bearingless rotor hubs. State-of-the-art finite element and optimization methods were incorporated to develop a mathematical model which is used to perform flexbeam sizing. The automation of this analysis tool enables flexbeam design iterations to be reduced from nearly six months to less than a week with a minimum of computational requirements. C.D.

A89-18891
NONDESTRUCTIVE TESTING OF COMPOSITE AIRCRAFT STRUCTURES WITH INFRARED AND SHEAROGRAPHIC IMAGING TECHNOLOGIES
JOHN W. NEWMAN (Laser Technology, Inc., Norristown, PA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 481-485.

The increased use of advanced composite materials for primary aircraft structures and blading has placed new and difficult demands on the traditional methods of nondestructive testing, from both the productivity and maintainability standpoints. Two new technologies, electronic shearography and thermal/microwave coupled infrared imaging, offer dramatic increases in testing throughput and sensitivity to defects in materials and structures. Electronic shearography has a proven application in the detection of unbonds, crushed core, impact damage, and delamination in composites, honeycomb, and foam-cored structures. Corrosion in aluminum honeycomb is easily detected. Thermal/microwave coupled infrared imaging can easily detect delaminations and entrapped moisture. The paper will provide a background to these new technologies and discuss field tests. Author

A89-18892
ACHIEVING RELIABILITY AND MAINTAINABILITY GOALS WITH A COMPOSITE MAIN ROTOR BLADE
JAMES T. HALL and HERMAN FRANKS (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 487-492.

The UH-1H Composite Main Rotor Blade (CMRB) represents the current state-of-the-art in main rotor blades. To complement the new design, stringent R&M requirements were imposed. The intensive design support program and an extensive test/validation/demonstration effort to qualify the blade are described. The CMRB has had the most extensive test program ever pursued in the development of a main rotor blade. Fatigue tests were performed on both clean and repaired blades. A MIL-STD-471A maintainability demonstration was conducted which included 37 blade repairs of typical field incurred damage. Following the demonstration, the repaired blade underwent a 100-hour whirl test. Numerous other tests, such as simulated tree strikes, rain/sand erosion, and paint adhesion were also performed. Author

A89-18894
GENESIS OF A FLEXIBLE TURNING CENTER
PAUL SANCLEMENTE and ROBERT D. FRENCH (General Electric Co., Lynn Aircraft Engine Production Div., MA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 497-503.

GE - Aircraft Engines has designed, built, and is operating a flexible turning center for jet engine hardware. Although the plant is in the forefront of manufacturing technology development, it was intended from the start to be a production facility. So while there was much to learn from being involved in all phases of the project, meeting production schedules was, and is, key to its success. This paper reviews the early history of the project and ends with a view of its recent production status. Author

A89-18895
AUTOMATED WIRE PREPARATION SYSTEM
DEBORAH J. MCCULLEY (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 505-511.

The first step toward an automated wire harness facility for the aerospace industry has been taken by implementing the Wire Vektor 2000 into the wire harness preparation area. An overview of the Wire Vektor 2000 is given, including the facilities for wire cutting, marking, and transporting, for wire end processing, and for system control. Production integration in the Wire Vektor 2000 system is addressed, considering the hardware/software debug system and the system throughput. The manufacturing changes that have to be made in implementing the Wire Vektor 2000 are discussed. C.D.

A89-18897
DYNAMIC MODELING OF A HELICOPTER LUBRICATION SYSTEM
WILLIAM A. WELSH (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 531-544. refs

A dynamics model of a typical helicopter transmission lubrication system is presented. The computer fluid and structural model is shown to correctly simulate both mean pressures and also a troublesome self-excited pressure oscillation phenomenon seen in test. The model is effectively utilized to predict the efficacy of design changes intended to stabilize the chatter. Author

A89-18906* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED TRANSMISSION STUDIES
JOHN J. COY (NASA, Lewis Research Center, Cleveland, OH) and ROBERT C. BILL (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 651-662. Previously announced in STAR as N88-21454. refs

The NASA Lewis Research Center and the U.S. Army Aviation Systems Command share an interest in advancing the technology for helicopter propulsion systems. In particular, this paper presents highlights from that portion of the program in drive train technology and the related mechanical components. The major goals of the program are to increase the life, reliability, and maintainability; reduce the weight, noise, and vibration; and maintain the relatively high mechanical efficiency of the gear train. The current activity emphasizes noise reduction technology and analytical code development followed by experimental verification. Selected significant advances in technology for transmissions are reviewed, including advance configurations and new analytical tools. Finally, the plan for future transmission research is presented. Author

A89-18907
ADVANCED LUBE SYSTEM DIAGNOSTICS FOR V-22
HENRY M. BELMAN and FRANK DIPASQUALE (Aeroquip Corp., Tedeco Div., Glenolden, PA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 663-671. refs

The next generation of military aircraft, entering service in the early to mid-1990s will incorporate innovative sensing technology in many systems in order to maximize reliability and maintainability characteristics, improve safety and operational readiness and reduce the cost of ownership. A sophisticated new concept in on-line, oil debris based diagnostics - the Quantitative Debris Monitor (QDM) - used in conjunction with a uniquely designed housing, which insures a very high probability of wear particle capture, has been applied to the V-22 so as to optimize early failure detection capability and reduce the 'false alarm' rate. The OSPREY is unique in the fact that it will be the first aircraft to utilize this system in both engines and gearboxes. This paper will discuss the details of the application of these devices - in the form of new sensors, supporting integrated circuits and novel oil debris separators - for each gearbox and engine of the V-22. Author

A89-18926
MATRIX ANALYSIS METHOD FOR COMPOSITE FLEXBEAM
SMRITIMAY DATTA and ROBERT R. FILLER (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 925-929.

A helicopter rotor composite flexbeam is discussed and a method of analysis is presented. The flexbeam is modeled into a number of beam elements. The analysis has two major divisions - overall beam load-displacement analysis and ply analysis in the individual beam elements for the computed loadings. The methodology presented for beam analysis is a direct method which is derived from the basic techniques of structural analysis. Since a composite flexbeam may be represented by an assemblage of one-dimensional elements only, the direct method is as powerful as the variational method of finite element analysis. Author

A89-18936#
ROBOTIC DEBURRING OF COMPLEX MACHINED PARTS
FREDERICK C. EDMAN and GARY H. BURDORF (McDonnell Douglas Helicopter Co., Mesa, AZ) AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Paper. 4 p.

Using an articulated-arm five axis robot, McDonnell Douglas Helicopter Company has developed a robotic deburring and blending cell for complex machined parts. Previous to the development of this robotic deburring cell, most deburring and blending was performed manually with hand-held airmotors equipped with abrasive disks, wheels, brushes, or rotary files. This labor-intensive methodology for deburring AH-64 Apache machined parts leads to inconsistent edge finishes from part to part, in addition to being fatiguing and repetitious for the operator. The robotic deburring cell was implemented into production in July of 1987. Some of the benefits achieved by the robotic cell are: 60 percent reduction in deburr cycle times, improved quality, and eliminated part rework. Author

A89-19125
DYNAMICS OF A RIGID ROTOR MOUNTED ON DISCONTINUOUSLY NON-LINEAR ELASTIC SUPPORTS
R. D. NEILSON and A. D. S. BARR (Aberdeen, University, Scotland) Institution of Mechanical Engineers, Proceedings, Part C - Mechanical Engineering Science (ISSN 0263-7154), vol. 202, no. C5, 1988, p. 369-376. Research supported by the Ministry of Defence. refs

The equations of motion of a rigid rotor mounted at both ends in discontinuously nonlinear supports and subject to excitation by arbitrary imbalance are presented. The methods used to solve the equations are described briefly and the responses obtained from the model and an experimental rig are discussed and compared. Good correlation is found. Over a range of shaft speed the presence of aperiodic responses characterized by spectral sidebands which diverge with increasing shaft speed is noted. An explanation of the mechanism generating these sidebands is advanced. Author

A89-19718
TURBINE DESIGN USING COMPLEX MODES AND SUBSTRUCTURING
H.-L. OLAUSSON (ABB Stal, AB, Finspong, Sweden) and B. J. TORBY (California State University, Long Beach) International Journal of Analytical and Experimental Modal Analysis (ISSN 0886-9367), vol. 3, Oct. 1988, p. 148-157. refs

A complex modal-analysis method for studying the behavior of a turbine near its design speed is presented. The modal calculations account for gyroscopic moments as well as nonsymmetric bearing effects. Results of calculations performed for a 650 MW ASEA STAL turbine installation are presented. K.K.

A89-19806#
THE COMBINATION OF SIMULATION AND RESPONSE METHODOLOGY AND ITS APPLICATION IN AN AGGREGATE PRODUCTION PLAN
ZHIMING CHEN and YUNCHENG FENG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Aug. 1988, p. B359-B365. In Chinese, with abstract in English. refs

This paper describes an algorithmic structure for combining simulation and optimization techniques both in theory and practice. Response surface methodology is used to optimize the decision variables in the simulation environment. A simulation-optimization software has been developed and successfully implemented, and its application to an aggregate production planning simulation-optimization model is reported. The model's objective is to minimize the production cost and to generate an optimal production plan and inventory control strategy for an aircraft factory. C.D.

A89-19909*# Korean Inst. of Science and Technology, Seoul.
PLENUM CHAMBER EFFECT ON WIND-TUNNEL RESONANCE BY THE FINITE-ELEMENT METHOD
IN LEE (Korea Advanced Institute of Science and Technology, Seoul, Republic of Korea) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2, p. 266-278) AIAA Journal (ISSN 0001-1452), vol. 26, Sept. 1988, p. 1087-1093. Previously cited in issue 18, p. 2658, Accession no. A86-38909. refs
(Contract NGL-05-020-243)

A89-19911#
BUCKLING AND FINAL FAILURE OF GRAPHITE/PEEK STIFFENER SECTIONS
SCOTT M. CAUSBIE (Boeing Commercial Airplane Co., Seattle, WA) and PAUL A. LAGACE (MIT, Cambridge, MA) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1, p. 280-287) AIAA Journal (ISSN 0001-1452), vol. 26, Sept. 1988, p. 1100-1106. Previously cited in issue 18, p. 2655, Accession no. A86-38831. refs

A89-20114
TELEPORT AS A CONCENTRATION POINT FOR DOMESTIC AND INTERNATIONAL TRAFFIC
ANAND KUMAR (Washington International Teleport, Washington, DC) IN: EASCON '88; Proceedings of the Twenty-first Annual Electronics and Aerospace Conference, Arlington, VA, Nov. 9-11, 1988. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 109-114.

The teleport concept is defined, and types of teleports are described. The Washington International Teleport is discussed as an example. It is argued that major teleports should concentrate on three major areas of implementation and growth to create a successful gateway linking domestic and international networks.

These areas are video networks, private networks, and international voice/data networks. I.E.

A89-20146*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MODERN WING FLUTTER ANALYSIS BY COMPUTATIONAL FLUID DYNAMICS METHODS
HERBERT J. CUNNINGHAM, JOHN T. BATINA, and ROBERT M. BENNETT (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 962-968. Previously cited in issue 22, p. 3690, Accession no. A88-51329. refs

A89-20188#
ANALYSIS OF ARTIFICIAL DISSIPATION MODELS FOR THE TRANSONIC FULL-POTENTIAL EQUATION
GEORGE S. DULIKRAVICH (Pennsylvania State University, University Park) AIAA Journal (ISSN 0001-1452), vol. 26, Oct. 1988, p. 1238-1245. Previously cited in issue 07, p. 1010, Accession no. A88-22536. refs

A89-20315#
EVALUATION OF ALUMINUM-LITHIUM ALLOYS IN COMPRESSION-STIFFENEED AIRCRAFT STRUCTURES
J. C. EKVALL and D. J. CHELLMAN (Lockheed Aeronautical Systems Co., Burbank, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 1001-1008. Previously cited in issue 17, p. 2691, Accession no. A87-39641. refs

A89-20324*# Notre Dame Univ., IN.
METHOD OF COLD SMOKE GENERATION FOR VORTEX CORE TAGGING
R. C. NELSON, T. T. NG (Notre Dame, University, IN), and K. D. VISSER Journal of Aircraft (ISSN 0021-8669), vol. 25, Nov. 1988, p. 1069-1071. refs
(Contract NCA2-162)

Attention is given to the flow-visualization problem posed by the 'dark-core' region of the vortices formed on the upper side of a delta wing; the low particle density in the core region minimizes the density of tracing particles whose presence is essential in LDV measurements. An effort is presently undertaken using TiCl4 smoke in subsonic wind tunnel tests of a 70-deg sweep delta wing model. O.C.

N89-13727# Ballistic Research Labs., Aberdeen Proving Ground, MD.
INTERNAL PRESSURE MEASUREMENTS FOR A LIQUID PAYLOAD AT LOW REYNOLDS NUMBERS
DAVID J. HEPNER, KEITH P. SOENCKSEN, BRADFORD S. DAVIS, and NICHOLAS G. MAIORANA Jun. 1988 63 p
(AD-A197438; AD-E900740; BRL-MR-3674) Avail: NTIS HC A04/MF A01 CSCL 01A

Spin-stabilized projectiles can experience poor flights due to the influence of liquid payloads. Substantial analytical and numerical work has been done on this problem, but quality experimental data on the primitive variables of the liquid (pressure and velocity) are still required to evaluate the accuracy and applicability of models and codes. In free gyroscope tests for Reynolds numbers less than 100, the broadening effect of low Reynolds numbers is also evident. Evidence of related liquid instabilities for actual flight data was reported. A full-scale three-degree-of-freedom flight simulator was used to examine both endwall and sidewall pressure fluctuations, as well as the phase relationship between the maximum pressure and cylinder orientation for a high Reynolds number of 18,200. Scale simulations of high viscosity liquid payloads were completed for a Reynolds number range of 3.1 to 8.9. Testing included establishing instrumentation reliability, repeating previously published low Reynolds number data, expanding the range in nondimensional coning frequency and Reynolds number, and providing a data base for comparisons with current linear theory applications at low Reynolds number. Based on these preliminary results, extensive testing can be accomplished on the BRL Flight Simulator using a full-scale cylinder and larger instrumentation payload capacity. GRA

N89-13735# Naval Ship Research and Development Center, Bethesda, MD.
A POTENTIAL FLOW SOLUTION ON MARINE PROPELLER AND AXIAL ROTATING FAN Final Report
Y. T. LEE, C. W. JIANG, and T. W. BEIN Aug. 1988 30 p
(AD-A198781; DTRC-88/031) Avail: NTIS HC A03/MF A01 CSCL 20D

Integral equations are derived to model the solid surfaces and the inlet condition for both external and internal flows with an axially rotating element. Vortex filaments are used to simulate the lifting surfaces. Global iterations for surface-panel source densities and vortex strengths are used in conjunction with the Neumann iterations for solving integral equations. A special kernel treatment is adopted in the solution scheme of the integral equation. Solutions converge within 10 to 20 iterations. Calculated results and measured data for a propeller tested in open water are in good agreement. Predictions are also made for an axial-flow pump. The overall performance parameters for the pump agree within a few percent of the design values. GRA

N89-13736# Illinois Inst. of Tech., Chicago. Fluid Dynamics Research Center.
MANAGEMENT AND CONTROL OF SEPARATION BY UNSTEADY AND VORTICAL FLOWS Final Technical Report, Oct. 1984 - Oct. 1987
HASSAN M. NAGIB, MUKUND ACHARYA, PATRICK H. REISENTHEL, JOHN L. WAY, and DAVID R. WILLIAMS Jun. 1988 7 p
(Contract F49620-84-C-0080)
(AD-A198902; AFOSR-88-0745TR) Avail: NTIS HC A02/MF A01 CSCL 01A

Management and Control of 2-D and 3-D separated flows by unsteady and/or vortical flows is investigated in a number of configurations aimed at an enhanced basic understanding of governing mechanisms. The investigations are aimed at impacting the design of future generations of aircraft with improved maneuverability for better performance and safety. Also, novel techniques are being developed for the measurement, mapping and documentation of these complex unsteady flowfields. GRA

N89-13746*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN EXPERIMENTAL AND ANALYTICAL EVALUATION OF THE TAPERED TENSION-TORSION STRAP CONCEPT
ALEXANDER LOUIE Nov. 1988 18 p
(NASA-TM-101049; A-88321; NAS 1.15:101049) Avail: NTIS HC A03/MF A01 CSCL 20D

A new free-tip rotor moment controller designed to increase torque output (a restoring moment) was proposed. The controller would be used as a retention device for the freely pitching tip of a helicopter rotor. The new design featured a tapered tension-torsion strap instead of the previously used parellel strap. A tapered strap has a larger separation between the tension wires at the retention end than at the oscillating end; separation is equal at both ends for a parallel strap. A simple dynamic analysis was developed and an experiment performed to evaluate this tapered strap concept. The test results indicated that the torsional spring stiffness of the strap, represented by a torsional pendulum, increased with the amount of taper. The predicted dynamic characteristics of the pendulum also confirmed this observation and correlated reasonably well with the experimental results. It could be concluded from the experimental and analytical results that the tapered strap accomplished increased torque output when compared to the parellel strap. Author

N89-13747*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SURFACE GRID GENERATION FOR COMPLEX THREE-DIMENSIONAL GEOMETRIES

RAYMOND CHING-CHUNG LUH Oct. 1988 15 p
(NASA-TM-101046; A-88318; NAS 1.15:101046) Avail: NTIS HC A03/MF A01 CSCL 20D

An outline is presented for the creation of surface grids from primitive geometry data such as obtained from CAD/CAM systems. The general procedure is applicable to any geometry including full aircraft with wing, nacelle, and empennage. When developed in an interactive graphics environment, a code based on this procedure is expected to substantially improve the turn around time for generating surface grids on complex geometries. Results are shown for a general hypersonic airplane geometry. Author

N89-13751# Illinois Inst. of Tech., Chicago. Fluid Dynamics Research Center.

MANAGEMENT AND CONTROL OF UNSTEADY AND TURBULENT FLOWS Annual Technical Report, Oct. 1986 - Oct. 1987

HASSAN M. NAGIB, MUKUND ACHARYA, THOMAS C. CORKE, PATRICK H. REISENTHEL, and CANDACE E. WARK Jun. 1988 15 p
(Contract F49620-86-C-0133)
(AD-A198091; AFOSR-88-0747TR) Avail: NTIS HC A03/MF A01 CSCL 20D

Progress in four areas of research has been achieved during the first year: (1) controlled transitioning boundary layers; phase coupled plane TS waves and oblique waves are used to study various types of transition including detuned modes, (2) turbulent boundary layer structure and control; the structures responsible for the turbulence production in high Reynolds number boundary layers have been documented and manipulated, (3) management of unsteady and three-dimensional flows; flows over airfoils, axisymmetric forebodies, vortex-wing interactions, and wing-body junctions, are examined with and without passive and active flow manipulators including zero-mass base bleed, (4) scanning laser anemometry; a technique capable of mapping the flowfield in a plane has been developed. GRA

N89-13754*# General Motors Corp., Indianapolis, IN. Allison Gas Turbine Div.

THE EFFECTS OF LEADING EDGE AND DOWNSTREAM FILM COOLING ON TURBINE VANE HEAT TRANSFER Final Report

L. D. HYLTON, V. NIRMALAN, B. K. SULTANIAN, and R. M. KAUFMAN Nov. 1988 175 p
(Contract NAS3-24619)
(NASA-CR-182133; NAS 1.26:182133; ALLISON-EDR-13481)
Avail: NTIS HC A08/MF A01 CSCL 20D

The progress under contract NAS3-24619 toward the goal of establishing a relevant data base for use in improving the predictive design capabilities for external heat transfer to turbine vanes, including the effect of downstream film cooling with and without leading edge showerhead film cooling. Experimental measurements were made in a two-dimensional cascade previously used to obtain vane surface heat transfer distributions on nonfilm cooled airfoils under contract NAS3-22761 and leading edge showerhead film cooled airfoils under contract NAS3-23695. The principal independent parameters (Mach number, Reynolds number, turbulence, wall-to-gas temperature ratio, coolant-to-gas temperature ratio, and coolant-to-gas pressure ratio) were maintained over ranges consistent with actual engine conditions and the test matrix was structured to provide an assessment of the independent influence of parameters of interest, namely, exit Mach number, exit Reynolds number, coolant-to-gas temperature ratio, and coolant-to-gas pressure ratio. Data provide a data base for downstream film cooled turbine vanes and extends the data bases generated in the two previous studies. The vane external heat transfer obtained indicate that considerable cooling benefits can be achieved by utilizing downstream film cooling. The data obtained and presented illustrate the interaction of the variables and should provide the airfoil designer and computational analyst the information required to improve heat transfer design capabilities for film cooled turbine airfoils. Author

N89-13755*# Purdue Univ., West Lafayette, IN. School of Aeronautics and Astronautics.

LDV MEASUREMENTS IN AN ANNULAR COMBUSTOR MODEL M.S. Thesis

DEAN A. BARRON Aug. 1986 161 p
(Contract NAS3-24350)
(NASA-CR-182207; NAS 1.26:182207; PURDUE-MS-34971)
Avail: NTIS HC A08/MF A01 CSCL 20D

The design and setup of a Laser Doppler Velocimeter (LDV) system used to take velocity measurements in an annular combustor model are covered. The annular combustor model is of contemporary design using 60 degree flat vane swirlers, producing a strong recirculation zone. Detailed measurements are taken of the swirler inlet air flow and of the downstream enclosed swirling flow. The laser system used is a two color, two component system set up in forward scatter. Detailed are some of the special considerations needed for LDV use in the confined turbulent flow of the combustor model. The LDV measurements in a single swirler rig indicated that the flow changes radically in the first duct height. After this, a flow profile is set up and remains constant in shape. The magnitude of the velocities gradually decays due to viscous damping. Author

N89-13756*# United Technologies Research Center, East Hartford, CT.

THE EFFECTS OF INLET TURBULENCE AND ROTOR/STATOR INTERACTIONS ON THE AERODYNAMICS AND HEAT TRANSFER OF A LARGE-SCALE ROTATING TURBINE MODEL, VOLUME 1 Final Report

R. P. DRING, M. F. BLAIR, H. D. JOSLYN, G. D. POWER, and J. M. VERDON Washington, D.C. Jul. 1987 173 p
(Contract NAS3-23717)
(NASA-CR-4079; E-3536; NAS 1.26:4079;
UTRC-R86-956480-VOL-1) Avail: NTIS HC A08/MF A01 CSCL 20D

A combined experimental and analytical program was conducted to examine the effects of inlet turbulence on airfoil heat transfer. Heat transfer measurements were obtained using low conductivity airfoils with miniature thermocouples welded to a thin, electrically heated surface skin. Heat transfer data were acquired for various combinations of low or high inlet turbulence intensity, flow coefficient (incidence), first-stator/rotor axial spacing, Reynolds number, and relative circumferential position of the first and second stators. Aerodynamic measurements include distributions of the mean and fluctuating velocities at the turbine inlet and, for each airfoil row, midspan airfoil surface pressures and circumferential distributions of the downstream steady state pressures and fluctuating velocities. Analytical results include airfoil heat transfer predictions and a examination of solutions of the unstead boundary layer equipment. Author

N89-13784# Texas A&M Univ., College Station. Turbomachinery Labs.

THE MEASUREMENT AND PREDICTION OF ROTORDYNAMIC FORCES FOR LABYRINTH SEALS Final Report, 1 Sep. 1982 - 31 Dec. 1987

D. W. CHILDS and D. L. RHODE Mar. 1988 212 p
(Contract F49620-82-K-0033)
(AD-A197185; AFOSR-88-0662TR) Avail: NTIS HC A10/MF A01 CSCL 13G

Measurements of rotordynamic (stiffness and damping) coefficients and leakage characteristics were completed for labyrinth-rotor/honeycombe stator seals. Comparisons to labryinth-rotor/smooth-stator seals showed no stability improvements. Tests were also carried out on smooth-rotor/honeycombe-stator seals and demonstrated superior stability and leakage performance for this type of seal if the entering flow is pre-rotated in the direction of rotation. A new bulk-flow theory for labyrinth seals has been developed and its prediction compares well with measured results for tooth-on-rotor labyrinths. Also, a more sophisticated model was developed which solves the 3-D Reynolds-averaged Navier-Stokes equations for compressible flow. GRA

N89-13794*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EFFECT OF ADVANCED COMPONENT TECHNOLOGY ON HELICOPTER TRANSMISSIONS
DAVID G. LEWICKI and DENNIS P. TOWNSEND 1989 18 p *Prepared for presentation at the International Power Transmission and Gearing Conference, Chicago, Ill., 25-27 Apr. 1989; sponsored by ASME Prepared in cooperation with Army Aviation Systems Command, Cleveland, Ohio*
(NASA-TM-101431; E-4531; NAS 1.15:101431; AVSCOM-TR-87-C-38) Avail: NTIS HC A03/MF A01 CSCL 01C

Experimental tests were performed on the NASA/Bell Helicopter Textron (BHT) 500 hp advanced technology transmission (ATT) at the NASA Lewis Research Center. The ATT was a retrofit of the OH-58C helicopter 236 kW (317 hp) main rotor transmission, upgraded to 373 kW (500 hp), with a design goal of retaining long life with a minimum increase in cost, weight, and size. Vibration, strain, efficiency, deflection, and temperature experiments were performed and the results were compared to previous experiments on the OH-58A, OH-58C, and UH-60A transmissions. The high-contact-ratio gears and the cantilevered-mounted, flexible ring gear of the ATT reduced vibration compared to that of the OH-58C. The ATT flexible ring gear improved planetary load sharing compared to that of the rigid ring gear of the UH-60A transmission. The ATT mechanical efficiency was lower than that of the OH-58A transmission, probably due to the high-contact-ratio planetary gears. Author

N89-13796 Old Dominion Univ., Norfolk, VA.
THE EFFECTS OF NONLINEAR DAMPING ON THE LARGE DEFLECTION RESPONSE OF STRUCTURES SUBJECTED TO RANDOM EXCITATION Ph.D. Thesis
CHUNCHU BHAVANI PRASAD 1987 161 p
Avail: Univ. Microfilms Order No. DA8805584

Effects of both nonlinear damping and large deflection stiffness are included in the theoretical anlaysis in an attempt to explain the experimental phenomena of aircraft panels excited at high sound pressure levels; that is the broadening of the strain response peak and the increase in modal frequency. Beams and symmetrically laminated plates subjected to acoustic excitation are considered in the analyses. A polynomial containing both linear and nonlinear damping terms is considered as a damping model. The Galerkin method is used to derive modal equations. Direct equivalent linearization is used to solve nonlinear damping terms to determine mean square maximum deflection, mean square maximum strain, and spectral density function of maximum strain for the structures. For beams, simply supported and clamped, three modes are considered in the analysis. Isotropic material is considered for beams. For laminated plates, simply supported and clamped, only single mode analysis is performed. This analytical investigation will help to broaden the basic understanding of the role of nonlinear damping on random response of structures and lead to better sonic fatigue design criteria. Dissert. Abstr.

N89-13816*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
BUCKLING CHARACTERISTICS OF HYPERSONIC AIRCRAFT WING TUBULAR PANELS
WILLIAM L. KO, JOHN L. SHIDELER (National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.), and ROGER A. FIELDS Dec. 1986 70 p
(NASA-TM-87756; L-16128; NAS 1.15:87756) Avail: NTIS HC A04/MF A01 CSCL 20K

The buckling characteristics of Rene 41 tubular panels installed as wing panels on a hypersonic wing test structure (HWTS) were determined nondestructively through use of a force/stiffness technique. The nondestructive buckling tests were carried out under different combined load conditions and different temperature environments. Two panels were subsequently tested to buckling failure in a universal tension compression testing machine. In spite of some data scattering because of large extrapolations of data points resulting from termination of the test at a somewhat low applied load, the overall test data correlated fairly well with theoretically predicted buckling interaction curves. The structural efficiency of the tubular panels was slightly higher than that of the beaded panels which they replaced. Author

N89-13817*# Florida Atlantic Univ., Boca Raton. Dept. of Ocean Engineering.
APPLICATION OF THE MOBILITY POWER FLOW APPROACH TO STRUCTURAL RESPONSE FROM DISTRIBUTED LOADING Progress Report
J. M. CUSCHIERI Dec. 1988 19 p
(Contract NAG1-685)
(NASA-CR-181342; NAS 1.26:181342) Avail: NTIS HC A03/MF A01 CSCL 20K

The problem of the vibration power flow through coupled substructures when one of the substructures is subjected to a distributed load is addressed. In all the work performed thus far, point force excitation was considered. However, in the case of the excitation of an aircraft fuselage, distributed loading on the whole surface of a panel can be as important as the excitation from directly applied forces at defined locations on the structures. Thus using a mobility power flow approach, expressions are developed for the transmission of vibrational power between two coupled plate substructures in an L configuration, with one of the surfaces of one of the plate substructures being subjected to a distributed load. The types of distributed loads that are considered are a force load with an arbitrary function in space and a distributed load similar to that from acoustic excitation. Author

N89-13819*# Toledo Univ., OH.
SOLUTION AND SENSITIVITY ANALYSIS OF A COMPLEX TRANSCENDENTAL EIGENPROBLEM WITH PAIRS OF REAL EIGENVALUES Final Report
DURBHA V. MURTHY Jan. 1989 25 p
(Contract NAG3-742)
(NASA-CR-182241; E-4560; NAS 1.26:182241) Avail: NTIS HC A03/MF A01 CSCL 20K

This paper considers complex transcendental eigenvalue problems where one is interested in pairs of eigenvalues that are restricted to take real values only. Such eigenvalue problems arise in dynamic stability analysis of nonconservative physical systems, i.e., flutter analysis of aeroelastic systems. Some available solution methods are discussed and a new method is presented. Two computational approaches are described for analytical evaluation of the sensitivities of these eigenvalues when they are dependent on other parameters. The algorithms presented are illustrated through examples. Author

N89-14372 Physics and Electronics Lab. TNO, The Hague (Netherlands).
PRECISION APPROACH RADARS TWENTHE AND VOLKEL (NETHERLANDS). MULTIPATH PROPAGATION PROBLEMS
J. C. A. VANGESSEL Mar. 1988 31 p In DUTCH; ENGLISH summary
(Contract A78/KLU/049)
(FEL-1988-15; TD-88-2572; ETN-89-93418) Avail: Physics and Electronics Lab. TNO, P.O. Box 96864, 2509 JG 'Gravenhage, Oude Waalsdorperweg 63, 's-Gravenhage, Netherlands

The problems caused by multipath propagation effects in the Precision Approach Radars (PAR) of Air Force bases were solved. Problems such as tracking errors and lock breaks hampered the air traffic control. The problems occurred when the aircraft were on the glide path from 3 miles up to touchdown, corresponding to a sector of 5 deg seen by the PAR. Screens consisting of fences with stainless steel wires with a 2 mm mesh width were placed in certain areas of the airfield, providing a 25 dB damping for a 3 cm wavelength. The results show that these screens solve the multipath propagation problems very effectively. ESA

N89-14373# Institute for Perception RVO-TNO, Soesterberg (Netherlands). Afdeling Audiologie.
SOUND ATTENUATION AND SPEECH TRANSMISSION QUALITY OF FIVE TYPES OF HEADSETS

A. M. MIMPEN Sep. 1987 19 p In DUTCH; ENGLISH summary
(Contract A86/M/161)
(IZF-1987-23; TD-87-4247; ETN-89-93448) Avail: NTIS HC A03/MF A01

Five types of headset intended for use in the Fokker-27 cockpit were compared. Sound attenuation was measured as a function of frequency with 10 subjects. Calculations show that the sound level under the headsets H10-36 and H10-86 in the cockpit does not exceed the recommended damage-risk criterion of 80 dB (A), while for the other headsets this criterion is violated. The speech transmission quality of the microphones, used at a short distance from the lips, is good to excellent (except for the headset H10-86). Speech intelligibility of the telephones is good to moderate. Headset H10-36 is recommended. ESA

N89-14376*# Schwartz Electro-Optics, Inc., Orlando, FL.
OPTICAL FIBER DATA TRANSFER SYSTEM
S. H. MCMILLAN Sep. 1988 124 p
(Contract NAS1-18331)
(NASA-CR-181704; NAS 1.26:181704) Avail: NTIS HC A06/MF A01 CSCL 09C

This Phase 2 effort applies the results of Phase 1 to design and fabricate an optical slip ring system for a helicopter rotor blade/wind tunnel application. In this application, there are two assemblies: one on the rotating portion of the mechanical system, one on the stationary portion. The assembly on the rotating portion digitizes and encodes 128 transducer signals from various parts of the blade, and optically transfers data across the noncontacting coupling. Two complete identical independent channels are provided. On the stationary side, the signals are decoded and one channel is transmitted in digital form to a computer for recording and analysis. The second channel reconstructs the analog transducer signals for real time observation. In the opposite direction, eight signal channels enable control signals to be passed from the stationary to the rotating part of the system. Power to the rotor mounted electronics is supplied via power slip rings. The advantages of the optical over the traditional electro-mechanical slip ring method of data transfer across a rotating joint are long life, low-maintenance, immunity to crosstalk, and wider bandwidth. Successful completion of this effort demonstrated that this method is practical and reliable, and can be implemented under difficult conditions of available space, power, environment, and stringent performance and equipment life requirements. Author

N89-14377*# Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems.
DESIGN OF FEEDBACK CONTROL SYSTEMS FOR UNSTABLE PLANTS WITH SATURATING ACTUATORS
PETROS KAPASOURIS, MICHAEL ATHANS, and GUNTER STEIN 17 Nov. 1988 30 p Proposed for presentation at the Symposium on Nonlinear Control Systems Design, 1989; sponsored by IFAC Sponsored in part by General Electric Corp. Research and Development Center
(Contract NAG2-297)
(NASA-CR-183392; NAS 1.26:183392) Avail: NTIS HC A03/MF A01 CSCL 09C

A new control design methodology is introduced for multi-input/multi-output systems with unstable open loop plants and saturating actuators. A control system is designed using well known linear control theory techniques and then a reference prefilter is introduced so that when the references are sufficiently small, the control system operates linearly as designated. For signals large enough to cause saturations, the control law is modified in such a way to ensure stability and to preserve, to the extent possible, the behavior of the linear control design. Key benefits of this methodology are: the modified feedback system never produces saturating control signals, integrators and/or slow dynamics in the compensator never windup, the directional properties of the controls are maintained, and the closed loop system has certain guaranteed stability properties. The advantages of the new design methodology are illustrated in the simulation of an approximation of the AFTI-16 (Advanced Fighter Technology Integration) aircraft multivariable longitudinal dynamics. Author

N89-14386*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL RESULTS FOR A TWO-DIMENSIONAL SUPERSONIC INLET USED AS A THRUST DEFLECTING NOZZLE
ALBERT L. JOHNS and PAUL L. BURSTADT 1984 14 p Presented at the 19th Joint Propulsion Conference, Seattle, WA, 27-29 Jun. 1983; cosponsored by AIAA, SAE and ASME Sponsored by NASA, Washington, D.C. Original contains color illustrations
(NASA-TM-83439; E-1737; NAS 1.15:83439) Avail: NTIS HC A03/MF A01 CSCL 20D

Nearly all supersonic V/STOL aircraft concepts are dependent on the thrust deflecting capability of a nozzle. In one unique concept, referred to as the reverse flow dual fan, not only is there a thrust deflecting nozzle for the fan and core engine exit flow, but because of the way the propulsion system operates during vertical takeoff and landing, the supersonic inlet is also used as a thrust deflecting nozzle. This paper presents results of an experimental study to evaluate the performance of a supersonic inlet used as a thrust deflecting nozzle for this reverse flow dual fan concept. Results are presented in terms of nozzle thrust coefficient and thrust vector angle for a number of inlet/nozzle configurations. Flow visualization and nozzle exit flow survey results are also shown. Author

N89-14397# Naval Postgraduate School, Monterey, CA.
DYNAMIC STALL COMPUTATIONS USING A ZONAL NAVIER-STOKES MODEL M.S. Thesis
JACK H. CONROYD, JR. Jun. 1988 212 p
(AD-A197942) Avail: NTIS HC A10/MF A01 CSCL 01A

A zonal Navier-Stokes model, is installed and verified on the NASA Ames Cray X/MP-48 computer and is used to calculate the flow field about a NACA 0012 airfoil oscillating in pitch. Surface pressure distributions and integrated lift, pitching moment, and drag coefficient versus angle of attack are compared to existing experimental data for four cases and existing computational data for one case. These cases involve deep dynamic stall and fully detached flow at and below a freestream Mach number of .184. The flow field about the oscillating airfoil is investigated through the study of pressure, vorticity, local velocity and stream function. Finally, the effects of pitch rate on dynamic stall are investigated. GRA

N89-14456*# California State Univ. at Long Beach.
TEMPERATURE EFFECT ON STRESS CONCENTRATION AROUND CIRCULAR HOLE IN A COMPOSITE MATERIAL SPECIMEN REPRESENTATIVE OF X-29A FORWARD-SWEPT WING AIRCRAFT
HSIEN-YANG YEH Aug. 1988 44 p
(Contract NGT-05-020-412)
(NASA-CR-179439; H-1514; NAS 1.26:179439) Avail: NTIS HC A03/MF A01 CSCL 20K

The theory of anisotropic elasticity was used to evaluate the anisotropic stress concentration factors of a composite laminated plate containing a small circular hole. This advanced composite was used to manufacture the X-29A forward-swept wing. It was found for composite material, that the anisotropic stress concentration is no longer a constant, and that the locations of maximum tangential stress points could shift by changing the fiber orientation with respect to the loading axis. The analysis showed that through the lamination process, the stress concentration factor could be reduced drastically, and therefore the structural performance could be improved. Both the mixture rule approach and the constant strain approach were used to calculate the stress concentration factor of room temperature. The results predicted by the mixture rule approach were about twenty percent deviate from the experimental data. However, the results predicted by the constant strain approach matched the testing data very well. This

showed the importance of the inplane shear effect on the evaluation of the stress concentration factor for the X-29A composite plate. Author

N89-14465*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PARAMETRIC STUDIES OF ADVANCED TURBOPROPS
J. G. MASER, D. G. FERTIS (Akron Univ., OH.), C. C. CHAMIS, and R. A. AIELLO 1988 16 p Presented at the 29th Structures, Structural Dynamics and Materials Conference, Williamsburg, VA, 18-20 Apr. 1988; sponsored by AIAA, ASME, ASCE, AHS and ACS
(NASA-TM-101389; E-4451; NAS 1.15:101389) Avail: NTIS HC A03/MF A01 CSCL 20K

The effects of geometric variables (sweep and twist) on the structural performance of advanced turboprops are investigated. The investigation is limited to aerodynamically efficient turboprops using an acceptable design configuration as a baseline. The baseline configuration is modified using a seven by seven array of independently varying sweep and twist parameters while maintaining acceptable aerodynamic efficiency. The turboprop structural performance is evaluated in terms of critical speeds, tip displacements, and vibration frequencies where geometric nonlinearities are included. The results obtained are presented in such a manner as to highlight the effects of sweep and twist on the structural performance of aerodynamically efficient turboprop configurations. Author

N89-14466# Foster-Miller Associates, Inc., Waltham, MA.
AUTOMATED FATIGUE CRACK GROWTH MEASUREMENT
Final Report, 28 Jul. 1987 - 28 Jan. 1988
TED E. KIRCHNER and JOHN MCCOY Jul. 1988 69 p
(Contract F33615-87-C-3240)
(AD-A198642; AFW-8767; AFWAL-TR-88-3032) Avail: NTIS HC A04/MF A01 CSCL 21E

Fatigue testing is a key element in the development of aircraft and engines. The higher performance temperatures of both airframe and engines of future aircraft makes precise high temperature fatigue testing vital. The goal of this program is to develop a new tool that will automate this test and provide fatigue crack measurement to a precision of 0.001 in. at varying temperatures up to 2000 F and likely higher. In the Phase I program reported here we have experimentally shown the feasibility of two different approaches using laser and X-ray technology. We have recommended that the laser approach be selected for hardware development. GRA

N89-14470*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A REVIEW OF FAILURE MODELS FOR UNIDIRECTIONAL CERAMIC MATRIX COMPOSITES UNDER MONOTONIC LOADS
DAVID E. TRIPP, JOHN H. HEMANN (Cleveland State Univ., OH.), and JOHN P. GYEKENYESI 1989 19 p Proposed for presentation at the 34th International Gas Turbine and Aeroengine Congress and Exposition, Toronto, Ontario, 4-8 Jun. 1989; sponsored by the American Society of Mechanical Engineers
(NASA-TM-101421; E-4520; NAS 1.15:101421) Avail: NTIS HC A03/MF A01 CSCL 20K

Ceramic matrix composites offer significant potential for improving the performance of turbine engines. In order to achieve their potential, however, improvements in design methodology are needed. In the past most components using structural ceramic matrix composites were designed by trial and error since the emphasis of feasibility demonstration minimized the development of mathematical models. To understand the key parameters controlling response and the mechanics of failure, the development of structural failure models is required. A review of short term failure models with potential for ceramic matrix composite laminates under monotonic loads is presented. Phenomenological, semi-empirical, shear-lag, fracture mechanics, damage mechanics, and statistical models for the fast fracture analysis of continuous fiber unidirectional ceramic matrix composites under monotonic loads are surveyed. Author

N89-14918*# Mississippi State Univ., Mississippi State. Dept. of Mathematics and Statistics.
OVERLAPPING GRIDS FOR FLOW FIELD CALCULATIONS Abstract Only
CHARLES WAYNE MASTIN *In* Hampton Inst., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship program 1988 p 84-85 Sep. 1988
Avail: NTIS HC A07/MF A01 CSCL 20D

Many problems in computational fluid dynamics (CFD) involve the calculation of flow fields within or around complex geometric configurations. The flow solution is computed on a computational grid. The construction of the grid is one of the major difficulties in the application of CFD to the analysis of flow about actual aircraft configurations. Due to geometric complexity, the grid has to be constructed in simple subregions and then all of these subgrids have to be pieced together to form a complete grid for the entire flow field. The entire grid, which is called a composite grid because it is formed from many parts, may have common regions. In either case, the computation of the flow field, using any numerical algorithm, will require the transfer of information between individual subgrids. The transfer of information is more difficult with overlapping grids. Algorithms have been developed and tested for automating the transfer of information between two overlapping grids. Author

N89-14924*# Arkansas State Univ., State University. Dept. of Computer Science.
A FLIGHT TEST DESIGN FOR STUDYING AIRBORNE APPLICATIONS OF AIR TO GROUND DUPLEX DATA LINK COMMUNICATIONS Abstract Only
CHARLES H. SCANLON *In* Hampton Inst., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program 1988 p 94-96 Sep. 1988
Avail: NTIS HC A07/MF A01 CSCL 17B

The Automatic En Route Air Traffic Control (AERA) and the Advanced Automated System (AAS) of the NAS plan, call for utilization of data links for such items as computer generated flight clearances, enroute minimum safe altitude warnings, sector probes, out of conformance check, automated flight services, and flow management of advisories. A major technical challenge remaining is the integration, flight testing, and validation of data link equipment and procedures in the aircraft cockpit. The flight test organizational chart, was designed to have the airplane side of data link experiments implemented in the NASA Langley Research Center (LaRC) experimental Boeing 737 airplane. This design would enable investigations into implementation of data link equipment and pilot interface, operations, and procedures. The illustrated ground system consists of a work station with links to a national weather database and a data link transceiver system. The data link transceiver system could be a Mode-S transponder, ACARS, AVSAT, or another type of radio system such as the military type HF data link. The airborne system was designed so that a data link transceiver, workstation, and touch panel could be interfaced with an input output processor to the aircraft system bus and thus have communications access to other digital airplane systems. Author

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GEOSCIENCES

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

A89-18259
THREE DIMENSIONAL HAZARD ZONES

DAVID P. SAUTER (U.S. Army, Atmospheric Sciences Laboratory, White Sands Missile Range, NM) IN: Symposium on Turbulence and Diffusion, 8th, San Diego, CA, Apr. 25-29, 1988, Preprints. Boston, MA, American Meteorological Society, 1988, p. 260-262. refs

The U.S. Army's Atmospheric Sciences Laboratory has developed a three-dimensional hazard model, '3DHZD', which can predict the horizontal and vertical extent of the vapor hazard due to toxic chemical vapors released by chemical spills from storage facilities or vehicles. Hazard volumes can be predicted in near-real time on a microcomputer, given the chemical and meteorological parameters. It can in this way be shown that, for an accidental spill of acrolein, a significant hazard will exist for low-flying helicopters. O.C.

A89-18554
AN AUTOMATED METHOD FOR FORECASTING THE PROBABILITY OF CLEAR AIR TURBULENCE [AVTOMATIZIROVANNYI SPOSOB PROGNOZA VEROIATNOSTI TURBULENTNOSTI V IASNOM NEBE]
T. V. LESHKEVICH (Gidrometeorologicheskii Nauchno-Issledovatel'skii Tsentr SSSR, Moscow, USSR) Meteorologiia i Gidrologiia (ISSN 0130-2906), Oct. 1988, p. 44-54. In Russian. refs

A physical-statistical relationship between clear air turbulence and local characteristics of the meteorological fields under various synoptic conditions in the 850-500 hPa layer. The synoptic conditions for the existence or abscence of intense clear air turbulence are identified. An objective synoptic statistical method for forecasting zones of intense turbulence and a program for calculating the probability of clear air turbulence at the 850, 700, and 500 hPa levels are presented. R.B.

A89-20265* Mesoscale Environmental Simulations, Inc., Hampton, VA.
NUMERICAL SIMULATIONS OF AN ISOLATED MICROBURST. I - DYNAMICS AND STRUCTURE
FRED H. PROCTOR (MESO, Inc., Hampton, VA) Journal of the Atmospheric Sciences (ISSN 0022-4928), vol. 45, Nov. 1, 1988, p. 3137-3160. refs
(Contract NAS1-17409; NAS1-18336)

Isolated and stationary microbursts are simulated using a time-dependent, high-resolution, axisymmetric numerical model. A microburst downdraft is initiated by specifying a distribution of precipitation at the top boundary of the model and allowing it to fall into the domain. Two case studies of a hazardous wet (high reflectivity) microburst are presented. The initial and boundary specifications, evolution, microphysics, ring vortex, burst front, vorticity, and structure of the microbursts are discussed. R.B.

N89-13832# California Univ., Riverside. Statewide Air Pollution Research Center.
ATMOSPHERIC PHOTOCHEMICAL MODELING OF TURBINE ENGINE FUELS AND EXHAUSTS. COMPUTER MODEL DEVELOPMENT, VOLUME 1 Final Report, Oct. 1984 - Dec. 1986
WILLIAM O. CARTER, ARTHUR M. WINER, ROGER ATKINSON, SUSAN E. HEFFRON, and MINN P. POE May 1988 260 p
(Contract F08635-C-80-0359)
(AD-A198690; AFESC/ESL-TR-87-35-VOL-1) Avail: NTIS HC A12/MF A01 CSCL 04A

A computer model capable of predicting photochemical reactivity of turbine engine fuel emissions and exhaust emissions from routine AF operations is developed. This Phase 2 report describes experimental work on engine exhaust components conducted in environmental chamber facilities. The results indicate that engine exhaust is significantly more reactive than the fuels themselves. The reaction mechanism incorporates new methods for lumping of complex reactive organic gas (ROG) mixtures when representing them in model simulations. This technical report is divided into two volumes. Volume 1 explains the computer model development, while Volume 2 is the User's Manual. GRA

N89-13833# California Univ., Riverside. Statewide Air Pollution Research Center.
ATMOSPHERIC PHOTOCHEMICAL MODELING OF TURBINE ENGINE FUELS AND EXHAUSTS. COMPUTER MODEL DEVELOPMENT, VOLUME 2 Final Report, Oct. 1984 - Dec. 1986
WILLIAM O. CARTER, ARTHUR M. WINER, ROGER ATKINSON, SUSAN E. HEFFRON, and MINN P. POE May 1988 210 p
(Contract F08635-C-80-0359)
(AD-A198691; AFESC/ESL-TR-87-35-VOL-2) Avail: NTIS HC A10/MF A01 CSCL 04A

This User's Manual documents how to use an atmospheric photochemical reactivity modeling software system which has been developed for the U.S. Air Force under this contract. The modeling software can be used to conduct floating box type airshed model simulations to determine the air quality impacts of many types of reactive organic gases (ROG) emitted under a variety of air pollution scenarios. GRA

N89-13839 Brunel Univ., Uxbridge (England).
THE QUALITY OF FIBRE REINFORCED THERMOPLASTICS MOULDINGS Ph.D. Thesis
HUGH ADRIAN POTTS 1987 362 p
Avail: Univ. Microfilms Order No. BRDX81180

The requirement for injection molded short carbon fiber reinforced thermoplastics in helicopter applications is based on component coat and weight savings. The presence of short fibers in a thermoplastic polymer can exert a significant influence upon the rheological properties of the melt. As it is the rheology of the material which determines melt flow performance and hence the flow-induced fiber orientation in the final molded part, accurate data are required to understand and predict polymer flow. Although standard procedures exist for determining the rheological characteristics of melts, their relevance to the injection modling proscess was questioned. Consequently, a high shear rate rheometer was developed, and the results for the filled and unfilled melts compared with the standard equipment. Significant effects involving thermal conductivity and fiber breaking were identified which leads to errors in the data produced using the standard device. Two techniques using reflected light and thermal imaging were successfully developed for the characterization of the orientation of short carbon fibers in injection molded parts. Welds are a common feature in injection molded parts. This study also addresses the problem of the knit weld in a specially designed test specimen. Applying fracture mechanics principles, the integrity of the welded structure was analyzed, and the results correlated with microstructural observations. Finally, impact studied using subcomponent geometries have addressed the effects of flow induced fiber orientation in specific geometrical features.
Dissert. Abstr.

N89-13854# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
ANALYSIS OF TEMPERATURE AND VELOCITY MICROTURBULENCE PARAMETERS FROM AIRCRAFT DATA AND RELATIONSHIP TO ATMOSPHERIC REFRACTIVE INDEX STRUCTURE M.S. Thesis
ELIZABETH A. BEECHER May 1988 180 p
(AD-A196542; AFIT/CI/NR-88-20) Avail: NTIS HC A09/MF A01 CSCL 04B

Due to inherent turbulence, the atmosphere has a temporally and spatially variable refractive index, which degrades propagating electromagnetic radiation. (C sub n)sq is a key parameter for describing refractive variations. Data was analyzed from several instruments involved in an electro-optics/meteorology experiment; scintillometer; thermosonde; radar vertical profiler, and instrumented aircraft. The aircraft measured (C sub T) sq and (C sub u) sq using hot and cold wire sensors and FM recording apparatus. The taped data was processed via FFT to produce one-dimensional variance spectra (wavenumber range 0.01 to 10/m). Flights usually produced a 10 km vertical profile processed to give roughly 0.5 km resolution. Spectral editing was based on regression analysis fit to -5/3 frequency dependence. A majority

of spectra showed the classic inertial subrange. (C sub n) sq and epsilon were calculated from (C sub T) sq and (C sub u) sq, respectively. In active regions, the following relationship can be derived. (C sub T) sq((C sub u) sq. = 1.6 R sub i)(P sub r - R sub i) (theta/g) (delta theta/delta z). GRA

N89-14616# Federal Aviation Administration, Washington, DC. Office of Environment and Energy.
A MICROCOMPUTER POLLUTION MODEL FOR CIVILIAN AIRPORTS AND AIR FORCE BASES, MODEL DESCRIPTION
H. M. SEGAL and P. L. HAMILTON (Minority Services, Inc., Washington, DC.) Aug. 1988 140 p
(AD-A199003; FAA-EE-88-4; AFESC/ESL-TR-88-53) Avail: NTIS HC A07/MF A01 CSCL 24A

This is one of three reports describing the Emissions and Dispersion Modeling System (EDMS). EDMS is a complex source emissions/dispersion model for use at civilian airports and Air Force bases. It operates in both a refined and a screening mode and is programmed for an IBM-XT (or compatible) computer. This report--MODEL DESCRIPTION--provides the technical description of the model. It first identifies the key design features of both the emissions (EMISSMOD) and dispersion (GIMM) portions of EDMS. It then describes the type of meteorological information the dispersion model can accept and identifies the manner in which it preprocesses National Climatic Center (NCC) data prior to a refined model run. The report presents the results of running EDMS on a number of different microcomputers and compares EDMS results with those of comparable models. The appendices elaborate on the information noted above and list the source code. GRA

N89-14899*# State Univ. of New York, Brockport. Dept. of the Earth Sciences.
USE OF THE TERMINAL AREA SIMULATION SYSTEM (TASS) TO STUDY MICROBURST WIND SHEARS
GREGORY P. BYRD *In* Hampton Inst., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program 1988 p 44-45 Sep. 1988
Avail: NTIS HC A07/MF A01 CSCL 04B

Ground-based and airborne Doppler radar and LIDAR systems are being designed to alert pilots when a hazardous windshear is present. A key element in this design effort is understanding the microburst itself. This is accomplished by means of the TASS model which was developed for NASA by Proctor (1987a,b). The time-dependent TASS model has two vesions: a two-demensional high resolution axisymmetric model, and a three-demensional model. The model includes a sophisticated parameterization of cloud microphysics and a friction layer, both of which are essential to a realistic simulation of the microburst phenomenon. The TASS model has been successfully tested on well-observed convective events. Author

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A89-17489
REDUCED CONSERVATIVE SINGULAR VALUE ANALYSIS FOR ROBUSTNESS
TSUYOSHI OKADA, MASAHIKO KIHARA, and YASUNORI NISHIO (Defense Academy, Yokosuka, Japan) International Journal of Control (ISSN 0020-7179), vol. 48, Oct. 1988, p. 1455-1473. refs

Criteria for the robust stability and sensitivity reduction of MIMO systems are developed analytically in the framework of the frequency-domain singular-value method. The derivation is given in detail, and numerical results for problems involving aircraft longitudinal and lateral motion are presented in graphs. The new criteria are shown to be significantly more effective than conservative criteria in evaluating robust stability. T.K.

A89-17965* Systems Control Technology, Inc., Palo Alto, CA.
EFFECT OF MODEL UNCERTAINTY ON FAILURE DETECTION - THE THRESHOLD SELECTOR
ABBAS EMAMI-NAEINI, MUHAMMAD M. AKHTER, and STEPHEN M. ROCK (Systems Control Technology, Inc., Palo Alto, CA) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. 33, Dec. 1988, p. 1106-1115. refs
(Contract NAS3-24079)

The performance of all failure detection, isolation, and accomodation (DIA) algorithms is influenced by the presence of model uncertainty. A unique framework is presented to incorporate a knowledge of modeling error in the analysis and design of failure detection systems. The tools being used are very similar to those in robust control theory. A concept is introduced called the threshold selector, which is a nonlinear inequality whose solution defines the set of detectable sensor failure signals. The threshold selector represents an innovative tool for analysis and synthesis of DIA algorithms. It identifies the optimal threshold to be used in innovations-based DIA algorithms. The optimal threshold is shown to be a function of the bound on modeling errors, the noise properties, the speed of DIA filters, and the classes of reference and failure signals. The size of the smallest detectable failure is also determined. The results are applied to a multivariable turbofan jet engine example, which demonstrates improvements compared to previous studies. I.E.

A89-18009
UNIVERSAL ADA TEST LANGUAGE (UATL) TO SUPPORT REAL-TIME SOFTWARE/SYSTEM INTEGRATION AND FACTORY/MAINTENANCE FAULT ISOLATION
JEHUDA ZIEGLER, JERRY M. GRASSO, LINDA BURGER-MEISTER, and BART VOYCE (ITT, ITT Avionics Div., Nutley, NJ) IN: AUTOTESTCON '88; Proceedings of the IEEE International Automatic Testing Conference, Minneapolis, MN, Oct. 4-6, 1988. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 85-92. refs
(Contract N60921-87-C-0285)

The universal Ada test language (UATL), developed to encourage, and provide support to, the use of Ada in eventually replacing ATLAS, BASIC, and other special-purpose test control languages for generating automatic test programs, is presented. The UATL consists of a set of modular, portable, Ada packages that define a higher-level test language that supports the generation of test programs in Ada. These packages provide the user with a complete complement of standardized reusable test functions that shorten the test-program-generation effort. These test functions include interactive test operator controls, real-time test data stimulus/response, data recording, and data reduction. The UATL also allows the sophisticated user to develop any unique test functions at the Ada code level. I.E.

A89-18015
ATE HARDWARE DIAGNOSTICS, FAULT DETECTION, AND FAULT ISOLATION TOOL (SELF-TEST ADAPTER)
RICHARD I. LAMBRECHT (Honeywell, Inc., Defense Avionics Systems Div., Albuquerque, NM) IN: AUTOTESTCON '88; Proceedings of the IEEE International Automatic Testing Conference, Minneapolis, MN, Oct. 4-6, 1988. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 125-128.

The question of multiple levels of self-test for automatic test equipment (ATE) is examined, and a three-level self-test concept is proposed. Level one will verify test resource communication and built-in test (BIT), level two will check all of the switching resources, and level three will test the measurement and output stimulus resources. All three levels are distinct in their functions but each is dependent on the successful completion of the functions tested at the previous level. Depending on the problems

encountered, only one or two levels of self-test will need to be run. I.E.

A89-18030
AN OVERVIEW OF SEDACS - A STATE OF THE ART TRD/TPS ENVIRONMENT
MARK R. HANSCH (Honeywell, Inc., Military Avionics Div., Golden Valley, MN) IN: AUTOTESTCON '88; Proceedings of the IEEE International Automatic Testing Conference, Minneapolis, MN, Oct. 4-6, 1988. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 253-255.

The support equipment data acquisition and control system (SEDACS) was developed to allow a prime contractor to control the development of test requirement documents (TRD) and associated ATLAS programs for the suite of avionics residing on an aircraft. The system allows multiple avionics manufacturers to supply data for the test program set (TPS) to SEDACS directly from facilities located in various sites in the nation. It utilizes a menu-driven interface, forms data entry, relational data storage, proprietary data protection, a sophisticated full-screen editor for test program development, and electronic transfer of source and object to the automatic test equipment (ATE) for execution. SEDACS integrates all these functions for complete configuration control and management by the prime contractor. A further overview of SEDACS is given. I.E.

A89-18034
HYBRID ARCHITECTURE OF FIELD-TESTED DIAGNOSTIC EXPERT SYSTEM
ARTHUR F. GRIFFIN and JOHN A. MAGUIRE (Hughes Aircraft Co., Long Beach, CA) IN: AUTOTESTCON '88; Proceedings of the IEEE International Automatic Testing Conference, Minneapolis, MN, Oct. 4-6, 1988. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 281-286. refs

Three approaches to diagnostic expert systems have emerged over the last decade: rule-based, dependency models, and deep-knowledge models. A fourth approach is a hybrid architecture that combines two or more of the three pure forms so that the strengths of one support the weaknesses of the other and vice versa. The advantages and disadvantages of each of these approaches are examined. Al-Ferret, a system that was field-tested by US Army technicians troubleshooting operational equipment, and which implements a rule-dependency hybrid architecture, is described. The beliefs that: (1) the hybrid architecture will become the dominant approach to practical diagnostic expert systems, and (2) cost and performance benefits of hybrids will be determined by the level of interaction between rule and model parts are also analyzed. I.E.

A89-18056#
THE ROLE OF TESTABILITY IN THE INTEGRATED DIAGNOSTIC PROCESS
WILLIAM L. KEINER (U.S. Navy, Naval Surface Warfare Center, Dahlgren, VA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 32-39. refs
(AIAA PAPER 88-3858)

This paper examines present and future roles for testability within the avionics integrated diagnostics process, emphasizing the use of computer-aided testability tools during the avionics system's design phase. The evolution of diagnostics is reviewed, and the definition of integrated diagnostics is discussed. The concept of embedded diagnostics is summarized, and the evolution and definition of testability are examined. A framework for integrated diagnostics process is presented, and diagnostics measures and authoring are considered. C.D.

A89-18062#
SDAR - A HIGH PRODUCTIVITY SOFTWARE ENGINEERING ENVIRONMENT FOR EMBEDDED SYSTEMS
DONALD CHIN (Athena Systems, Inc., Sunnyvale, CA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 80-87. refs
(AIAA PAPER 88-3865)

This paper describes a high productivity Computer Aided Software Engineering (CASE) environment that assists with the early phase of the software development life cycle. The method and tools are geared specifically for real-time embedded software, which is prevalent in digital avionics systems. They are based on significant extensions to the Real-Time Structured Analysis methods. With the extended method, the specifications are fully executable, yet retain the benefits of the structured methods. A set of tools from the environment allows the specification to be automatically analyzed and simulated to rapidly build a behavioral prototype. The simulation can be used for overall system validation and demonstration, evaluation of design trade-offs, predicting timing performance, and detection of constraint violations. A highly interactive, graphical user interface makes the environment easy to use even by less experienced users. A library of reusable executable models customized for embedded software systems facilitates the rapid construction of the specifications. Author

A89-18064#
A STRUCTURED APPROACH TO SYSTEM DESIGN
C. INGVAR SVENSSON (Boeing Commercial Airplanes, Seattle, WA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 95-103.
(AIAA PAPER 88-3867)

Current approaches to systems design frequently result in large, incremental costs during system integration testing and service introduction to remove design errors that were introduced during the requirements and design phases of the life-cycle. This study was conducted to assess the possibility of reducing system development cost by elimination or early detection of design errors through the use of a systematic design approach. The study indicates that such possibilities do exist and should be exploited. Author

A89-18065#
AVIONICS FAILURE PROPAGATION ANALYSIS TOOL
YOSHIKI NAKAMURA, ABHIJIT CHAKRAVARTY, and IRVING R. REESE (Boeing Commercial Airplanes, Seattle, WA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 104-109.
(AIAA PAPER 88-3868)

The Avionics Failure Propagation Analysis Tool (AFPAT) is a computer program designed and built to provide failure propagation visibility for a network of avionics subsystems. It is programmed in the Artificial Intelligence (AI) language PROLOG and is hosted on both PC-compatible and Apollo workstations. This analysis tool helps identify potential design integration problems among the avionics line replaceable units (LRUs) during the equipment design and testing phases. It can also assist avionics/flight systems design engineers in the preparation of system failure analyses for airplane certification support. Author

A89-18083*# Research Triangle Inst., Research Triangle Park, NC.
A SIMULATION-BASED FAULT INJECTION EXPERIMENT TO EVALUATE SELF-TEST DIAGNOSTICS FOR A FAULT-TOLERANT COMPUTER
ROBERT L. BAKER, L. SCOTT MANGUM, and CHARLOTTE O. SCHEPER (Research Triangle Institute, Research Triangle Park, NC) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 220-226. refs
(Contract NAS1-17964)
(AIAA PAPER 88-3897)

The design and results of a fault injection experiment conducted in the Airlab facility at NASA-Langley using a logic network simulator are described. An attempt was made to determine the effectiveness of the diagnostic self-test sequences used to detect failures in the communicator/interstage (C/I) of a fault-tolerant processor (FTP). Identification of the undetected faults in the C/I Status Register logic resulted in changes in the diagnostic test sequences implemented for the FTP. K.K.

A89-18086*# Duke Univ., Durham, NC.
AN APPROACH TO SOLVING LARGE RELIABILITY MODELS
MARK A. BOYD, MALATHI VEERARAGHAVAN, JOANNE BECHTA DUGAN, and KISHOR S. TRIVEDI (Duke University, Durham, NC) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 243-250. Research supported by the Research Triangle Institute. refs
(Contract NAG1-70; AF-AFOSR-84-0132)
(AIAA PAPER 88-3905)

This paper describes a unified approach to the problem of solving large realistic reliability models. The methodology integrates behavioral decomposition, state trunction, and efficient sparse matrix-based numerical methods. The use of fault trees, together with ancillary information regarding dependencies to automatically generate the underlying Markov model state space is proposed. The effectiveness of this approach is illustrated by modeling a state-of-the-art flight control system and a multiprocessor system. Nonexponential distributions for times to failure of components are assumed in the latter example. The modeling tool used for most of this analysis is HARP (the Hybrid Automated Reliability Predictor). Author

A89-18087#
ADA IN AVIONICS - BEYOND VALIDATION
W. B. KEEN (Plessey Avionics, Ltd., Havant, England) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 251-255.
(AIAA PAPER 88-3907)

The validation of Ada compilers is necessary but not sufficient, particularly for constrained, real-time, embedded systems. It has distorted compiler development away from real world support features and so has delayed Ada's wide scale application. The evaluation criteria required for avionic applications must firstly consider technical feasibility in terms of configurabiity of the Ada run-time system and the impact on hardware design; and secondly, the cost and performance implications. Plessey Avionics has applied Ada to a range of avionic systems and have observed the rapid maturation of Ada compilers. Armed with the appropriate evaluation criteria, the adoption of Ada for avionic applications is seen to provide significant benefits over previous languages. Consequently, Plessey Avionics has adopted Ada for several projects even though Ada was not a specific customer requirement. Author

A89-18088#
A FAULT TOLERANT AVIONICS MULTIPROCESSING SYSTEM ARCHITECTURE SUPPORTING CONCURRENT EXECUTION OF ADA TASKS
DAVID W. BEST, KEVIN L. MCGAHEE, and ROGER K. SHULTZ (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 256-262. refs
(AIAA PAPER 88-3908)

A distributed multiprocessing computer architecture which fulfills the requirements of fully integrated avionics systems is described. The PRISM (prototype, reconfigurable, integrated system for multiprocessing) architecture is designed to provide a fault tolerant and damage tolerant network of processor, memory, and I/O modules. An overview of the multiprocessing system architecture is presented as well as a discussion of the requirements and support for the distributed Ada programming system. K.K.

A89-18111#
ON THE EFFECTIVENESS OF MULTIVERSION SOFTWARE IN DIGITAL AVIONICS
ALGIRDAS AVIZIENIS and MICHAEL R. LYU (California, University, Los Angeles) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 422-427. refs
(AIAA PAPER 88-3903)

Ways of attaining effective tolerance of design faults by means of multiversion software are discussed. Two recent investigations (U. of Virginia/U. of California at Irvine, and UCLA/Honeywell) that have produced differing results are compared. A design paradigm for multiversion software is presented. K.K.

A89-18115#
USE OF THE GALA AND PALAS TOOLS TO ENHANCE THE DEVELOPMENT OF AVIONIC SOFTWARE
P. CORON (SFENA, Velizy-Villacoublay, France) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 445-457.
(AIAA PAPER 88-3943)

Two software tools for assuring avionics software safety and quality are presented. One is a configuration and modification management tool called Palas and a tool for automatic code generation called Gala. The Gala advantages, graphic language, real-time aspects, organization are examined. The Palas functions are reviewed and the use of Palas in workshops is reported on. C.D.

A89-18137#
AN AUTOMATED METHODOLOGY FOR PARTITIONING SOFTWARE FUNCTIONS IN A DISTRIBUTED AVIONICS ARCHITECTURE
M. ABDI-MORADI (TRW, Inc., TRW Defense System Group, Houston, TX) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 585-592.
(AIAA PAPER 88-3971)

Designing a modern avionics system includes the partitioning of software functions into a fintie set of subsystems. This paper describes an automated approach to partitioning based on a pre-established set of objectives and constraints. A program called 'Bus' partitions the functions into subsystems, with the objective of minimizing data flow between subsystems and meeting a constraint on the availability of computer resources. Another program called 'Subsys' will generate a set of subsystems with the objectives of: (1) creating stand-alone functional entities, (2) maintaining simple interfaces between the subsystems, and (3) minimizing bus traffic between processors. A program called 'Type' creates subsystems based on grouping of functions which have common identification (ID) numbers. The ID numbers assigned by the designer, represent function characteristics such as: criticality, type of data handled, the function execution rate, or some other factor related to an objective which should influence the functional partitioning. By using the automated approach, the author concludes that the partitioning task can be performed faster, but more importantly, the process ensures traceability between subsystems and functions and produces a clear audit trail for future reassessment or modification of the design. Author

A89-18141#
A PARALLEL MODULAR SIGNAL PROCESSOR
MARK COLESTOCK (Control Data Corp., Minneapolis, MN) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC,

American Institute of Aeronautics and Astronautics, 1988, p. 607-613. refs
(AIAA PAPER 88-3981)

The parallel modular signal processor (PMSP) is a high-speed airborne programmable VLSI signal processor capable of a peak FET processing rate of 625 million operations per second. Special software tools are also needed to match this new-generation signal processor. The PMSP's software tools and modular architecture are designed to meet the requirements of today and into the 1990s. Author

A89-18160#
INTER-PARTITION DATA INTEGRITY IN THE ASYNCHRONOUS DATAC ENVIRONMENT
DAVID E. BAKKEN (Boeing Commercial Airplanes, Seattle, WA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 724-730. refs
(AIAA PAPER 88-4010)

The Digital Autonomous Terminal Access Communication (DATAC) system, a two-way multiple-access data bus for avionics applications, is described, with a focus on data-integrity problems arising when time-sliced processes or process groups communicate via DATAC variables. Particular attention is given to the Integrated Avionics Computer System software developed to solve these problems in future transport aircraft. The partition interface and RTE routine implementation are discussed and illustrated with diagrams, and the relative advantages of hardware and software solutions to the integrity problem are considered. T.K.

A89-18162#
GAAS 32-BIT SINGLE BOARD COMPUTER
JAN W. WINE (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 738-741. refs
(AIAA PAPER 88-4012)

This paper describes the architecture and design of an all-gallium arsenide (GaAs) 32-bit, single board computer. The GaAs single board computer is part of a technology development program to produce a radiation hard, low power, high speed GaAs processing system suitable for a variety of applications. This paper focuses on an architecture designed for an embedded system, where space and power are limiting constraints. Author

A89-18163#
A MIL-STD-1750A, SINGLE-BOARD COMPUTER FOR EMBEDDED MULTIPROCESSOR APPLICATIONS
JOHN M. DREES (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 742-747.
(AIAA PAPER 88-4015)

This paper details the development of a standard-building-block 1750A-multiprocessor-single-board computer. It also describes a MIL-STD-1750A development environment that supports these concepts. Such topics as using a cache memory scheme in a multiprocessing environment and using the VME bus as a multiprocessing system bus are also discussed. Author

A89-18166#
ADA EXECUTIVE FOR DISTRIBUTED AVIONICS PROCESSING
DAVID W. LYNESS (TAU Corp., Long Beach, CA), ROBERT A. MANSKE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and RICHARD A. ROGERS (Rogers Aerospace, Redondo Beach, CA) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 761-766.
(AIAA PAPER 88-4042)

A robust Ada-based executive for distributed avionics applications is being implemented within the Air-to-Air Attack Management Program. Algorithms and control/display concepts for cooperative, multiple target attack in beyond visual range air combat are being developed. A discussion of the current status of the executive function is presented along with a look at future plans for development of a comprehensive Ada executive for generalized distributed avionics applications. Author

A89-18178#
AI APPLICATIONS TO TACTICAL DECISION AIDS
C. R. OVENDEN (Smiths Industries Aerospace and Defence Systems, Ltd., Cheltenham, England) IN: AIAA/IEEE Digital Avionics Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 842-846. Research supported by the Alvey Directorate of England.
(AIAA PAPER 88-4027)

As the environment in which military aircraft operate becomes increasingly hostile and the advances in avionics systems provide the crew with ever more data, mission effectiveness will be put at risk by the increase in crew workload. The tactical decision aid (TDA) is a system designed to alleviate this workload problem by using the incoming data to supply the crew with high-level information upon which tactical decisions can be made. This paper outlines the primary processes of the TDA namely sensor fusion and mission planning which have been approached from an AI perspective. The test-bed for this work has been a ground attack mission and in particular the hostile ingress and egress phases of the mission. Author

A89-18864
SOFTWARE DEVELOPMENT FOR LARGE SCALE AVIONIC INTEGRATION PROGRAMS
RALPH HAMPP and CECIL RICHARDSON (IBM Corp., Federal Systems Div., Owego, NY) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 191-200. refs

Good management and control of software development is a necessity in today's digital avionic environment. The last 20 years have seen a major trend away from the analog systems of the 1950s to the digital avionics of the 1980s. This trend encompasses not only the extensive computer systems found on almost all modern airplanes and helicopters, but also every newly developed black box is designed around a microprocessor and uses digital firmware. Laboratory facilities needed to validate the performance of these systems and their black boxes have also undergone a digital transformation with insignificant focus on the ability to simulate hardware before the hardware is delivered. This paper describes the structured approach that IBM uses to manage and control software development on large scale avionic programs. The paper also describes the software specification process, system validation techniques, and test facilities used by IBM Federal Systems (FS) since these are so closely related to the software development. Author

A89-18922
HOLOMETRICS - AN INFORMATION TRANSFORMATION METHODOLOGY
C. T. GUNSALLUS, W. L. PELLUM, and W. G. FLANNELLY (Kaman Aerospace Corp., Bloomfield, CT) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 879-885.

Mathematical signal processing and information correlation techniques have been developed which make real time rotating system load determination possible using only fixed system information. These mathematical techniques are presented. In addition, the results of these techniques when applied to recorded flight data are shown as a comparison between the recorded rotating system parameter(s) and the same parameter(s) as determined by the mathematical techniques applied to fixed system information. The mathematical technique and some results which have been obtained are presented. Author

A89-18937#
A FIXED BASE DATA SYSTEM FOR FLIGHT TESTING
DONALD L. MARSHALL (McDonnell Douglas Helicopter Co., Mesa, AZ) and JAMES L. WILLIS (New Mexico State University, Las Cruces) AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Paper. 7 p.

A new flight test data system for testing of current and future generation helicopters is described. The system uses off-the-shelf main frame computers and a hybrid of peripherals not previously utilized in telemetry system applications. Included are high-speed I/O processors, computer disks, fast laser printer/plotters, and a unique utilization of distributed microcomputer preprocessors that allow future expandability. The design goal is to permit modular expansion and/or change with little or no effect on other system modules. C.D.

A89-19560
A PARALLEL ARCHITECTURE FOR A REAL-TIME BLADE ELEMENT ROTORCRAFT SIMULATION
HERBERT GILLMAN, III (Advanced Rotorcraft Technology, Inc., Mountain View, CA) IN: Aerospace simulation III; Proceedings of the SCS Multiconference, San Diego, CA, Feb. 3-5, 1988. San Diego, CA, Society for Computer Simulation International, 1988, p. 117-126.

A methodology which makes it possible to design and evaluate parallel processing architectures independent of hardware is presented. The methodology was applied to an existing real-time serial simulation of the X-wing circulation control rotor system on NASA's rotor system research aircraft. The results indicate that an update rate of 100 Hz is attainable with relatively low cost hardware that is currently available. K.K.

A89-19679
DEVELOPING ERROR-FREE SOFTWARE
B. G. KOLKHORST and A. J. MACINA (IBM Corp., Systems Integration Div., Houston, TX) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 3, Nov. 1988, p. 25-31.

The authors describe experience gained in designing reconfiguration-error-free software. From 1982-1985, this division reduced software product defects to 0.11 errors per thousand lines of source code. Four measurements defining software quality are described. Also discussed is NASA's development of a standardized software support environment, and the US Department of Defense Software Technology for Adaptive Reliable Systems (STARS) program. These environments provide for early control, standardization, and integration of requirements, leading to more easily maintained software and reduction of critical skill level for its maintenance. I.E.

A89-19811#
A METHOD OF COMPUTER AIDED DESIGN OF STRUCTURAL TYPE - AN APPLICATION OF EXPERT SYSTEM AND FUZZY SETS THEORY
YONGSHUN ZHANG and FAJIE WEI (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Aug. 1988, p. B387-B391. In Chinese, with abstract in English. refs

The conception of CAD (Computer Aided Design) is briefly discussed. Moreover, the application of expert system and fuzzy sets theory to CAD is described. Two examples of choosing structural type of airplane wings are given in this paper to illustrate the method discussed here. A degree of 'satisfaction' for index of structural weight and cost is expressed by a value of the membership function of fuzzy sets. The membership functions embody experiences of experts. The results of the two examples are satisfactory. Author

A89-19860#
THE DEVELOPMENT AND APPLICATION OF SOFTWARE QUALITY INDICATORS
WILLIAM A. WHITFILL, III (General Dynamics Corp., Fort Worth, TX) AIAA, Digital Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988. 5 p.
(AIAA PAPER 88-3946)

This paper elaborates on the methodologies used to develop and apply software quality indicators (SQIs) that assist software managers in their control of software development projects. The use of Operational Flight Programs and Quality Improvement Program reports in such methodologies is addressed. The application of SQIs to avionics software for the F-16 aircraft is reviewed. C.D.

A89-19861#
HIGH-SPEED DATA BUS PROCESSING NODE
DARYLE B. HAMLIN (Unisys Corp., Computer Systems Div., Saint Paul, MN) AIAA, Digital Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988. 13 p.
(AIAA PAPER 88-4009)

Future avionics system architectures and concepts are becoming increasingly dependent upon VHSIC/VLSI technology that supports very highly integrated, distributed processing nodes. This paper describes an implementation of such a processing node which is based on a 3.8 MIPS MIL-STD-1750A CPU supporting 256K of local memory combined with a dual-redundant interface to a fiber-optic, linear token-passing, high-speed, serial data bus and a standard PI-bus backplane interconnect. This node is a common module implementation featuring surface-mount technology on a single-width, SEM E printed circuit module supporting custom CMOS, ECL, and hybrid devices. The architectural features of the high-speed processing mode that provide for high performance, distributed processing, fault tolerance, high reliability, interoperability, and standardized devices are described. C.D.

A89-19862#
INTEGRATED CNI TERMINAL SOFTWARE ARCHITECTURE
RICHARD A. BRYSON (TRW, Inc., Military Electronics and Avionics Div., San Diego, CA) AIAA, Digital Systems Conference, 8th, San Jose, CA, Oct. 17-20, 1988. 9 p.
(AIAA PAPER 88-4022)

This paper describes the current architecture and features of the integrated communication-navigation-identification (CNI) family of integrated avionic systems and how they apply to the PAVE PILLAR preferred system architecture for the next generation of avionics. The key features are a hierarchically distributed design from the avionics authority (pilot, mission tape/disk or mission data computer) down through the CNI subsystem and into the line-replaceable modules, infusion of expert system technology into the integrated built-in test and maintenance segment, and an integration of the resource management and integrated built-in test and maintenance segments at each level of the hierarchy to effect efficient dynamic reconfiguration of the common modules of these systems. Author

A89-20139#
ZONAL GRID GENERATION METHOD FOR COMPLEX CONFIGURATIONS
E. ATTA, L. BIRCKELBAW, and K. HALL (Lockheed-Georgia Co., Marietta) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 911-913. Previously cited in issue 08, p. 1140, Accession no. A87-22528. refs

N89-14749# Boeing Military Airplane Development, Seattle, WA.
CEPS: AN ARTIFICIAL INTELLIGENCE APPROACH TO AVIONICS MAINTENANCE
DAVID W. PAPENHAUSEN and BRENT L. HADLEY *In* Colorado Univ., Proceedings of the Air Force Workshop on Artificial Intelligence Applications for Integrated Diagnostics p 208-217 Jul. 1987
Avail: NTIS HC A23/MF A01 CSCL 12I

This discussion presents CEPS, the B-1B CITS Expert Parameter System. CEPS combines expert system technology, conventional programming and a large data base to provide a system which assists in maintenance diagnostics. This approach

optimizes the use of avionics design knowledge, avionics maintenance expertise, and statistical analysis of past and present failure indications to improve fault detection and isolation. Development of a prototype CEPS applied to the B-1B avionics is being performed by the Boeing Military Airplane Company under contract to the Air Force's Aeronautical Systems Division, B-1B Program Office. This paper presents a brief background of CEPS and describes the elements which compose the prototype system. Author

N89-14758# Lockheed Missiles and Space Co., Palo Alto, CA. Research and Development Div.
ON-BOARD EXPERT DIAGNOSTICS FOR AN AVIONICS SUBSYSTEM
PRESTON A. COX *In* Colorado Univ., Proceedings of the Air Force Workshop on Artificial Intelligence Applications for Integrated Diagnostics p 349-351 Jul. 1987
Avail: NTIS HC A23/MF A01 CSCL 12I

Fault detection and isolation in military weapons systems is an area of interest to the military. Current on-board diagnostic tools report a costly number of faults that cannot be reproduced or isolated by maintenance technicians. Maintenance testing of a subsystem that cannot be found to be faulty is costly in terms of equipment downtime and maintenance manhours. The need exists for diagnostic tools that will provide an improved fault detection and isolation capability. Expert systems technology can contribute significantly to satisfying this need. This paper describes a program to develop an Expert Integrated Diagnostician to apply advanced expert system capabilities to improving on-board fault detection and isolation in the military avionics domain. Author

N89-14760# McDonnell Aircraft Co., St. Louis, MO.
AVIONICS FAULT TREE ANALYSIS AND ARTIFICIAL INTELLIGENCE FOR FUTURE AIRCRAFT MAINTENANCE
MICHAEL E. HARRIS and THOMAS D. SNODGRASS *In* Colorado Univ., Proceedings of the Air Force Workshop on Artificial Intelligence Applications for Integrated Diagnostics p 363-374 Jul. 1987
Avail: NTIS HC A23/MF A01 CSCL 12I

The F/A-18 aircraft has demonstrated that reduced Life Cycle Costs and improved operational readiness can be designed-in without retreating from performance requirements when emphasis is properly balanced between Reliability, Maintainability and Design. The Avionics Fault Tree Analyzer (AFTA) is a suitcase size flight line tester capable of extending the F/A-18 fighter's built-in-test (BIT) fault isolation capabilities beyond the Weapon Replaceable Assembly (WRA), to the Shop Replaceable Assembly (SRA) Level. The AFTA was developed as an interim support tool for the Navy prior to attainment of total organic support capability, and as an alternate method of support to reduce Life Cycle Cost for F/A-18 foreign military sales. With the transformation of the AFTA concept from ground support equipment to avionics, a quantitative improvement in Life Cycle Costs will be obtained through the application of Artificial Intelligence (AI) techniques. AI is expected to see applications to practical problems in many disciplines; and one of which is the implementation of the military fault diagnostic system. Using AI techniques, a smart BIT is being developed which will reduce false alarms, identify intermittent failures, and improve fault isolation to the lowest possible element. Increasing density of computer memory, modularly designed avionic functions and the use of very large scale and high speed integrated devices will allow future aircraft to fly with the AFTA function. Ramifications such as eliminating the need for intermediate avionic repair facilities, increased aircraft operational readiness, decrease in aircraft recurring cost, and a reduction in spares investment are discussed. This paper will summarize the AFTA concept, Life Cycle Cost advantages, and the implementation of Artificial Intelligence in future avionic designs relative to improved reliability and maintainability. Author

N89-14761# Raytheon Co., Bedford, MA.
EXPERT SYSTEMS IN HIGHER ECHELON MAINTENANCE ACTIVITIES
JOSEPH C. HINTZ *In* Colorado Univ., Proceedings of the Air Force Workshop on Artificial Intelligence Applications for Integrated Diagnostics p 375-383 Jul. 1987
Avail: NTIS HC A23/MF A01 CSCL 12I

Large, complex weapons systems are maintained by several echelons of troubleshooting personnel. Each echelon repairs a certain category of faults and notifies a higher echelon if unable to effect repairs. As the level of the echelon increases, the mean-time-to-repair, the training level of the maintenance personnel, the complexity of troubleshooting tools, and the difficulty in locating faults all increase. In addition, multiple faults become much more likely as maintenance-induced faults appear. An expert system that aids a higher echelon maintenance team in one subsystem (a phased array antenna) of a ground-based radar system is discussed. At this time, the expert system exceeds 33,000 lines of code (500+ rules). Lower level echelons will have repaired 95 percent of the faults by using sophisticated BITE and computer-aided troubleshooting techniques. The faults requiring a higher echelon will require expert experienced assistance in successful troubleshooting techniques. The expert system utilized knowledge of previous maintenance activities and system level symptoms to determine the type of fault most probable. It then selects the information sources that are most useful in making a more accurate diagnosis and instructs the user in the procedures used to obtain the information. For example, diagnostic tests may be executed singly or in groups. Futhermore, the tests may be executed once in a search for hard faults or in a loop when searching for intermittents. Schematics may be used for connectivity information. Diagnostic test pseudo-code and fault mapping data may be considered to isolate the fault to plausible regions of malfunction. Discussion includes the use of meta-knowledge in the expert system to control the execution of rules, the development of an interface between the expert system and an existing graphical data base of schematics, and the expert system's ability to diagnose intermittent and multiple faults. In concludes with lessons learned and future plans. Author

N89-14763# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.
THE B-1B CENTRAL INTEGRATED TEST SYSTEM EXPERT PARAMETER SYSTEM
GERARD J. MONTGOMERY *In* Colorado Univ., Proceedings of the Air Force Workshop on Artificial Intelligence Applications for Integrated Diagnostics p 388-393 Jul. 1987 Previously announced in IAA as A87-16839
Avail: NTIS HC A23/MF A01 CSCL 12I

The B-1B Central Integrated Test System (CITS) provides a comprehensive on aircraft diagnostic capability and records approximately 19,600 parameters. The B-1B CITS Expert Parameter System (CEPS) is an initiative to improve B1B diagnostic capabilities by applying expert system and data analysis techniques to the in-flight recorded data. The manner in which CEPS enhances B-1B on and off aircraft diagnostic capabilities and reduces false alarm, can not duplicate and re-test okay accurrences will be presented. The CEPS capabilities will be discussed and an overview of the accomplishments and status of the CEPS program will be given. This paper will illustrate the applicability of the B-1B CEPS concepts to other existing and future weapon systems. The ability to reduce future weapon system built-in test requirements through the use of on-aircraft expert systems will be discussed, along with the need for a ground based diagnostic system. Author

N89-14795*# California Univ., Los Angeles. Lab. for Flight Systems Research.
EFFICIENT LOAD MEASUREMENTS USING SINGULAR VALUE DECOMPOSITION Final Report, 1 Jan. 1987 - 31 Mar. 1988
KUNG YAO and A. V. BALAKRISHNAN 1988 18 p
(Contract NAG2-433)
(NASA-CR-184614; NAS 1.26:184614) Avail: NTIS HC A03/MF A01 CSCL 12A

Various basic research was performed on efficient load measurement estimation techniques for aircraft structure analysis. An overview is presented of the load measurement problem. Two

basic equivalent approaches to load measurement evaluations were considered. Under approach 1, the load values are modeled as depending linearly on the measured values. Under approach 2, the measured values depend linearly on the load values. By using the modern Singular Value Decomposition method, it was shown that under all conditions of the number of loads and number of gages, approach 1 is equivalent to approach 2. By using the conventional normal equation (linear regression) approach, approach 1 is only valid when the number of loads is equal to or greater than the number of gages, while approach 2 is the reverse. Furthermore, except for the case of the number of loads equals the number of gages, the load prediction formulas under the two approaches are not equivalent. 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.

A89-18912
EXPERIMENTAL ASSESSMENT OF A TURBULENCE INGESTION NOISE THEORY
JOHN SIMONICH, ROBERT SCHLINKER (United Technologies Research Center, East Hartford, CT), and ROY AMIET IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 731-745. refs

A model helicopter rotor was tested in a closed anechoic chamber to assess the accuracy of a rotor noise theory for nonisotropic turbulence ingestion. The measured aerodynamic properties were used as inputs to a noise prediction procedure. The agreement between the experimental data and predictions is good, although the analysis generally overpredicts the quasi-tonal low to mid range frequencies and underpredicts the higher broadband signals. The predicted sound power level as a function of polar angle is in close agreement with measurements, except near the rotor plane, which is not modeled by the present analysis. V.L.

A89-18913
A COMPARISON OF ACOUSTIC PREDICTIONS WITH MODEL ROTOR TEST DATA FROM THE NASA 14 X 22 FT WIND TUNNEL
CHRISTIAN J. SCHWINDT and JAMES M. FITZGERALD (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 747-756. refs

A study to correlate the predictions of the NASA-developed ROTONET rotorcraft acoustic prediction code and the Sikorsky in-house rotorcraft acoustic prediction code with model wind tunnel tests is presented. The prediction methodology models thickness, steady and unsteady loading effects, with the unsteady loading derived from forward flight and simple wake models. The predictions have been compared with the acoustic data on the basis of similarity of the acoustic pressure time histories. Author

A89-18914* Planning Research Corp., Hampton, VA.
TIP-PATH-PLANE ANGLE EFFECTS ON ROTOR BLADE-VORTEX INTERACTION NOISE LEVELS AND DIRECTIVITY
CASEY L. BURLEY (Planning Research Corp., Hampton, VA) and RUTH M. MARTIN (NASA, Langley Research Center, Hampton, VA) IN: AHS, Annual Forum, 44th, Washington, DC, June 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, p. 757-771. refs

Acoustic data of a scale model BO-105 main rotor acquired in a large aeroacoustic wind tunnel are presented to investigate the parametric effects of rotor operating conditions on blade-vortex interaction (BVI) impulsive noise. Contours of a BVI noise metric are employed to quantify the effects of rotor advance ratio and tip-path-plane angle on BVI noise directivity and amplitude. Acoustic time history data are presented to illustrate the variations in impulsive characteristics. The directionality, noise levels and impulsive content of both advancing and retreating side BVI are shown to vary significantly with tip-path-plane angle and advance ratio over the range of low and moderate flight speeds considered. Author

A89-18948
MEASUREMENTS IN THE FIELD OF A SPARK EXCITED COMPRESSIBLE AXISYMMETRIC JET
S. EMAMI (General Dynamics Corp., Fort Worth, TX), C. OSTOWARI, and A. AHMED (Texas A & M University, College Station) Experiments in Fluids (ISSN 0723-4864), vol. 7, no. 1, 1989, p. 69-71. refs

Acoustic phase (ensemble) averaged measurements were performed in a constant temperature, axisymmetric, Mach 0.6 jet of air. These measurements show that the noise directly radiated by the coherence structure in the jet flow field was responsible for the directivity of the acoustic field. Author

A89-19672
CONTRIBUTIONS TO THE THEORY OF SOUND PRODUCTION BY VORTEX-AIRFOIL INTERACTION, WITH APPLICATION TO VORTICES WITH FINITE AXIAL VELOCITY DEFECT
M. S. HOWE (BBN Laboratories, Inc., Cambridge, MA) Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0080-4630), vol. 420, no. 1858, Nov. 8, 1988, p. 157-182. Navy-supported research. refs

The sound produced when a vorticity field is cut by an airfoil in low-Mach-number flow is analyzed. A general formula is presented for the acoustic pressure when the airfoil is rigid and the chord is acoustically compact. This makes it possible to express the radiation in terms of an integral over the region occupied by the vorciticity; the integrand contains factors describing the effect of the thickness, twist, and camber of the airfoil. Explicit analytical results are obtained for a rectilinear vortex, having small core diameter and finite axial velocity defect, which is cut by a nonlifting airfoil of large aspect ratio. B.J.

A89-19902#
FREQUENCY-DOMAIN METHOD FOR THE COMPUTATION OF PROPELLER ACOUSTICS
J. B. H. M. SCHULTEN (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) AIAA Journal (ISSN 0001-1452), vol. 26, Sept. 1988, p. 1027-1035. Research supported by Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. Previously cited in issue 04, p. 569, Accession no. A88-16537. refs

A89-19903#
HOLE TONE GENERATED FROM ALMOST CHOKED TO HIGHLY CHOKED JETS
Y. UMEDA, H. MAEDA, and R. ISHII (Kyoto University, Japan) AIAA Journal (ISSN 0001-1452), vol. 26, Sept. 1988, p. 1036-1043. refs

The hole tone generated from the interaction of high-speed jets with a round hole was experimentally investigated in order to clarify its generation mechanism. Measurements of far-field pressure waves as well as schlieren flow visualization were carried out. The frequency characteristics of the present hole tone are similar to those of hole tones radiated from a low-speed jet. Flow visualization confirms that this hole tone is generated by essentially the same feedback mechanism as that of the impinging tone radiated from high-speed jets. When a ring vortex interacts with the plate with a hole, an acoustic pulse is emitted with a strong directional peak in the upstream direction. The acoustic pulse propagates outside the jet and forces the generation of a new

eddy on reaching the nozzle lip. The new eddy grows as it propagates downstream to interact with the circumference of the hole. Author

A89-20143*# Planning Research Corp., Hampton, VA.
ACOUSTIC TRANSMISSIBILITY OF ADVANCED TURBOPROP AIRCRAFT WINDOWS
FERDINAND W. GROSVELD (Planning Research Corp., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 942-947. Previously cited in issue 04, p. 568, Accession no. A88-16530. refs
(Contract NAS1-16978)

N89-14818# Bolt, Beranek, and Newman, Inc., Canoga Park, CA.
DETAILED DESIGN SPECIFICATION FOR A PROTOTYPE ASSESSMENT SYSTEM FOR AIRCRAFT NOISE (ASAN) Interim Report, 12 Feb. - 15 Oct. 1987
FIDELL SANFORD, MICHAEL HARRIS, and NICHOLAAS REDDINGUIS Jul. 1988 93 p
(Contract F33615-86-C-0530)
(AD-A197936; BBN-R-6499) Avail: NTIS HC A05/MF A01 CSCL 12G

The U.S. Air Force Noise and Sonic Boom Impact Technology (NSBIT) Program is sponsoring a multi-stage effort to create a computer system containing tools needed by the environmental planning community to perform a variety of tasks related to assessing the environmental impacts of aircraft noise on people, animals, and structures. This interim report provides a detailed design specification for a prototype version of the NSBIT Assessment System for Aircraft Noise (ASAN) that is the major project of the first stage of this effort. The purposes and expected uses of ASAN are presented in Fidell and Harris (1987). The general functional capabilities of this system are described by Harris and Fidell (1987). The current report describes the organization of ASAN, its functional capabilities, and its major software modules. GRA

N89-14820*# Planning Research Corp., Hampton, VA.
USERS' MANUAL FOR THE LANGLEY HIGH SPEED PROPELLER NOISE PREDICTION PROGRAM (DFP-ATP)
M. H. DUNN and G. M. TARKENTON Washington, DC NASA Jan. 1989 46 p
(Contract NAS1-18000)
(NASA-CR-4208; NAS 1.26:4208) Avail: NTIS HC A03/MF A01 CSCL 20A

The use of the Dunn-Farassat-Padula Advanced Technology Propeller (DFP-ATP) noise prediction program which computes the periodic acoustic pressure signature and spectrum generated by propellers moving with supersonic helical tip speeds is described. The program has the capacity of predicting noise produced by a single-rotation propeller (SRP) or a counter-rotation propeller (CRP) system with steady or unsteady blade loading. The computational method is based on two theoretical formulations developed by Farassat. One formulation is appropriate for subsonic sources, and the other for transonic or supersonic sources. Detailed descriptions of user input, program output, and two test cases are presented, as well as brief discussions of the theoretical formulations and computational algorithms employed. Author

N89-14821*# Planning Research Corp., Hampton, VA. Aerospace Technologies Div.
NUMERICAL SIMULATION AND COMPARISON OF SYMMETRICAL/SUPERCRITICAL AIRFOILS FOR THE NEAR TIP REGION OF A HELICOPTER IN FORWARD FLIGHT
F. F. BADAVI Washington, DC NASA Jan. 1989 54 p
(Contract NAS1-18000)
(NASA-CR-4212; NAS 1.26:4212) Avail: NTIS HC A04/MF A01 CSCL 20A

Aerodynamic loads on a multi-bladed helicopter rotor in forward flight at transonic tip conditions are calculated. The unsteady, three-dimensional, time-accurate compressible Reynolds-averaged thin layer Navier-Stokes equations are solved in a rotating coordinate system on a body-conformed, curvilinear grid of C-H topology. Detailed boundary layer and global numerical comparisons of NACA-0012 symmetrical and CAST7-158 supercritical airfoils are made under identical forward flight conditions. The rotor wake effects are modeled by applying a correction to the geometric angle of attack of the blade. This correction is obtained by computing the local induced downwash velocity with a free wake analysis program. The calculations are performed on the Numerical Aerodynamic Simulation Cray 2 and the VPS32 (a derivative of a Cyber 205 at the Langley Research Center) for a model helicopter rotor in forward flight. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A89-18949
NEW PROPOSALS FOR NEW DIRECTIONS - 1992 AND THE GATT APPROACH TO TRADE IN AIR TRANSPORT SERVICES
PAUL V. MIFSUD (KLM Royal Dutch Airlines, New York) Air Law (ISSN 0165-2079), vol. 13, Oct. 1988, p. 154-171. refs

Developments significantly affecting both European and North American air transport are discussed. These are: (1) the Single European Act which calls for an open 'internal market' by the end of 1992; (2) the invasion of a mature, deregulated, and consolidated U.S. airline industry into international air transport; and (3) the current Uruguay Round, which is causing GATT trade negotiators to consider application of the GATT principles to trade in services. It is noted that consideration must be given to the complications of multiple routings, third country obligations, and intercarrier arrangements. K.K.

A89-18950
PROPOSED REVISIONS TO AMERICA'S NATIONAL AIRSPACE SYSTEM - A CRISIS IN LEADERSHIP?
ALAN ARMSTRONG Air Law (ISSN 0165-2079), vol. 13, Oct. 1988, p. 172-177. refs

The paper discusses the legislative origins of a debate concerning the extent to which Mode 'C' (altitude reporting) transponder equipment may be required of aircraft operated in U.S. airspace. The current proposal regarding Mode 'C' equipment and airspace reconfiguration advanced by the FAA is examined as well as Congressional and general aviation's response to the proposal. An attempt is made to find alternate solutions to the problems which caused the debate in the first place. K.K.

A89-20136#
GENERAL AVIATION COST EFFECTIVENESS
RICHARD E. ETHERINGTON (Gates Learjet Corp., Wichita, KS) Journal of Aircraft (ISSN 0021-8669), vol. 25, Oct. 1988, p. 890-896. Previously cited in issue 03, p. 413, Accession no. A87-14037. refs

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GENERAL

A89-17867#
THE X-20 SPACE PLANE - PAST INNOVATION, FUTURE VISION

TERRY L. SUNDAY (Martin Marietta Corp., Astronautics Group, El Paso, TX) and JOHN R. LONDON, III (Florida Institute of Technology, Las Cruces, NM) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 17 p. refs (IAF PAPER 88-598)

The X-20 space plane, known as Dyna-Soar, never reached operational status -- it was cancelled in December 1963, before the first prototype was built. This paper examines both the history and the technology of Dyna-Soar. The space plane's unique design and its proposed missions are examined, along with the ever-changing political, economic and programmatic environments that led to its conception, its long, painful gestation period, and its demise. Author

A89-20251
THE X-PLANES: X-1 TO X-31 (2ND REVISED AND ENLARGED EDITION)

JAY MILLER (Aerofax, Inc., Grand Prairie, TX) New York, Orion Books, 1988, 216 p. refs

Development histories are presented for the family of 'X-designated' experimental aircraft designed for, and operated by, NACA and NASA from 1945 to the present. The initial aircraft of the series, the rocket-powered X-1, investigated the dynamic flight characteristics of an aircraft passing the sonic barrier into the supersonic speed regime. Additional noteworthy aircraft included the variable wing-sweep X-5, the uncompleted nuclear-powered X-6, the vectorable-thrust VTOL X-14, the hypersonic X-15, the tilt-wing/nacelle VTOL X-18, and the BLC-incorporating X-21. Among next-generation X-aircraft are the X-30 testbed for the hypersonic National Aerospace Plane and the X-31 post-stall condition maneuvering aircraft. O.C.

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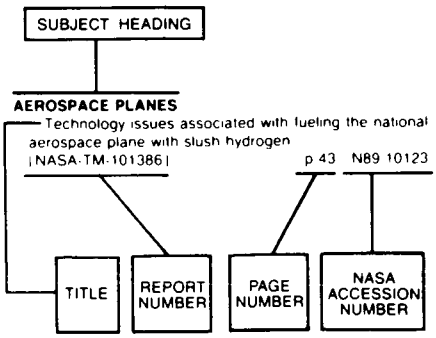

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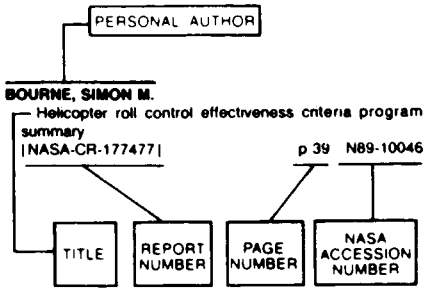

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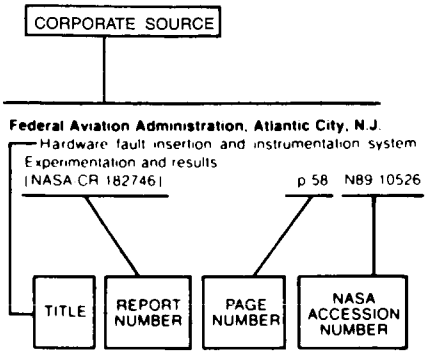

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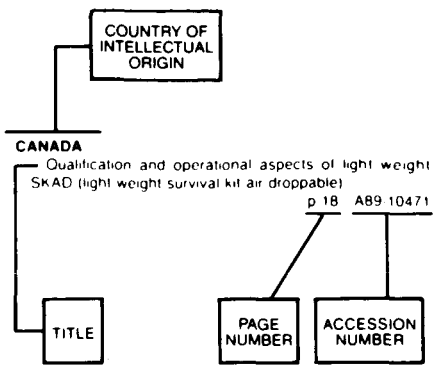

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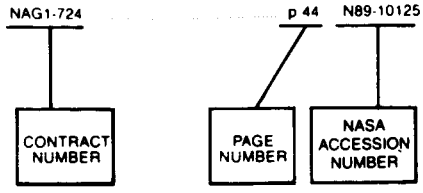

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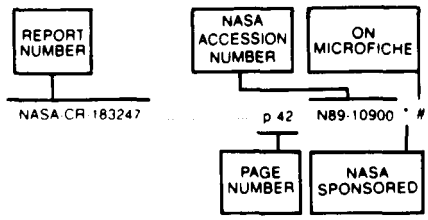

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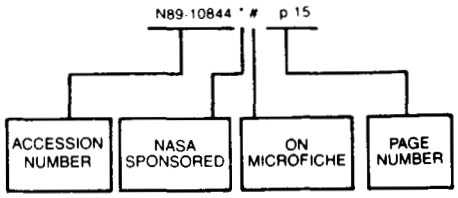

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