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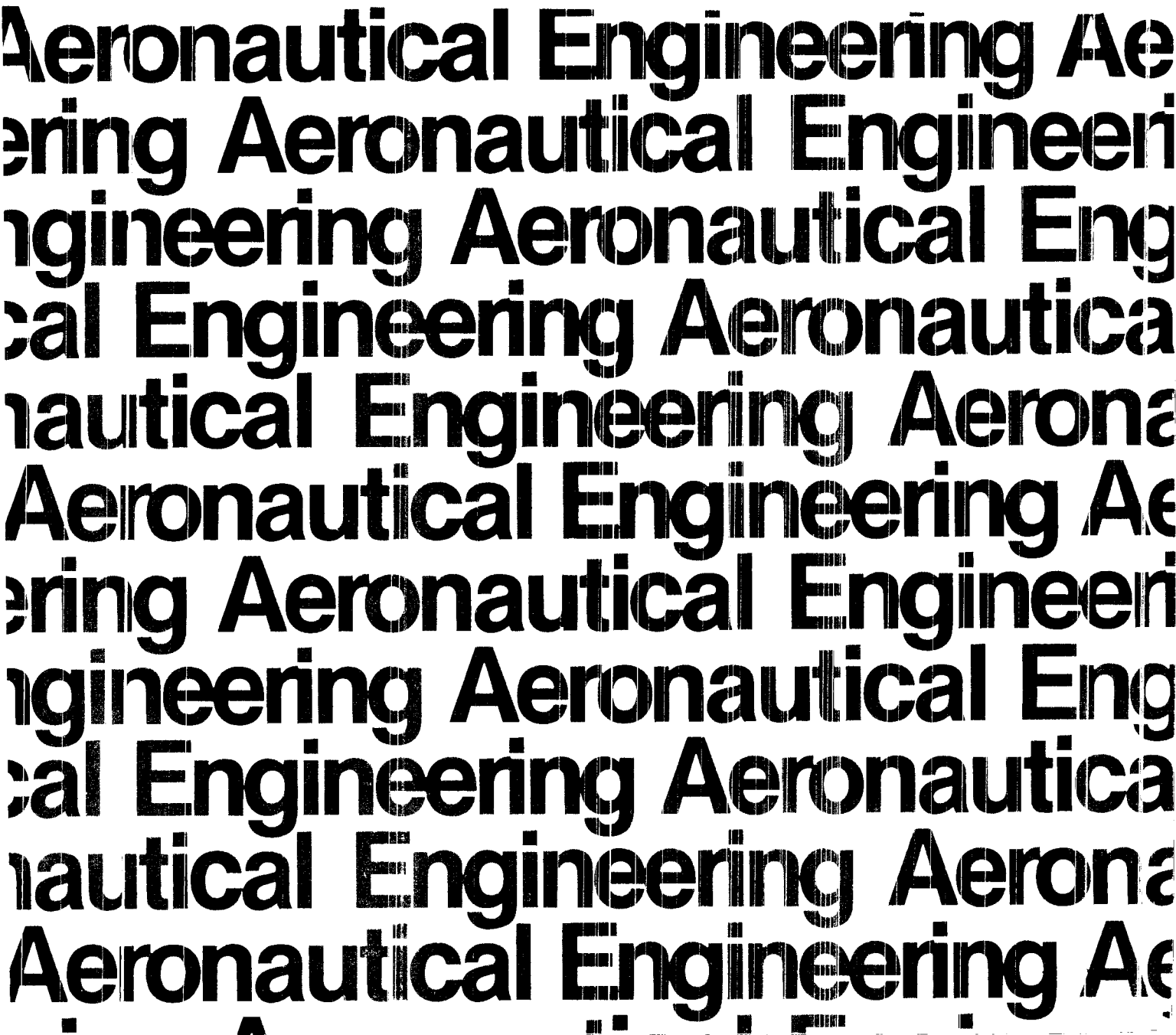
NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

NASA SP-7037(231)
October 1988

National Aeronautics and Space Administration



NASA SP-7037(231)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 231)

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 September 1988 in

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

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

This supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161, price code A07.

INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 469 reports, journal articles and other documents originally announced in September 1988 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category

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

An annual cummulative index will be published.

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

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Category 04	**Aircraft Communications and Navigation** Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.	579
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Category 10	**Astronautics** Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications, spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.	607
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.	608

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Category 12 Engineering 612
Includes engineering (general); communications and radar; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

Category 13 Geosciences 622
Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

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

Category 15 Mathematical and Computer Sciences 623
Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

Category 16 Physics 625
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 626
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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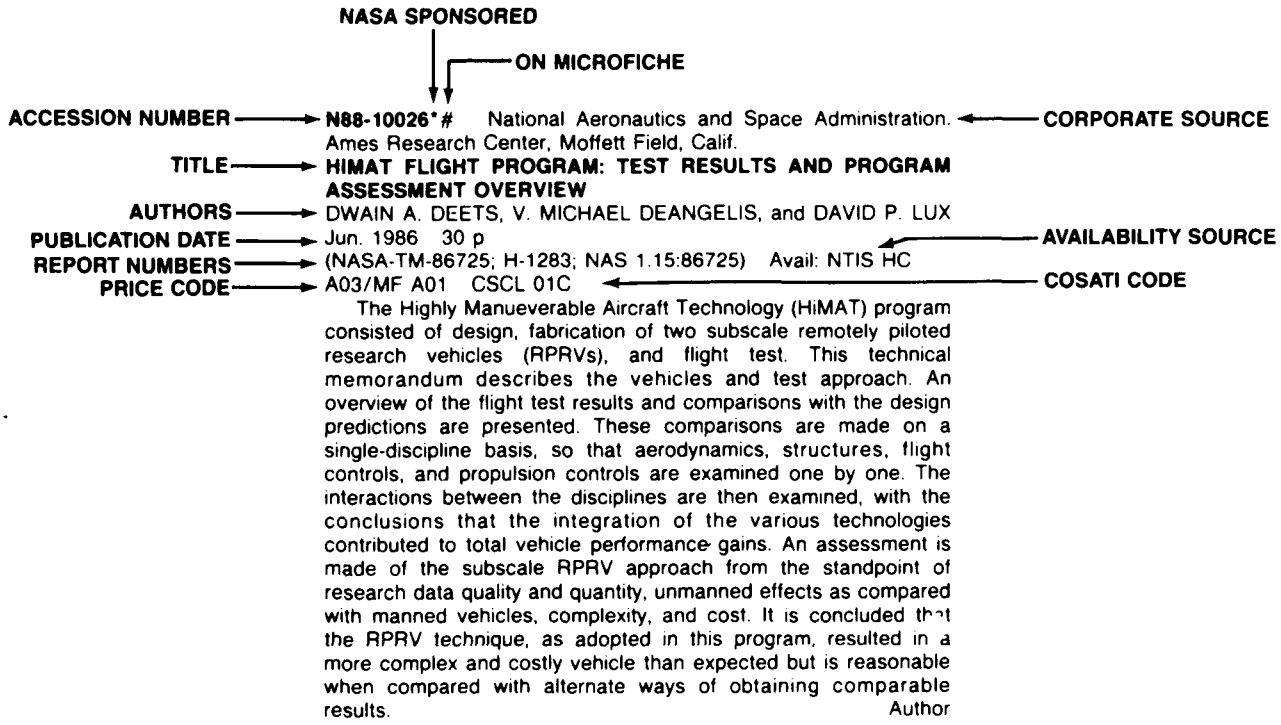
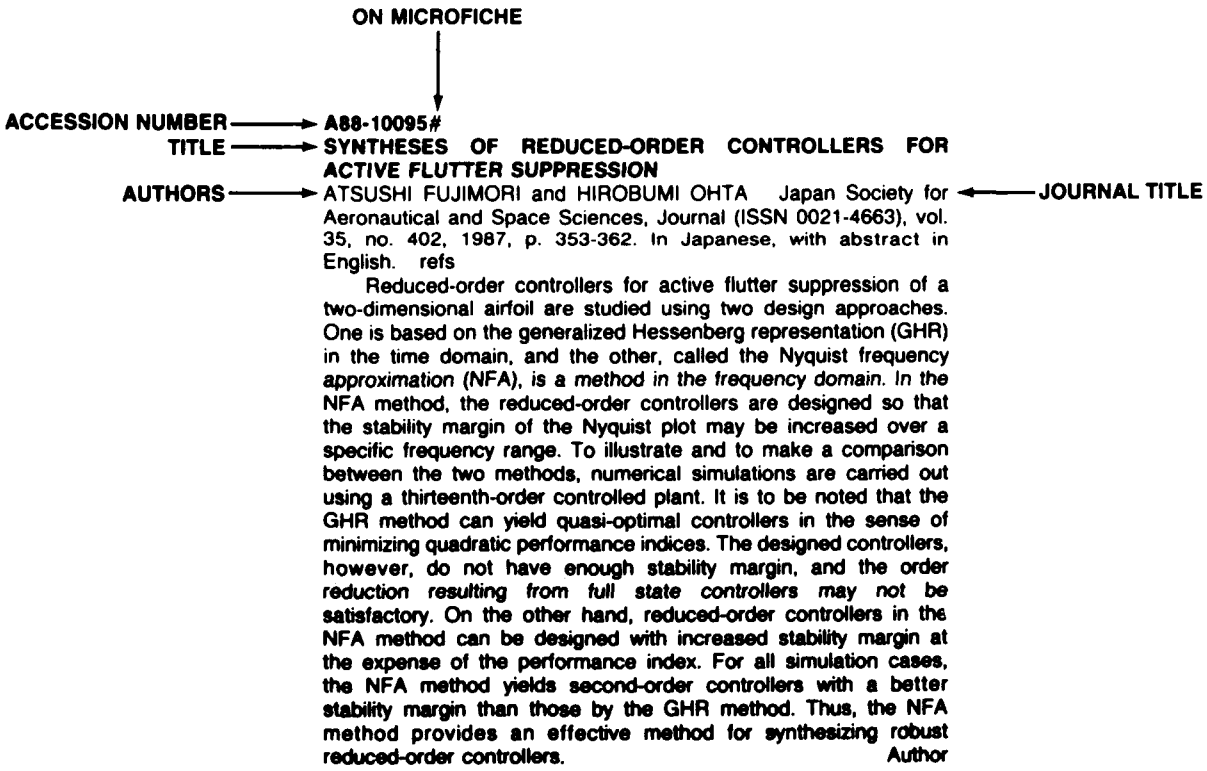
TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 231)

OCTOBER 1988

01

AERONAUTICS (GENERAL)

A88-41809
CALCULATION OF THE HYDRODYNAMIC EFFICIENCY OF A WING PROPELLER [K RASCHETU GIDRODINAMICHESKOGO KOEFFITSIENTA POLEZNOGO DEISTVIIA KRYL'EVOGO DVIZHITELIA]
D. N. GORELOV (AN SSSR, Vychislitel'nyi Tsentr, Omsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), April 1988, p. 31-33. In Russian. refs

The hydrodynamic efficiency of the wing propeller is calculated with allowance for the properties of the drive-wing system. The effect of the drive is estimated for a wing executing translational and rotational motions. It is found that, under operating conditions corresponding to small Strouhal numbers, the effect of the drive is small, while at large Strouhal numbers it may become substantial. V.L.

A88-42346
THERMOPLASTIC COMPOSITE MANUFACTURING TECHNOLOGY FOR A FLIGHT STANDARD TAILPLANE
G. R. GRIFFITHS, W. D. HILLIER, and J. A. S. WHITING (Westland, PLC, Helicopter Div., Yeovil, England) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 308-316. Research supported by the Ministry of Defence Procurement Executive.

The ability of thermoplastic-matrix composites to yield novel structural configurations offering reduced weight and superior damage tolerance is presently assessed in light of the development of a helicopter horizontal stabilizer and fin. After discussing the material selection criteria, processing methods, joining and fastening techniques, and test regimes employed, attention is given to the cost benefits derivable from automation of the thermoplastic composite production processes to include robotic tape-laying and thermoplastic filament-winding. O.C.

A88-42402
A RESIN TRANSFER MOULDED GRAPHITE BISMALEIMID COMPOSITE ENGINE COWLING BEAM
L. M. DANE and R. BROUWER (DSM Advanced Composites, Geleen, Netherlands) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1217-1228.

Manufacturing of a composite engine cowling beam by conventional prepreg tape laying methods poses severe difficulties and is impractical in production environment. This paper describes the design, specifications for the resin processing, injection equipment and parameters, and the results of testing of a simplified version of the rear cowling beam for Fokker 50 aircraft manufactured by resin transfer moldable (RTM) resin processing from a bismaleimide (BMI) formulation. The RTM-grade BMI material is charactedrized by extremely low viscosity at room temperature, has mechanical properties comparable to standard epoxies and hot/wet properties superior to epoxies, and complies with the ATS 1000-001 fire-safety norm. The results demonstrate the feasibility of RTM as an alternative techique to prepreg lay-up in producing high-quality structural BMI products in a reproducible manner. I.S.

A88-42863#
THE RAF MAINTENANCE DATA SYSTEM - NEW DEVELOPMENTS
J. J. D. BROWN (RAF, Maintenance Analysis and Computing Establishment, Morley, England) IN: Reliability '87; Proceedings of the Sixth Conference, Birmingham, England, Apr. 14-16, 1987. Volume 1. London, Institute of Quality Assurance, 1987, p. 3B/2/1 to 3B/2/9.

The history of maintenance data collection activities in the RAF is briefly reviewed, and the development of an on-line Maintenance Data System (MDS) and the Station Engineering Management Aid (SEMA) are discussed. The MDS system is designed to provide data on the faults on all types of RAF equipment, catalogue of items used in RAF equipment, narrative engineering information, and aircraft fatigue life consumption. The system will be expanded to contain modification embodiment and preventive maintenance data. The general configuration of the system is shown, and its functions are discussed. V.L.

A88-42864#
RELIABILITY AND LIFE CYCLE COST OF MILITARY AIRCRAFT - THE VITAL LINK. I - THE CONTEXT
D. W. DANIEL (Ministry of Defence Procurement Executive, London, England) IN: Reliability '87; Proceedings of the Sixth Conference, Birmingham, England, Apr. 14-16, 1987. Volume 1. London, Institute of Quality Assurance, 1987, p. 3B/3/1 to 3B/3/4.

The initiatives of the Ministry of Defence (MOD) and industry's response to the provision of models and methods for the evaluation of system cost-effectiveness from the earliest stages of development are examined. Particular attention is given to the relationship between improved reliability on the one hand and lower costs and improved operational performance on the other. It is shown why evaluation tools are urgently required, and a strategic framework for their development is provided. V.L.

A88-42865#
RELIABILITY AND LIFE CYCLE COST OF MULITARY AIRCRAFT - THE VITAL LINK. II - MODELS AND METHODS
C. G. GRAY and D. J. GREEN (Hunting Engineering, Ltd., Ampthill, England) IN: Reliability '87; Proceedings of the Sixth Conference, Birmingham, England, Apr. 14-16, 1987. Volume 1. London, Institute of Quality Assurance, 1987, p. 3B/3/5 to 3B/3/12.

The combined modeling of life cycle engineering cost (LCEC) and operational availability is examined with particular reference to the evaluation of the effect of changes in reliability on in-service costs. Large accounting-type models, supported by verifiable databases, have been developed for assessing the LCEC of military aircraft; the accumulated data, experience, and expertise are being used to develop more compact and transportable models for cost predictions. Both the LCEC and operational availability models

can be used to explore the effects of changes in a variety of factors, including aircraft reliability and maintainability, and policies for operation and support. V.L.

A88-42925#
IMPACT OF PRODUCT SUPPORT ON AVIATION SAFETY
LLOYD W. CURTIS (Cessna Aircraft Co., Citation Marketing Div., Wichita, KS) IN: Vertical flight training needs and solutions; Proceedings of the AHS National Specialists' Meeting, Arlington, TX, Sept. 17, 18, 1987. Alexandria, VA, American Helicopter Society, Inc., 1987, p. 115-121.

Product support can and should assume a predominant role in helping to assure safe operations. This is accomplished through support of flight and ground crew training, design reviews, maintenance engineering, condition monitoring, product performance evaluation, product design improvement, publications, parts status control, and customer communications. Author

A88-43193
THE FRENCH AERONAUTICS AND SPACE INDUSTRY [L'INDUSTRIE AERONAUTIQUE ET SPATIALE FRANCAISE]
J.-A. LARPENT (Groupement des Industries Francaise Aeronautiques et Spatiales, Paris, France) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 129, 1988, p. 47-50. In French.

The French aerospace industry is discussed with respect to both technological achievements and its impact on the French economy. Over 50 percent of the military hardware of the French army is produced by the aeronautical industry. Current aeronautical programs include the A320 with its CFM 56-5 engine, the Mirage 2000 with its M53 engine, the Ariane 4 launchers, the Hades and Mistral missiles, and the TDF-1, Telecom 1B, and SPOT 2 satellites. Among the future programs discussed are the ACT tactical aircraft, the ATR-72 regional transport aircraft, the Ariane 5, and Columbus. R.R.

A88-43350
METS MEETS THE F-15E SUPPORTABILITY CHALLENGE
WILSON D. YATES, III (McDonnell Aircraft Co., Saint Louis, MO) IN: Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 26-28, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 280-282.

The Mobile Electronic Test Set (METS) F-15 avionics intermediate shop (AIS) automatic test equipment (ATE) is described. METS takes advantage of the stimuli/measurement capability for a print circuit board available for portable testers. Because METS uses six parallel high-speed microprocessors and distributed processing techniques, it provides a real-time multitasking test environment. The extensive built-in testing (BIT) capability of each unit is utilized by METS to assist in the fault isolation. The evolution of F-15 AIS ATE to the METS is presented as a function of a combination of changes in US Air Force operational requirements and improvements in line replaceable unit (LRU) testability. I.E.

A88-43368
SUPPORTING THE ADVANCED TECHNOLOGY AIRSHIP
LARRY S. MICKEL and EUGENE E. NEWMAN (Westinghouse Electric Corp., Baltimore, MD) IN: Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 26-28, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 383-388. refs

After a brief history of lighter-than-air craft, the authors describe support systems for the US Navy's Advanced Technology Airship (ATA) suveillance platform program. Topics covered are: airship mooring, supportability aloft, in-flight replenishment, and support of aeronauts on prolonged missions. I.E.

A88-43370
DEVELOPMENT AND IMPLEMENTATION OF A MAINTENANCE OPERATIONS CONCEPT
WILLIAM R. HERSHEY and ROBERT LOH (Mitre Corp., McLean, VA) IN: Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 26-28, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 395-400. refs

Considering its future maintenance needs, the Federal Aviation Administration (FAA) is sponsoring the development of an operations concept. The goal of this effort is to describe the human role in facilities maintenance. Instead of relying on narrative scenario descriptions, the approach relies largely on diagrams similar to those used for structured analysis. The approach and its potential benefits are outlined. A four-phase plan will take the concept from development through operational transition to integration. The focus here is on the developmental first phase of this plan, which includes graphic techniques for representing the operations concept and some ways to automate these techniques. While the examples pertain to FAA facilities maintenance, the techniques also apply to human operations in other working environments. I.E.

A88-45243
FBW DAMAGE REPAIR CONCEPTS EXAMINED
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 8, July 1988, p. 12-15.

A kit for the field repair of fly-by-wire (FBW) flight control system damage is now being developed by the U.S. Navy under the Battle Damage Repair (BDR) program. The kit consists of an adhesive tape and a tape applicator. The repair procedure is briefly described, and results of initial aerodynamic testing are presented. Ongoing studies will determine the feasibility of an operational BDR kit for the complete flight control system on the F/A-18, with possible applications to other FBW aircraft. V.L.

A88-45474
FLIGHT TESTING OF A BALLOON PROBE [LETNAIA EKSPERIMENTAL'NAIA OTRABOTKA AEROSTATNOGO ZONDA]
V. P. KARIAGIN, R. S. KREMNEV, V. V. KUZNETSOV, V. M. LASHMANOV, V. P. NIKIFOROV et al. Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 26, May-June 1988, p. 448-456. In Russian.

The paper describes the aircraft flight testing of the Vega balloon probe designed to investigate the circulation characteristics of the Venusian atmosphere. It is concluded that the flight tests have confirmed the correctness of all the design solutions obtained for the Vega balloon probe, the lander, and the descent vehicle as a whole. B.J.

N88-23715*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
JOINT UNIVERSITY PROGRAM FOR AIR TRANSPORTATION RESEARCH, 1986
FREDERICK R. MORRELL, comp. Apr. 1988 115 p Meeting held in Hampton, Va., 8-9 Jan. 1987; sponsored by NASA, Langley Research Cetner, Hampton, Va. and FAA, Washington, D.C. Sponsored by NASA, Washington
(NASA-CP-2502; L-16406; NAS 1.55:2502) Avail: NTIS HC A06/MF A01 CSCL 01B

The research conducted under the NASA/FAA sponsored Joint University Program for Air Transportation Research is summarized. The Joint University Program is a coordinated set of three grants sponsored by NASA and the FAA, one each with the Mass. Inst. of Tech., Ohio Univ., and Princeton Univ. Completed works, status reports, and bibliographies are presented for research topics, which include computer science, guidance and control theory and practice, aircraft performance, flight dynamics, and applied experimental psychology. An overview of activities is presented.

N88-23728*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
METHODOLOGY FOR MATCHING EXPERIMENTAL AND COMPUTATIONAL AERODYNAMIC DATA
CAROL D. WIESEMAN May 1988 13 p Presented at the AIAA/ASME/ASCE/AHS/ASC 29th Structures, Structural Dynamics, and Materials Conference in Williamsburg, Va., 18-20

Apr. 1988 Previously announced in IAA as A88-32324
(NASA-TM-100592; NAS 1.15:100592; AIAA-88-2392) Avail: NTIS HC A03/MF A01 CSCL 01B

Correction factor methodologies have been developed which use steady experimental or analytical pressure or force data to correct steady and unsteady aerodynamic calculations. Three methods of calculating correction factors have been developed to match steady surface pressure distributions, to match airfoil section forces and moments. Data for a rectangular supercritical wing that was previously tested in the NASA Langley Research Center Transonic Dynamics Tunnel have been used to determine correction factors to match surface pressure distributions for a range of Mach numbers. Author

N88-23729*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A NUMERICAL STUDY OF THE HOT GAS ENVIRONMENT AROUND A STOVL AIRCRAFT IN GROUND PROXIMITY
THOMAS J. VANOVERBEKE and JAMES D. HOLDEMAN 1988 28 p Prepared for presentation at the 24th Joint Propulsion Conference, Boston, Mass., 11-13 Jul. 1988; sponsored in part by AIAA, ASME, SAE, and ASEE
(NASA-TM-100895; E-4138; NAS 1.15:100895) Avail: NTIS HC A03/MF A01 CSCL 01B

The development of Short Takeoff Vertical Landing (STOVL) aircraft has historically been an empirical- and experience-based technology. In this study, a 3-D turbulent flow CFD code was used to calculate the hot gas environment around an STOVL aircraft operating in ground proximity. Preliminary calculations are reported for a typical STOVL aircraft configuration to identify key features of the flow field, and to demonstrate and assess the capability of current 3-D CFD codes to calculate the temperature of the gases ingested at the engine inlet as a function of flow and geometric conditions. Author

N88-23745*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MANUFACTURING REQUIREMENTS
BRUCE J. HOLMES, CLIFFORD J. OBARA, GLEN L. MARTIN, and CHRISTOPHER S. DOMACK (PRC Kentron, Inc., Hampton, Va.) *In its* Laminar Flow Aircraft Certification p 171-183 May 1986
Avail: NTIS HC A14/MF A01 CSCL 01B

In recent years, natural laminar flow (NLF) has been proven to be achievable on modern smooth airframe surfaces over a range of cruise flight conditions representative of most current business and commuter aircraft. Published waviness and boundary layer transition measurements on several modern metal and composite airframes have demonstrated the fact that achievable surface waviness is readily compatible with laminar flow requirements. Currently, the principal challenge to the manufacture of NLF-compatible surfaces is two-dimensional roughness in the form of steps and gaps at structural joints. Results of recent NASA investigations on manufacturing tolerances for NLF surfaces, including results of a flight experiment are given. Based on recent research, recommendations are given for conservative manufacturing tolerances for waviness and shaped steps.
Author

N88-24573# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
COMPOSITE REPAIR OF CRACKED ALUMINUM ALLOY AIRCRAFT STRUCTURE Final Report, Oct. 1981 - Apr. 1984
FORREST A. SANDOW and RAYMOND K. CANNON Sep. 1987 48 p
(AD-A190514; AFWAL-TR-87-3072) Avail: NTIS HC A03/MF A01 CSCL 01C

A bonded composite patch repair of fatigue-cracked aluminum on aircraft has advantages over a standard bolted metal patch repair, such as no severe stress concentrations (no bolt holes), fatigue-resistant patch, thinner patch, simple molding techniques, a sealed interface to help prevent corrosion, and usually no inspection (NDI) problems. The objective of this program was to determine the effect of composite patches on stress intensity and crack growth characteristics of aluminum. This was accomplished by studying metal thickness and patch parameters (area, thickness, and ply orientation) effects on crack growth rate of the composite patch/aluminum specimen. Both room temperature and elevated temperature (250 F) curing adhesives were studied. The testing procedure consists of edge cracking a 4-inch x 18-inch 2024-t3 aluminum specimen to a length of between 03 and 05 inch. The aluminum is then prepared for bonding, normally using the phosphoric acid non-tank anodize (PANTA) method, primed, and patched. The specimen then cycled to failure. Both constant amplitude and flight spectrum loading were used. Patch material for most specimens was 5521/4 boron/epoxy. Results have shown thickness of the metal being repaired to be the most significant factor in the repair process. There was also a significant difference in results between constant amplitude and spectrum tests. 1/8-inch thick aluminum constant amplitude tests showed lifetime extensions of about 15 times, while 1/16-inch and 1/8 inch thick spectrum waded specimens showed extensions of about 15 and 7 times respectively. GRA

N88-24574# International Trade Administration, Washington, D.C.
COMPETITIVE ASSESSMENT OF THE U.S. CIVIL HELICOPTER INDUSTRY
Apr. 1988 109 p
(PB88-186325) Avail: NTIS HC A06/MF A01 CSCL 01A

The competitive assessment of the U.S. civil helicopter industry is the 44th industry assessment published by the Trade Development unit of the U.S. Department of Commerce. Trade Development has major responsibility for developing U.S. government policy on competitiveness and export promotion. Contents by chapter are as follows: The U.S. Civil Helicopter Industry; Structure of the Industry; Economic Characteristics of the Industry; Factors Affecting Industry Growth; Foreign Competition; Industry Outlook; Implications of U.S. Government Policies on the Helicopter Industry. GRA

N88-24576# Federal Aviation Administration, Atlantic City, N.J. Office of Aviation Policy and Plans.
FAA AVIATION FORECASTS FISCAL YEARS 1988-1999
Feb. 1988 195 p
(AD-A191711; FAA-APO-88-1) Avail: NTIS HC A09/MF A01 CSCL 01A

This report contains Fiscal Years 1988-1999 FAA forecasts of aviation activity at FAA facilities. These include airports with FAA control towers, air route traffic control centers, and flight service stations. Detailed forecasts were made for the four major users of the National Aviation System: air carriers, air taxi/commuters, general aviation and the military. The forecasts have been prepared to meet the budget and planning needs of the constituent units of the FAA and to provide information that can be used by state and local authorities, by the aviation industry, and by the general public. The overall outlook for the forecast period is for continued economic growth, rising real fuel prices, and moderate inflation. Based upon these assumptions, aviation activity by fiscal year 1999 is forecast to increase by 33.4 percent at towered airports, 33.5% at air route traffic control centers, and 11.7% in flight services performed. Hours flown by general aviation are forecast to increase 6.1% and helicopter hours flown, 33.3%. Scheduled domestic revenue passenger miles (RPMs) are forecast to increase by 81.3%, and regionals/commuters by 16.9%. percent. Scheduled domestic revenue passenger miles (RPM's) are forecast to increase 75.8 percent, with scheduled international RPM's forecast to increase by 81.3 percent, and regionals/commuters RPM's forecast to increase by 16.9 percent. GRA

02

AERODYNAMICS

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

A88-41808
ONE-DIMENSIONAL MODELING OF A PULSATION CYCLE DURING THE INTERACTION BETWEEN A SUPERSONIC JET AND AN OBSTACLE [ODNOMERNOE MODELIROVANIE PUL'SATSIONNOGO TSIKLA PRI VZAIMODEISTVII SVERKHZVUKOVOI STRUI S PREGRADOI]
B. SH. AL'BAZAROV, A. I. RUDAKOV, and A. S. FATOV (AN SSSR, Vychislitel'nyi Tsentr, Krasnoyarsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), April 1988, p. 26-30. In Russian. refs

A method for calculating the parameters of self-oscillatory interaction between an underexpanded supersonic jet and an obstacle is developed on the basis of a one-dimensional approximation. The regions of abrupt changes in flow parameters are replaced by discontinuities with a jump in the cross-sectional area of the flow tube. With such an approach, the calculation of the interaction of shock waves between themselves and with an obstacle is reduced to solving the problem of the breakdown of an arbitrary discontinuity at the jump of the cross-sectional area of the flow tube. The motion dynamics of the discontinuities is examined. V.L.

A88-42196*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VISCOUS INDUCED DRAG
GEORGE C. GREENE (NASA, Langley Research Center, Hampton, VA) AIAA, Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988. 8 p. refs
(AIAA PAPER 88-2550)

A fundamentally new approach to the aircraft minimum induced drag problem is presented. The method, a 'viscous lifting line', is based on the minimum entropy production principle and does not require the planar wake assumption. An approximate, closed form solution is obtained and compared with several classical results. In addition, the problem of optimizing in-plane wing sweep with constant wing root bending moment is considered. Like the classical lifting line theory, this theory predicts that induced drag is proportional to the square of the lift coefficient and inversely proportional to the wing aspect ratio. Unlike the classical theory, it predicts that in-plane wing sweep may significantly reduce induced drag, that induced drag is Reynolds number dependent, and that the optimum spanwise circulation distribution is non-elliptic. Author

A88-42452*# Pennsylvania State Univ., University Park.
COMPARISON OF COMPUTATIONAL METHODS FOR THREE-DIMENSIONAL TURBULENT TURBOMACHINERY FLOWS
K. R. KIRTLEY, M. WARFIELD, and B. LAKSHMINARAYANA (Pennsylvania State University, University Park) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, May-June 1988, p. 207, 208. Previously cited in issue 20, p. 2916, Accession no. A86-42740. refs
(Contract NSG-3266)

A88-42456#
CALCULATION OF ANNULAR NOZZLE TRISONIC FLOWFIELDS BY THE METHOD OF CHARACTERISTICS
B. N. WANG and J. D. HOFFMAN (Purdue University, West Lafayette, IN) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, May-June 1988, p. 228-235. Previously cited in issue 20, p. 2915, Accession no. A86-42686. refs

A88-42457*# Massachusetts Inst. of Tech., Cambridge.
VORTEX SHEDDING IN HIGH-SPEED COMPRESSOR BLADE WAKES
A. H. EPSTEIN, J. B. GERTZ, P. R. OWEN, and M. B. GILES (MIT, Cambridge, MA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, May-June 1988, p. 236-244. USAF-NASA-supported research. refs

The wakes of highly loaded compressor blades are generally considered to be turbulent flows. Recent work has suggested that the blade wakes are dominated by a vortex streetlike structure. The experimental evidence supporting the wake vortex structure is reviewed. This structure is shown to redistribute thermal energy within the flowfield. The effect of the wake structure on conventional aerodynamic measurements of compressor performance is noted. A two-dimensional, time-accurate, viscous numerical simulation of the flow exhibits both vortex shedding in the wake and a lower-frequency flow instability that modulates the shedding. The numerical results are shown to agree quite well with the measurement from transonic compressor rotors. Author

A88-42459#
TRANSONIC INLET/NACELLE CODE
RAM SINHA (Lockheed-California Co., Burbank) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, May-June 1988, p. 252-255. Research supported by the Lockheed-California Company Independent Research and Development Program. refs

A fast, accurate, fully automated, and user-friendly computer code, based on the work of Caughey and Jameson, has been developed for the aerodynamic design of two-dimensional and axisymmetric inlets/nacelles at transonic flight speeds. The code development is described herein. Calculated surface pressure distributions and drag coefficient values are compared with the experimental data over a wide range of inlet operating conditions with excellent agreement. The code is intended for preliminary inlet design studies and is restricted to zero angle of attack with no centerbody. More sophisticated codes are available at Lockheed to account for these effects. Author

A88-42461#
THREE-DIMENSIONAL FLOW IN DEEP ROTATING STALL CELLS OF AN AXIAL COMPRESSOR
K. MATHIOUDAKIS and F. A. E. BREUGELMANS (Institut von Karman de Dynamique des Fluides, Rhode-Saint-Genese, Belgium) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, May-June 1988, p. 263-269. refs

The results of measurements of the three-dimensional flowfield within a single-stage compressor operating in deep rotating stall are presented in this paper. A technique employing a triple hot-wire probe has been used for the measurements. The obtained results provide a detailed description of the flow in rotating stall cells. The structure of the cells is described by using fundamental fluid flow concepts. Radial organization of the cells, interaction with the unstalled flow, and stalling of a rotor blade passage are discussed on the basis of the results. The generality of the present observations is discussed by comparing them with the results of other investigations. Author

A88-42799
FLOW-INDUCED OSCILLATIONS OF A NOVEL DOUBLE-WING SPRING-MASS SYSTEM
P. I. KING (USAF, Institute of Technology, Wright-Patterson AFB, OH) and G. D. ALLEN (U.S. Air Force Academy, Colorado Springs, CO) IN: Fluid transients in fluid structure interaction - 1987; Proceedings of the Third Symposium, Boston, MA, Dec. 13-18, 1987. New York, American Society of Mechanical Engineers, 1987, p. 27-34. refs

A unique oscillating double-wing device having possible applications in fluid flow measurement technology and wind energy conversion has been preliminarily investigated. The device utilizes the coupling of alternating aerodynamic forces to a spring-mass system to produce harmonic oscillations. A critical speed initiates oscillations which appear to be related to an alternating lift and

flow separation effect. The subsequent alternating loads depend on the separation distance between the wings and is partially explained by sudden jumps in lift coefficient observed in new data on ground effect. The amplitude and frequency of oscillations are dependent on airspeed, equilibrium position, mass and spring constant. The system frequency response reduces to either of two universal curves depending on the static equilibrium position of the oscillating wing. Author

A88-43008#
BOUNDARY LAYER MEASUREMENTS ON AN AIRFOIL AT A LOW REYNOLDS NUMBER IN AN OSCILLATING FREESTREAM
M. BRENDEL and T. J. MUELLER (Notre Dame, University, IN) AIAA Journal (ISSN 0001-1452), vol. 26, March 1988, p. 257-263. Research supported by the University of Notre Dame. Previously cited in issue 18, p. 2807, Accession no. A87-42393. refs
(Contract N00014-83-K-0239)

A88-43028*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PASSIVE VENTING SYSTEM FOR MODIFYING CAVITY FLOWFIELDS AT SUPERSONIC SPEEDS
FLOYD J. WILCOX, JR. (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 26, March 1988, p. 374-376. refs

The drag of airfoils in transonic flow can be reduced through the use of a passive venting system that employs a porous plate for part of the airfoil upper surface with a vent chamber underneath the porous plate Attention is given to the results obtained with a wind tunnel model employing such a porous floor system. This passive venting system has been used to extend the length/height value before the onset of high drag-producing closed cavity flow at supersonic speeds. O.C.

A88-43029#
BASE CAVITY AT ANGLES OF INCIDENCE
MAURI TANNER (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, Federal Republic of Germany) AIAA Journal (ISSN 0001-1452), vol. 26, March 1988, p. 376, 377.

An investigation of the influence of tail surfaces on base pressures has yielded some results for a base cavity at angles-of-incidence. The measurements were performed at Mach numbers from 0.5 to 1.0; the Reynolds number, based on the cylinder diameter, was 340,000, and the angle-of-incidence had values of 0-25 deg. The base pressure coefficient for all Mach numbers is greater for the cavity base than for the base without a cavity. O.C.

A88-43088
SUPERSONIC FLOW PAST BODIES IN THE PRESENCE OF EXTERNAL HEAT SOURCES [SVERKHZVUKOVOE OBTEKANIE TEL PRI NALICHII VNESHNIKH ISTOCHNIKOV TEPLOVYDELENIIA]
P. IU. GEOGRIEVSKII and V. A. LEVIN (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) Pis'ma v Zhurnal Tekhnicheskoi Fiziki (ISSN 0320-0116), vol. 14, April 26, 1988, p. 684-687. In Russian. refs

The paper presents calculations on the supersonic flow past regions with heat sources and on the effect of these sources on the wave drag of axisymmetric blunt bodies of revolution located downstream. Flow past a sphere at a freestream Mach number of 3 is examined, and wave drag is shown to decrease substantially during the appearance of flow reversal. The sphere drag coefficient is evaluated as a function of the distance between the sphere and the hot spot for different intensities of heat delivery. B.J.

A88-43164
A MULTIGRID-RELAXATION SCHEME FOR THE NAVIER-STOKES EQUATIONS
W. SCHROEDER and D. HAENEL (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: Multigrid methods: Theory, applications, and supercomputing; Proceedings of the Third Copper Mountain Conference, Copper Mountain, CO, Apr. 5-10, 1987. New York, Marcel Dekker, Inc., 1988, p. 555-577. refs

An implicit method for the steady state solution of the thin-layer Navier-Stokes equations is presented. The method is an extension of a scheme described earlier to curvilinear, body-fitted coordinate systems. A fast rate of convergence is obtained by using the multigrid concept in form of the Full Approximation Storage (FAS) scheme in the algorithm. The computational results for the interaction of an oblique shock wave with a boundary layer on a flat plate and subsonic and supersonic NACA 0012 airfoil flows show the accuracy and the efficiency of the method. Author

A88-43190
DRAG REDUCTION FOR SUBSONIC TRANSPORT AIRCRAFT - TRENDS AND CURRENT PROSPECTS [REDUCTION DE LA TRAINEE DE LA'AVION DE TRANSPORT SUBSONIQUE - TENDANCES ET PERSPECTIVES ACTUELLES]
V. SCHMITT (ONERA, Direction de l'Aerodynamique, Chatillon-sous-Bagneux, France) (Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 129, 1988, p. 4-18. In French. refs

Transport aircraft drag sources and reduction techniques are reviewed, and theoretical and flight test results are presented. Friction drag accounts for almost 50 percent of aircraft drag, and the turbulent friction reduction techniques of riblets ('internal' boundary layer manipulators) and large eddy breakup ('external' boundary layer manipulators) are discussed. Maintenance of the laminar boundary layer by natural laminar flow and by wall suction is also considered in detail. Other sources of drag include pressure drag and induced drag. Validation of drag reduction methods by prediction of the transition from laminar to turbulent flow is also discussed. R.R.

A88-43191
TRANSPORT AIRCRAFT DRAG REDUCTION BY APPLICATION OF LAMINAR FLOW TECHNIQUES [REDUCTION DE LA TRAINEE DES AVIONS DE TRANSPORT PAR LAMINARITE ETENDUE]
J. RENEAUX (ONERA, Chatillon-sous-Bagneux, France) (Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 129, 1988, p. 19-33. In French. refs

Criteria for the laminar flow/turbulence transition are reviewed, and several designs for laminar flow wings are presented. The concept of natural laminar flow involves the generation of pressure gradients which have a stabilizing effect on the laminar boundary layer, and it has been applied to the design of a horizontal stabilizer for a business aircraft and to the wing design of a short-haul aircraft. The laminar flow control technique, involving wall suction of the boundary layer, has been applied to the design of an airfoil for a large-capacity long-range aircraft. Drag reduction results for these techniques are presented, and aerodynamic problems of the laminar flow wings are considered. R.R.

A88-43192
EXPERIMENTAL STUDY OF TURBULENT-SKIN-FRICTION REDUCTION USING RIBBED SURFACES [ETUDE EXPERIMENTALE DE LA REDUCTION DU FROTTEMENT TURBULENT AU MOYEN DE PAROIS RAINUREES]
E. COUSTOLS, C. GLEYZES (ONERA, Centre d'Etudes et de Recherches de Toulouse, France), V. SCHMITT (ONERA, Chatillon-sous-Bagneux, France), and P. BERRUE (Aerospatiale, Paris, France) (Colloque d'Aerodynamique Appliquee, 24th, Poitiers, France, Oct. 26-28, 1987) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 129, 1988, p. 34-46. In French. refs

Experimental results of turbulent-skin-friction reduction by modifying the aerodynamic surfaces with riblets which are aligned in the direction of the mean flow have been obtained. Subsonic wind tunnel results for zero-pressure gradient flows are first

presented, and various measurement techniques (hot-wire anemometry, spectral analysis, skin-friction measurements) have been used to identify modifications to the mean flow and the turbulent structure. Drag coefficient variations on an Airbus-type fuselage model have been obtained in an F2 wind tunnel in order to investigate the effect of riblets on slender bodies. R.R.

A88-43242*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE NUMERICAL SIMULATION OF TRANSONIC SEPARATED FLOW ABOUT THE COMPLETE F-16A
JOLEN FLORES and NEAL M. CHADERJIAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988. 22 p. refs
(Contract NAS2-11555)
(AIAA PAPER 88-2506)

The thin-layer, Reynolds-averaged, Navier-Stokes equations are used to simulate the transonic viscous flow about the complete F-16A fighter aircraft. These computations demonstrate how computational fluid dynamics (CFD) can be used to simulate turbulent viscous flow about realistic aircraft geometries. A zonal grid approach is used to provide adequate viscous grid clustering on all aircraft surfaces. Zonal grids extend inside the F-16A inlet and up to the compressor face while power on conditions are modeled by employing a zonal grid extending from the exhaust nozzle to the far field. A simple solution adaptive grid procedure is used on the wing surface and good agreement with experimental data is obtained. Computations for the F-16A in side slip are also presented. Author

A88-43303
EXPERIMENTAL STUDY OF THE WALL PRESSURE FIELD DOWNSTREAM OF A WING/BODY JUNCTION [ETUDE EXPERIMENTALE DU CHAMP PARIETAL DE PRESSION A L'AVAL D'UN APPENDICE DE PAROI]
GILLES ROBERT (Lyon, Ecole Centrale, Ecully, France) and EDMOND BENARROUS (Societe METRAFLU, Ecully, France) (Societe Francaise d'Acoustique, Association Aeronautique et Astronautique de France, and CNRS, Colloque d'Acoustique Aeronautique et Navale, 10th, Marseille, France, Nov. 19-21, 1986) Revue d'Acoustique (ISSN 0557-7713), vol. 20, no. 82, 1987, p. 20-26. In French. Research supported by the Delegation Generale pour l'Armement. refs

Experimental measurements of the wall pressure field downstream of a NACA 0021 wing profile/body junction have made possible the identification of the principal flow zones (the boundary layer, wake, and horseshoe vortex). In the study, the wall pressure fluctuations are characterized by their rms value and by their spectral energy density. It is found that the wing profile/flow interaction phenomena affect the pressure spectra over a large frequency range, with spectral changes of up to + or - 5 dB. Results are presented as a function of Strouhal number, permitting measurements obtained for a wide velocity range (40 to 130 m/s) to be grouped. R.R.

A88-43473
THE VISUALIZATION OF THE FLOWFIELD ABOUT A DELTA WING WITH SPANWISE BLOWING
J. ER-EL (Technion - Israel Institute of Technology, Haifa) Experiments in Fluids (ISSN 0723-4864), vol. 6, no. 6, 1988, p. 419-421.

This paper describes a nonintrusive method for the visualization of the flow about a delta wing with spanwise blowing jets, based on the schlieren technique. The effects of the jet/leading-edge vortex interference are visualized by using both air and helium for the jets. The visualization of the leading-edge vortex trajectories and their breakdown, as well as the influence of the jets on them is achieved by spannwise blowing of air. The visualization of the jets' paths and the effects of the leading-edge vortices on these paths is achieved by spanwise blowing of helium. Author

A88-43619
EFFECT OF THE BOUNDARY LAYER ON THE FLOW RATE AND SPECIFIC PULSE OF A CONVERGING NOZZLE [VLIIANIE POGRANICHNOGO SLOIA NA RASKHOD I UDEL'NYI IMPUL'S SUZHAIUSHCHEGOSIA SOPLA]
R. K. TAGIROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 77-81. In Russian. refs

The effect of gas viscosity on the specific pulse and flow rate coefficients of a converging nozzle is investigated on the basis of a boundary layer model. It is shown that the presence of a boundary layer may lead to either an increase or a decrease in flow rate in comparison with that of a nonviscous gas. It is shown that the boundary layer has little effect on the specific pulse of the converging nozzle. V.L.

A88-43623
EFFECT OF THE POSITION OF THE BOUNDARY LAYER LAMINAR-TURBULENT TRANSITION POINT ON BODY DRAG IN A SONIC GAS FLOW [VLIIANIE POLOZHENIIA TOCHKI PEREKHODA LAMINARNOGO POGRANICHNOGO SLOIA V TURBULENTNYI NA VELICHINU SOPROTIVLENIIA TELA V ZVUKOVOM POTOKE GAZA]
V. V. VYSHINSKII and E. N. KUZNETSOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 90, 91. In Russian. refs

A88-43632
SOLUTION OF A PROBLEM CONCERNING FLOW PAST A FINITE-SPAN WING [O RESHENII ZADACHI OBTEKANIIA KRYLA KONECHNOGO RAZMAKHA]
Z. KH. NUGMANOV and V. M. ROMANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 108-110. In Russian. refs

The problem of flow past a finite-span wing is solved by using an approach representing a further development of the basis function method proposed in a previous study (Nugmanov, 1979). In contrast to the original method, the approach presented here involves solving singular integral equations. A significant saving in computational effort is achieved by transforming the kernels of the integral equations. Flow past a rectangular ring with a Zhukovskii profile is calculated as an example. V.L.

A88-43755*# North Carolina State Univ., Raleigh.
EFFECTS OF SURFACE PRESSURES AND STREAMLINE METRICS ON THE CALCULATION OF LAMINAR HEATING RATES
CHRISTOPHER J. RILEY, FRED R. DEJARNETTE (North Carolina State University, Raleigh), and VINCENT ZOBY (NASA, Langley Research Center, Hampton, VA) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 8 p. refs
(AIAA PAPER 88-2708)

The effect of streamline geometry and pressure distributions on surface heating rates is examined for slender, spherically blunted cones. The modifications to the approximate aeroheating code include a curve fit of pressures computed by an Euler solution over a range of Mach numbers and cone angles. The streamline geometry is then found using the surface pressures and inviscid surface properties. Previously, streamlines were determined using the inviscid properties at the edge of the boundary layer when accounting for the effects of entropy-layer swallowing. Streamline calculations are now based on inviscid surface conditions rather than boundary-layer edge properties. However, the heating rates are calculated using inviscid properties at the edge of the boundary layer. Resulting heating rates compare favorably with solutions from the viscous-shock-layer equations. Author

A88-43868#
A QUASI-STEADY APPROACH OF WAKE EFFECTS ON LEADING EDGE TRANSFER RATES
N. T. VAN DRESAR and R. E. MAYLE (Rensselaer Polytechnic Institute, Troy, NY) IN: Heat transfer in gas turbine engines; Proceedings of the Symposium, ASME Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987. New York, American Society of Mechanical Engineers, 1987, p. 1-10. refs

Mass transfer experiments are described for a circular cylinder with a steady incident wake flow. Measurements of the velocity, turbulence intensity, intermittency, and integral length scale within the wake are presented together with measurements of the stagnation mass transfer as a function of the cylinder's position in the wake. Comparison of the results indicates that although the increase in mass transfer occurring along the wake centerline depends on the turbulence intensity, length scale, and possibly other factors, the functional relation with respect to the cylinder's lateral position in the wake depends on the intermittency and not turbulence level. In addition, a simple quasi-steady theory is developed to account for the unsteady effects caused by the passing of wakes in the incident flow on the stagnation transfer rate at the leading edge of a gas turbine airfoil. Author

A88-43875#
TURBULENT TRANSPORT ON THE ENDWALL IN THE REGION BETWEEN ADJACENT TURBINE BLADES
R. J. GOLDSTEIN and R. A. SPORES (Minnesota, University, Minneapolis) IN: Heat transfer in gas turbine engines; Proceedings of the Symposium, ASME Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987. New York, American Society of Mechanical Engineers, 1987, p. 75-83. refs

The heat/mass transfer analogy is used to examine local transport coefficients for two different endwall boundary layer thicknesses and two freestream Reynolds numbers, in a study of the complex three-dimensional flow in the endwall region near the base of a turbine blade. Naphthalene is cast into a mold on the plate, and the rate of naphthalene sublimation is determined at over 6000 locations on the simulated endwall by a computer-aided data acquisition system. Extremely high transport coefficients on the endwall indicate locations of potential overheating and failure in an actual turbine. O.C.

A88-43913#
TURBULENCE PRODUCTION OVER A ROUGH WALL AT MACH 3
G. L. SEIBERT, M. S. MAURICE, and N. SCAGGS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Symposium on Laser Anemometry, 3rd, ASME Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987, Proceedings. New York, American Society of Mechanical Engineers, 1987, p. 101-107. refs

Boundary layer profile measurements over a constructed rough wall were made in a high Reynolds number, Mach 3 wind tunnel. The two-dimensional turbulent boundary layer measurements were made using a two component laser velocimeter in forward scatter. Reynolds numbers varied from 48 to 350 million per meter for a flow over roughness elements which were 0.5 cubic millimeter in size spaced uniformly one millimeter apart across the lower wall of the tunnel. Profiles were measured on the centerline of the tunnel for four specific Reynolds numbers. Results include representative scatter plots and profiles showing velocity measurements and various turbulence parameters through the boundary layer. The resulting profiles show the effects of biasing and resolution limitations in L.V. measurements along with traditional trends in velocity, turbulence intensity, and correlation parameter profiles. The calculated turbulence parameters indicate the strong influence of roughness on the turbulent transport properties, but do not indicate any appreciable Reynolds number dependence in the range tested for this flow. Limitations and recommendations are also presented. Author

A88-43918*# Purdue Univ., West Lafayette, Ind.
LDA MEASUREMENT OF THE PASSAGE FLOW FIELD IN AN ANNULAR AIRFOIL CASCADE
R. C. STAUTER and S. FLEETER (Purdue University, West Lafayette, IN) IN: International Symposium on Laser Anemometry, 3rd, ASME Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987, Proceedings. New York, American Society of Mechanical Engineers, 1987, p. 215-224. NASA-supported research. refs

Models to predict the complex three-dimensional flow through turbomachine blade rows are being developed. To verify these models and direct necessary refinements, it is necessary that predictions be correlated with data obtained in experiments which model the fundamental three-dimensional blade row flow phenomena. This paper describes a series of experiments performed in a large scale, subsonic, annular cascade facility specifically designed to provide such data. In particular, the effect of incidence angle on the three-dimensional passage flow field through an annular cascade of cambered airfoils is investigated and quantified, accomplished by obtaining detailed and expensive LDA data. These data demonstrate and quantify the development of the passage vortices through the airfoil passage and their strong interaction with the endwall boundary layers. Author

A88-43996
THEORY OF FLOW PAST YAWED AND SWEPT WINGS OF LARGE ASPECT RATIOS [TEORIIA OBTEKANIIA SKOL'ZIASHCHIKH I STRELOVIODNYKH KRYL'EV BOL'SHIKH UDLINENII]
V. V. STRUMINSKII (AN SSSR, Sektor Mekhaniki Neodnorodnykh Sred, Moscow, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 300, no. 1, 1988, p. 55-57. In Russian. refs

Some recently proposed methods for calculating swept wings of large aspect ratios, based on approximate assumptions, are briefly reviewed. The assumptions underlying these methods, such as the secondary flow assumption, are then critically examined, and three theorems are proposed which apply to yawed and swept wings of high aspect ratios in the path of a turbulent flow. A system of Reynolds equations for yawed and swept wings is written. V.L.

A88-44438
SEPARATION OF THREE-DIMENSIONAL LAMINAR BOUNDARY LAYERS ON A PROLATE SPHEROID
TUNCER CEBECI and WENHAN SU (Douglas Aircraft Co., Long Beach, CA) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 191, June 1988, p. 47-77. refs
(Contract F49620-84-C-0007)

The steady three-dimensional boundary-layer equations obtained from an analytic solution of the inviscid flow equations are used to investigate the laminar flow around a prolate spheroid at 6 deg angle of attack. It is found that the flow consists of a region of positive crossflow which is followed by a substantial region of negative crossflow, a separation line, and two terminal lines beyond which solution of the boundary layer equation could not be obtained. A method for identification of the skin friction line has been developed. Results show that the finite difference scheme based on the characteristic box permits calculations with an accuracy equal to that of the scheme based on the regular box under the condition that a stability criterion is used to select the grid intervals. R.R.

A88-44490*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
POROUS WIND TUNNEL CORRECTIONS FOR COUNTERROTATION PROPELLER TESTING
GEORGE L. STEFKO and ROBERT J. JERACKI (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988. Previously announced in STAR as N88-22019. refs
(AIAA PAPER 88-2055)

Wind tunnel interference corrections have direct impact on measured propeller efficiency. A systematic series of wind tunnel tests was done in the porous-wall NASA Lewis 8- by 6-Foot Wind Tunnel to determine the wind tunnel interference corrections to the NASA Lewis counterrotation propeller test data. The test results were compared with calculations from a potential flow code to determine the interference corrections. At a Mach number of 0.8, the interference corrections resulted in a -0.008 Mach number correction which reduced the counterrotation propeller net efficiency data by 0.46 percent at the reduced Mach number. Additional wind tunnel tests were done to measure the effect of propeller thrust on wind tunnel wall interference. No wall interference corrections due to propeller thrust were found

necessary for the high speed counterrotation propeller data obtained in the porous wall NASA Lewis 8- by 6-Foot Wind Tunnel. Author

A88-44501
GLOBAL PRESSURE RELAXATION PROCEDURE FOR COMPRESSIBLE TURBULENT STRONG INTERACTION FLOWS
H. T. LAI and P. K. KHOSLA (Cincinnati, University, OH) Computers and Fluids (ISSN 0045-7930), vol. 16, no. 3, 1988, p. 217-228. refs
(Contract N00014-79-C-0849)

Numerical turbulent solutions of the compressible RNS equations are obtained by means of the global pressure relaxation procedure. The ellipticity of the RNS equations in this computational approach is conveniently but appropriately represented by the streamwise pressure gradient term in a multi-pass boundary-layer-like marching technique. The numerical formulation includes the full effect of the elliptic pressure interaction and, therefore, allows computation of strong viscous-inviscid interacting flows. The flow regimes considered contain many of the characteristic features of complex fluid flows, e.g. recirculation, embedded shock waves and mixing shear layers. Simple algebraic turbulent closure models are employed. Results are presented for axisymmetric geometries. Comparison is made with available experimental and numerical data. Author

A88-44502* IBM Watson Research Center, Yorktown Heights, N.Y.
NUMERICAL PREDICTION OF FLOW IN SLENDER VORTICES
LUIS G. REYNA (IBM Thomas J. Watson Research Center, Yorktown Heights, NY) and STEFAN MENNE (NASA, Langley Research Center, Hampton, VA; Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) Computers and Fluids (ISSN 0045-7930), vol. 16, no. 3, 1988, p. 239-256. refs

The slender vortex approximation was investigated using the Navier-Stokes equations written in cylindrical coordinates. It is shown that, for free vortices without external pressure gradient, the breakdown length is proportional to the Reynolds number. For free vortices with adverse pressure gradients, the breakdown length is inversely proportional to the value of its gradient. For low Reynolds numbers, the predictions of the simplified system agreed well with the ones obtained from solutions of the full Navier-Stokes equations, whereas for high Reynolds numbers, the flow became quite sensitive to pressure fluctuations; it was found that the failure of the slender vortex equations corresponded to the critical condition as identified by Benjamin (1962) for inviscid flows. The predictions obtained from the approximating system were compared with available experimental results. For low swirl, a good agreement was obtained; for high swirl, on the other hand, upstream effects on the pressure gradient produced by the breakdown bubble caused poor agreement. I.S.

A88-44525#
TWO-DIMENSIONAL NAVIER-STOKES PREDICTION OF FLIGHT CHARACTERISTICS OF MODIFIED BOEING 767 CAVITY FLOW
DEEPAK OM (Boeing Co., Seattle, WA) AIAA, Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988. 10 p. Research supported by the Boeing Commercial Airplane Co. refs
(AIAA PAPER 88-2508)

A two-dimensional Navier-Stokes Code was used to predict the flowfield of the modified Boeing 767 cavity flow at flight condition. The code employs the split explicit predictor-corrector algorithm of MacCormack in conservation law form. The purpose was to examine the unsteadiness of the shear layer and obtain details of the flowfield. First, the cavity configuration without any blowing was simulated. Grid refinement was done to study its effect on the flowfield solution. Then, the effect of lip blowing was investigated using fine grid. Comparison with the flight test data verified the computational results qualitatively. The shear layer which was steady in the computation, both with and without lip blowing, was also observed to be steady in the flight test. Author

A88-44573
POSSIBLE TYPES OF FLOW ON LEE-SURFACE OF DELTA WINGS AT SUPERSONIC SPEEDS
S. N. SESHADRI and K. Y. NARAYAN (National Aeronautical Laboratory, Bangalore, India) Aeronautical Journal (ISSN 0001-9240), vol. 92, May 1988, p. 185-199. refs

Oil-flow visualization and static pressure measurements are employed in an experimental investigation of the flow on the lee surface of flat-top wedge delta wings (normal angle 10 or 20 deg; sweep angle 45, 50, 60, or 70 deg) at Mach 0.3-3.0 in the 0.3 x 0.3-m test section of the National Aeronautical Laboratory trisonic wind tunnel. The results are presented in extensive graphs, photographs, and diagrams, and nine distinct flow types are defined and characterized in detail. It is demonstrated that increasing the wing thickness has little effect on the flow type, although the boundaries separating some flow types on the Mach-number/angle-of-attack plane may be shifted. T.K.

A88-44589#
AN UPWIND METHOD FOR SOLVING THE NAVIER-STOKES EQUATIONS [EIN UPWIND-VERFAHREN ZUR LOESUNG DER NAVIER-STOKES-GLEICHUNGEN]
W. SCHROEDER Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen, no. 28, 1988, p. 1-11. In German. refs

An unfactorized, implicit difference method for calculating steady solutions to the compressible Navier-Stokes equations is presented. A one-sided, high-resolution difference scheme and flux-vector splitting are used to approximate the convective and pressure terms, avoiding the need for artificial stiffness. The numerical results for the laminar flow about a NACA 0012 airfoil in the 0.05-1.5 Mach number range show good convergence properties and demonstrate the wide applicability of the method. C.D.

A88-44590#
EXPERIMENTAL INVESTIGATION OF WALL EFFECTS ON WIND TUNNEL MEASUREMENTS ON AIRFOILS SUBJECTED TO NEAR-SONIC FLOWS [EXPERIMENTELLE UNTERSUCHUNG DER WANDEINFLUESSE BEI WINDKANALMESSUNGEN AN SCHALLNAH ANGESTROEMTEN TRAGFLUEGELPROFILEN]
T. FRANKE Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen, no. 28, 1988, p. 12-18. In German. refs

The causes of wall interference and the effects of it on the steady pressure measurement of supercritical profiles are investigated in a small transonic wind tunnel. The narrow chamber width and the short inlet length enhances the wall interference and makes its amelioration more difficult. However, the adoption of flexible walls resulted in good agreement of the measured pressure distributions with measurements performed in other wind tunnels with twice the chamber width and approximately the same Reynolds numbers. The disturbances caused by the side walls are strongly three-dimensional in character and depend on the displacement thickness and its gradient. The pressure, velocity, and shear stress curves as a function of lateral displacement demonstrate the structure, strength, and propagation of the wall effects. C.D.

A88-44657#
IDEAL OPTIMIZATION OF COUNTERROTATING PROPELLERS
BRUCE G. MCKAY (Douglas Aircraft Co., Long Beach, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p. refs
(AIAA PAPER 88-2801)

The recent interest in counterrotating propellers has resulted in the development of a variety of complex advanced methods to analyze and design these systems. In engine/aircraft integration, emphasis is concentrated on parametric studies related to

optimizing engine configurations as a function of a multitude of design variables. To support conceptual and preliminary design studies, an ideal induced counterrotating propeller optimization program has been developed. This paper shows that an ideal induced methodology is sufficient to determine propeller characteristics and trends generated by variations in design. The method has been developed using H. Glauert's, C.N.H. Lock's, and T. Theodorsen's propeller theories. Incorporation of these propeller theories into the program permits the user to optimize solutions to either a Goldstein or Theodorsen radial circulation distribution. Application of this method has shown good correlation with experimental data in predicting induced effects and demonstrating performance trends. This paper presents a brief review of the appropriate theory with major emphasis on applications relating to parametric design trades. Corrections for viscous effects are discussed. Author

A88-44661#
EFFECT OF INLET GEOMETRY ON THE PERFORMANCE OF SMALL CENTRIFUGAL COMPRESSORS
C. RODGERS (Sundstrand Corp., Sundstrand Turbomach Div., San Diego, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p. refs
(AIAA PAPER 88-2812)

An account is given of test results on the effects of inlet geometry on the performance of a small, 83.3-mm tip diameter centrifugal compressor. A simple axial extension ratio and/or diffusion parameter value is defined which, if maintained during operations, will curtail significant compressor performance degradation due to inlet flow distortion. Small, single-stage centrifugal compressors of this typa are employed in high power density APUs. O.C.

A88-44662#
STATOR VANE RESPONSE DUE TO THE IMPINGEMENT OF THE WAKE OF AN UNLOADED ROTOR
T. ZANDBERGEN (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 16 p. refs
(AIAA PAPER 88-2814)

An experimental investigation was carried out to study turbofan engine noise generation caused by rotor/stator blade wake interaction. The experiment was primarily designed to enable a verification and validation of a theoretical fan noise model which is based on the assumption of small perturbations. To this end, the first phase of the experiment reported here involved an unloaded rotor while the mean loading on the stator was very low. Furthermore, to make the rotor acoustically transparent the rotor blades were replaced by thin cylindrical rods acting as wake generators only. A description is given of the experimental model and the test techniques, together with results of rotor wake velocity and stator vane pressure measurements (both steady and unsteady). Data of some noise measurements in the intake of the model are also presented. Author

A88-44666#
COMPUTATION OF HYPERSONIC RAMJET-INLET FLOWFIELDS USING AN UPWIND PARABOLIZED NAVIER-STOKES CODE
REINHOLD A. GERBSCH and RAMESH K. AGARWAL (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. Research sponsored by the McDonnell Douglas Independent Research and Development Program. refs
(AIAA PAPER 88-2828)

A real-gas, upwind, parabolized Navier-Stokes code has been developed to calculate two-dimensional, hypersonic, turbulent, multiple-strut ramjet flowfields. The code is based on Roe's upwind algorithm and a real gas, and employs curve fits to obtain transport and thermodynamic properties of equilibrium air. In addition, the Baldwin-Lomax algebraic turbulence model has been modified for hypersonic applications and incorporated in the code. The code has built-in geometric and mesh-generation capabilities to calculate hypersonic ramjet-inlet flowfields. To march through regions of small separation, the FLARE approximation has also been implemented. The results of PNS computations are compared with those obtained using the full Navier-Stokes equations. Author

A88-44705*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
TURBULENCE MODELING IN HYPERSONIC INLETS
W. F. NG, A. C. TAYLOR, III (Virginia Polytechnic Institute and State University, Blacksburg), and K. AJMANI AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. refs
(Contract NAG3-676)
(AIAA PAPER 88-2957)

A study is conducted to analyze the performance of different turbulence models when applied to flow through a Mach 7.4 hypersonic inlet. The analysis, which is two-dimensional, is done by comparing computational results from a Parabolized Navier-Stokes code and a full Navier-Stokes code, with experimental data. The McDonald-Camarata (MC) and Baldwin-Lomax (BL) models were the two zero-equation models used in the study. The Turbulent Kinetic Energy (TKE) model was chosen as a representative higher order model. The MC model, when run with transition of flow, provides a solution which compares excellently with the data. Transition has a first order effect on the overall solution provided by the code. The BL model predicts separation of flow in the inlet, which contradicts experimental findings. The TKE model does not perform any better than the MC and BL models, despite the fact that it is a higher order turbulence model. The BL and TKE models predict transition in the inlet at a location which is much earlier than observed in the experiment. This may be attributed to the empirical constants used to determine the point of transition. Author

A88-44722#
THE USE OF SWIRL FOR FLOW CONTROL IN PROPULSION NOZZLES
K. KNOWLES (Royal Military College of Science, Shrivenham, England) and P. W. CARPENTER (Exeter, University, England) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. refs
(AIAA PAPER 88-3003)

In certain off-design conditions it is desirable to vary the effective area of turbofan propulsion nozzles, for instance to aid component matching or to reduce fan noise on approach. It has been suggested that the mass flux reductions associated with swirl could be used to achieve such variations. This paper addresses the questions of whether swirl can achieve the required mass flux reductions and whether this can be done with minimal thrust losses. A quasi-cylindrical theory is used to analyze the swirling flow and comparisons are made with variable-area nozzles for specific case studies. For a low-specific-thrust engine of high bypass ratio (BPR of about 12) the required fan nozzle mass flux reduction cannot be achieved using swirl and in any case swirl gives a far faster rate of decay of thrust with fan nozzle mass flux than does a variable-area nozzle. For a ducted fan of BPR of about 4 a 10 percent reduction in core nozzle mass flux can be achieved with swirl for slightly less thrust loss than with a varialbe-area nozzle. The swirl profile, however, needs to be carefully optimized. Author

A88-44753#
FINITE ELEMENT SOLUTION OF 3D TURBULENT NAVIER-STOKES EQUATIONS FOR PROPELLER-DRIVEN SLENDER BODIES
RUSSELL H. THOMAS, JOSEPH A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg), and DOMINIQUE H. PELLETIER (Montreal, Universite, Montreal, Canada) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. Navy-supported research. refs
(AIAA PAPER 88-3089)

A weak Galerkin formulation of the FEM, in conjunction with

the penalty method, has been used to solve the Reynolds-averaged Navier-Stokes equations in the present study of three-dimensional turbulent flow over the stern of a slender, pusher propeller-driven body affected by the wake from a slender planar appendage. The propeller was modeled by axial and tangential body forces varying over a disk at the propeller location. The results obtained compare favorable with wind tunnel experiment results, and swirl was more accurately predicted than with previous methods. O.C.

A88-44754#
NAVIER-STOKES COMPUTATIONS FOR FLOWFIELD OF AN ADVANCED TURBOPROP
YUICHI MATSUO, CHUICHI ARAKAWA (Tokyo, University, Japan), SHIGERU SAITO, and HIROSHI KOBAYASHI (National Aerospcae Laboratory, Chofu, Japan) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 13 p. refs
(AIAA PAPER 88-3094)

Viscous transonic rotational flows around a single rotation ATP at cruise conditions are simulated using Reynolds-averaged full Navier-Stokes equations with two different turbulence models; the zero-equation model of Baldwin-Lomax and the two-equation q - omega model of Coakely. An implicit finite-difference method is used for solution procedures. The numerical solution captured viscous flow features such as boundary layer separation and shock/boundary-layer interaction. Both turbulence models showed good agreement with experimental data in the predicted aerodynamic performances. However, the two-equation model predicted wider separated region than the zero-equation model. Author

A88-44769#
FLOW FIELD AROUND A PROPELLER BY NAVIER-STOKES EQUATION ANALYSIS
MAKOTO KOBAYAKAWA (Kyoto University, Japan) and ICHIRO HATANO AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. refs
(AIAA PAPER 88-3150)

A flow field around a propfan is obtained through finite difference procedure. Viscous effects are incorporated with a thin layer approximation of the Navier-Stokes equations. An implicit approximate factorization technique is used to solve this boundary value problem. An analytical grid generation by the Poisson's equations is employed. A flow field around an eight bladed propfan in cruise condition with Mach number of 0.8 is calculated for two Reynolds numbers in which one corresponds to laminar boundary layer and the other to turbulent boundary layer. The viscous effects diminish the shock wave on the blade surfaces and moderate the steep change of pressure as was seen in the Euler analysis. Author

A88-44770#
PREDICTED FLOW FIELD AROUND THE ADVANCED PROPELLER AT TAKE-OFF
SHIGERU SAITO, HIROSHI KOBAYASHI (National Aerospace Laboratory, Chofu, Japan), YOSHIYA NAKAMURA (Ishikawajima-Harima Heavy Industries Co., Ltd., Mizuho, Japan), and YUICHI MATSUO (Tokyo University, Japan) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p. refs
(AIAA PAPER 88-3151)

Aerodynamic performances and noise at take-off conditions are predicted by two different aerodynamic codes developed and evaluated with the wind tunnel results. The extended lifting line theory known as LCM is a quick code and proven to be a useful tool for predicting the preliminary design data of propeller component on performance and noise. Another feature of this code is the ability to deal with the case of finite shaft angle of attack. The predicted increment of ground noise level is shown to agree well with the measurement. The full Navier-Stokes code demonstrated the capability to simulate the flow field around the propeller such as the leading edge vortex at high blade angle, the horseshoe vortex at blade root, or the boundary layer development. The computed noise using this code to obtain source intensity distribution coincides well with LCM results, which means that the linear potential source modeling is good enough in this speed range. Author

A88-44772#
THICK BOUNDARY LAYER ASSESSMENT FOR NOZZLE FLOW
H. KEHTARNAVAZ, D. E. COATS (Software and Engineering Associates, Inc., Carson City, NV), and Y. KRONZON (Pennsylvania State University, University Park) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p. refs
(Contract F04611-86-C-0055)
(AIAA PAPER 88-3160)

The effect of thick boundary layers on nozzle flow performance have been investigated. The relationship between the boundary layer and the core flow for a variety of real engine parameters has been established. Euler/boundary layer solutions are compared against the full Navier-Stokes solver and parabolized Navier-Stokes solver. These solutions have been compared to the standard JANNAF TDK/BLM computer code. The interaction between the viscous layer and the core flow has been studied for a thick boundary layer where the 'thin' shear layer equations are not valid. This study is for perfect gas with constant gamma. The validity and restrictions for 'thin' shear layer assumption for thick boundary layers have been studied. Author

A88-44819*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ARTIFICIAL DISSIPATION MODELS FOR HYPERSONIC EXTERNAL FLOW
SEOKKWAN YOON and DOCHAN KWAK (NASA, Ames Research Center, Moffett Field, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. refs
(AIAA PAPER 88-3277)

Four artificial dissipation models which augment central difference schemes were examined for hypersonic external flows. The models were a first and third order dissipation model, a directionally scaled first and third order dissipation model, a flux limited dissipation model, and a flux difference split dissipation model. Each model was implemented in the lower-upper symmetric-Gauss-Seidel (LU-SGS) algorithm to solve the full Navier-Stokes equations. The latter two models can be regarded as total variation diminishing (TVD) schemes. Test results for model problems showed that the flux limited dissipation model was robust enough to predict a high speed blunt body flow with strong shock and expansion waves. The flux difference split dissipation model was capable of shock capturing with higher resolution, but was less robust. First and third order dissipation models turned out to be neither accurate nor robust enough for high Mach number flow computations. Author

A88-45124*# Scientific Research Associates, Inc., Glastonbury, Conn.
AN IMPLICIT NAVIER-STOKES ANALYSIS OF TURBINE ROTOR-STATOR INTERACTION
HOWARD J. GIBELING, RICHARD C. BUGGELN, SHYI-YAUNG CHEN (Scientific Research Associates, Inc., Glastonbury, CT), and HELEN V. MCCONNAUGHEY (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 15 p. refs
(Contract NAS8-36801)
(AIAA PAPER 88-3090)

An implicit Navier-Stokes analysis using a single deforming mesh has been developed for the unsteady rotor-stator interaction problem. The technique has been used to simulate the flow through a turbine stator-rotor stage. Periodic two-dimensional solutions have been obtained using 1000 time steps per cycle without iteration at each time step. Computed surface pressure distributions

compare favorably with experimental data available for this configuration. Author

A88-45277#
LOW-SPEED AERODYNAMICS OF APEX FENCES ON A TAILLESS DELTA CONFIGURATION
KEITH D. HOFFLER, DHANVADA M. RAO (Vigyan Research Associates, Inc., Hampton, VA), and MARK C. FRASSINELLI (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 25, April 1988, p. 295-301. Previously cited in issue 24, p. 3535, Accession no. A86-49593.
(Contract FY1456-85-O-0032)

A88-45278*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
UNSTEADY LOW-SPEED AERODYNAMIC MODEL FOR COMPLETE AIRCRAFT CONFIGURATIONS
JOSEPH KATZ (NASA, Ames Research Center, Moffett Field, CA) and BRIAN MASKEW (Analytical Methods, Inc., Redmond, WA) Journal of Aircraft (ISSN 0021-8669), vol. 25, April 1988, p. 302-310. Previously cited in issue 23, p. 3414, Accession no. A86-47683. refs

A88-45279#
LIFT MODULATION WITH LATERAL WING-TIP BLOWING
D. A. TAVELLA, N. J. WOOD, C. S. LEE, and L. ROBERTS (Stanford University, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, April 1988, p. 311-316. refs

The utilization of a thin jet of air exiting in the spanwise direction from a slot at each of the tips of a straight wing has been investigated as a means of generating weak lift modulation. A theory showing the analytical relationship between blowing intensity and aerodynamic forces was developed, and its results were compared against experiments. It was found that the lift gain due to lateral blowing depends on the 2/3-power of the jet-blowing intensity. Author

A88-45280#
AERODYNAMIC CHARACTERISTICS AND FLOW ROUND CROSS PARACHUTES IN STEADY MOTION
C. Q. SHEN and D. J. COCKRELL (Leicester, University, England) Journal of Aircraft (ISSN 0021-8669), vol. 25, April 1988, p. 317-323. Research supported by Irvin Great Britain, Ltd. Previously cited in issue 03, p. 286, Accession no. A87-13798. refs

A88-45282#
FLOW-AROUND AIRFOILS WITH BLUNT, ROUND, AND SHARP TRAILING EDGES
B. E. THOMPSON (Scientific Research Associates, Inc., Glastonbury, CT) and J. H. WHITELAW (Imperial College of Science and Technology, London, England) Journal of Aircraft (ISSN 0021-8669), vol. 25, April 1988, p. 334-342. SERC-NSERC-supported research. Previously cited in issue 08, p. 1041, Accession no. A87-22651. refs

A88-45289#
EVALUATION OF TWO SINGULAR INTEGRALS FROM THIN AIRFOIL THEORY
RAJENDRA K. BERA (National Aeronautical Laboratory, Bangalore, India) Journal of Aircraft (ISSN 0021-8669), vol. 25, April 1988, p. 383, 384.

Two Cauchy integrals that have useful applications in second-order thin airfoil theory are presently evaluated in closed form. Attention is given to the evaluation of the integrals H(n) and I(n). O.C.

A88-45301#
CALCULATION OF STEADY TRANSONIC VISCOUS FLOWS WITH SMALL SEPARATION BUBBLE AROUND AN ARBITRARY AIRFOIL
HUILIU ZHANG and QIPENG CAO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, March 1988, p. A103-A107. In Chinese, with abstract in English. refs

An innovative method for calculating steady transonic viscous flows around an arbitrary airfoil with a small separation bubble is presented. The concept of inviscid-viscous interaction makes it possible to calculate complex transonic flow field at a lower cost with less computer storage. The inviscid flows are governed by the conservative full potential equations and solved by a fast algorithm. The flow field around the airfoil is transformed into the inner of the unit circle by the conformal mapping in which the FFT technique is used. The boundary layer equations are numerically solved using the C-S-K box method. Two examples of transonic viscous flows around a NACA 64A010 airfoil with a free stream Mach number 0.8 and angles of attack 4 and 3.5 deg, respectively, are calculated. Author

A88-45318#
PREDICTION OF THE STALL CHARACTERISTICS OF MULTIELEMENT AIRFOILS WITH CONFLUENT BOUNDARY LAYER
BAOQIN ZHANG and ZHILIANG LU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, April 1988, p. B123-B131. In Chinese, with abstract in English. refs

A computing model with confluent boundary which computes the stall characteristics of multielement airfoils in a separated flow has been developed. A high-order-singularity panel method is used for the potential-flow solution. The characteristics of ordinary and confluent boundary layer and viscous wake based on the potential-flow solution are obtained. A separated-wake model is used when the separation at the trailing edge of a certain element of the multielement airfoils occurs. The final viscous solution is obtained by representing the boundary-layer displacement thickness with an appropriate source distribution and by a viscous-potential interactive technique. The calculated pressure distribution, the lift, and the drag for angles of attack up to stall are in good agreement with experimental measurements. Author

A88-45472
INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF THE VEGA BALLOON PROBE [ISSLEDOVANIE AERODINAMICHESKIKH KHARAKTERISTIK AEROSTATNOGO ZONDA PROEKTA 'VEGA']
S. N. ALEKSASHKIN, V. P. KARIAGIN, K. M. PICHKHADZE, R. CH. TARGAMADZE, and A. V. TERTERASHVILI Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 26, May-June 1988, p. 434-440. In Russian.

Results are presented on the aerodynamic characteristics of the balloon probe (BP) which is part of the Vega 1 and 2 spacecraft. The BP was intended to study the global circulation of Venus at the level of the cloud layer. Particular consideration was given to the static aerodynamic characteristics, the properties of the balloon shell at various stages of balloon filling, and the dynamic characteristics of the balloon with respect to the center of mass. The wind tunnel testing method is described, and results are presented concerning the dependence of balloon shell loading on the degree of filling and the dynamic characteristics. B.J.

A88-45616#
FINITE DIFFERENCE ANALYSIS OF A ROTOR IN HOVER AND AXIAL TRANSLATION
R. GANESH RAJAGOPALAN (Iowa State University of Science and Technology, Ames) and CHIN K. LIM AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. Research supported by Iowa State University of Science and Technology. refs
(AIAA PAPER 88-2891)

A new procedure has been used to analyze the flow field and performance of helicopter rotors. The method is versatile enough to allow for the inclusion of compressibility, turbulence and other nonlinear viscous effects without being computationally intensive. The method has been tested on a rotor in hover and axial

translation and the results compare very well with available experimental data. Flow field characteristics show excellent trend of the physics of flow. Author

A88-45619#
ROTOR-STATOR INTERACTION IN MULTI-STAGE AXIAL-FLOW TURBINES
O. P. SHARMA, T. L. BUTLER (Pratt and Whitney, East Hartford, CT), R. P. DRING, H. D. JOSLYN (United Technologies Corp., East Hartford, CT), E. RENAUD et al. AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 17 p. refs
(AIAA PAPER 88-3013)

The present consideration of the influence of periodic unsteadiness induced by upstream airfoils' wakes and vortices in downstream airfoil passage boundary layers and secondary flows proposes a semiempirical model accounting for the wake-boundary layer interaction, and furnishes improved estimates of heat loads and losses in turbine rotor midspan regions. Experimental data are obtained from a large scale rotating turbine rig to illustrate the impact of unsteadiness on the characteristics of secondary flows in the downstream rotor and stator passages. Large variations are noted in the size and strength of rotor secondary flow vortices, as rotor passages sweep through the flow distortions generated by upstream stator airfoils. O.C.

A88-45621#
EFFECTS OF COMPRESSIBILITY ON THE STRUCTURE OF FREE SHEAR LAYERS
M. SAMIMY (Ohio State University, Columbus) and G. S. ELLIOTT AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p. refs
(Contract N00014-87-K-0169)
(AIAA PAPER 88-3054A)

A planar two-dimensional constant pressure compressible shear layer was formed by mixing of a supersonic flow and a subsonic flow at the trailing edge of a 0.5 mm thick splitter plate. Two cases were investigated. The supersonic, subsonic, and the convective Mach numbers were 1.8, 0.51, and 0.51 for case 1, and 1.96, 0.37, and 0.64 for case 2, respectively. A two-component coincident LDV system was utilized to obtain detailed mean and turbulence data. The growth rate ratio of case 2 to the incompressible counterpart was approximately 20 percent less than that of the case 1. Preliminary results seem to indicate that as the convective Mach number increases, the lateral extent and/or coherency of large scale structures in the supersonic side of the shear layer drop. This limits the lateral transport of kinetic energy and also the entrainment of the flow from supersonic side which in turn decreases the growth rate. Author

A88-45676#
NUMERICAL ANALYSIS OF AN NACA 0012 AIRFOIL WITH LEADING-EDGE ICE ACCRETIONS
MARK G. POTAPCZUK (Akron, University, OH) Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 193, 194. Abridged. Previously cited in issue 08, p. 1033, Accession no. A87-22415. refs

A88-45677#
EXPERIMENTAL EXAMINATION OF THE LEADING-EDGE SUCTION ANALOGY
JOSEPH ER-EL (Technion - Israel Institute of Technology, Haifa) and YITZHAK ZOHAR Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 195-199. refs

The potential and vortical components of the normal force and their chordwise distribution, as defined by the Leading-Edge Suction Analogy (LESA), as well as the normal force itself and its chordwise distribution, were obtained experimentally and were compared with the predicted results. The comparison was carried out for the delta wings having leading-edge sweep angles of 75 and 60 deg. The experimental results were obtained from surface pressure measurements by invoking the linearized potential-flow wing theory, which was also used in the derivation of LESA. The comparison shows that, for the low-aspect-ratio wing, the agreement between measured and predicted results is in the 0-20 deg incidence range. In the high-aspect-ratio wing, the differences between experiment and theory are large for the potential and vortical components of the normal force coefficient and their longitudinal loadings, and considerably smaller for the normal force coefficient. Thus, LESA appears less valid for the high-aspect-ratio wing than was previously thought on the basis of a comparison of the normal force coefficient values only. Author

A88-45678#
INFLUENCE OF THE ASPECT RATIO ON THE AERODYNAMICS OF THE DELTA WING AT HIGH ANGLE OF ATTACK
JOSEPH ER-EL (Technion - Israel Institute of Technology, Haifa) and YITZHAK ZOHAR Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 200-205. refs

The influence of aspect ratio on the contribution of the leading-edge vortices to the loading of the delta wing has been studied experimentally. The study is based on surface pressure measurements of four wings having aspect ratios of 1.07-2.80 (55 to 75 deg sweep angles). Results show that the suction induced by the leading-edge vortices increases with incidence as long as they are not affected by vortex breakdown. In higher-aspect-ratio wings, when vortex breakdown is present on the wing, the vortex-induced suction continues to increase with incidence at a decreasing rate until the breakdown has reached the apex region. In lower-aspect-ratio wings, however, the vortex-induced suction decreases with incidence as the breakdown crosses the trailing edge. The magnitude of the slope of this decrease is smaller in lower-aspect-ratio wings. This may indicate that lower-aspect-ratio delta wings are preferable for future aircraft designed for poststall flight. Author

A88-45682#
NEW PANEL METHOD FOR SUPERSONIC FLOWS ABOUT ARBITRARY CONFIGURATIONS
YUICHI MARUYAMA, SADAO AKISHITA (Mitsubishi Electric Corp., Kanagawa, Japan), and AKIHITO NAKAMURA (Mitsubishi Space Software Corp., Kanagawa, Japan) Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 229-235. Previously cited in issue 23, p. 3385, Accession no. A86-47684. refs

A88-45683#
CONTROL OF VORTICAL LIFT ON DELTA WINGS BY TANGENTIAL LEADING-EDGE BLOWING
N. J. WOOD and L. ROBERTS (Stanford University, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 236-243. Previously cited in issue 08, p. 1034, Accession no. A87-22450. refs

A88-45684*# Old Dominion Univ., Norfolk, Va.
EFFECTS OF ASPECT RATIO AND SIDEWALL BOUNDARY-LAYER IN AIRFOIL TESTING
A. V. MURTHY (Old Dominion University Research Foundation, Norfolk, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 244-249. Previously cited in issue 08, p. 1036, Accession no. A87-22542. refs
(Contract NAG1-334)

A88-45685#
VELOCITY FIELD OF A LIFTING ROTOR BLADE IN HOVER
N. M. KOMERATH, T. L. THOMPSON, O. J. KWON, and R. B. GRAY (Georgia Institute of Technology, Atlanta) Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 250-257. refs
(Contract DAAG29-82-K-0094)

Detailed measurements have been made using a laser velocimeter in the close vicinity of a lifting, single-bladed model rotor blade in simulated hover conditions to validate codes for predicting rotorcraft aerodynamics. Data acquired at a rotor tip speed of 32 m/s and a tip Reynolds number of 270,000 are compared with predictions made using a thick-bladed panel code coupled to a prescribed wake calculation. Rotor inflow

measurements are seen to agree closely with panel code results, even when examined with high chordwise resolution. Agreement is less definite in the near wake, where strong tip vortex effects are felt, and the vortex core model becomes important. Tip vortex formation is clearly visible from the data. Deviations from periodicity are insignificant in the close vicinity of the blade. Particle spin-out effects are seen to be pronounced in the vortex core when using conventional seeding materials but to be greatly reduced by the use of incense seeding. The precise measurement of vortex core velocity profiles is seen to be within reach. Author

A88-45686#
PASSIVE DEVICES FOR AXISYMMETRIC BASE DRAG REDUCTION AT TRANSONIC SPEEDS
P. R. VISWANATH (National Aeronautical Laboratory, Bangalore, India) Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 258-262.

Experiments have been made to assess the effectiveness of several base modifications or passive devices for reducing base drag and total afterbody drag at transonic speeds. The modifications tested include base cavities, ventilated cavities, and two vortex suppression devices. Results show that, while appreciable base drag reductions are possible with many of the devices examined, the net total drag reductions are relatively lower, presumably because of the additional losses associated with the devices. Author

A88-45687*# Purdue Univ., West Lafayette, Ind.
COMPUTATIONAL TRANSONIC FLUTTER BOUNDARY TRACKING PROCEDURE
JOHN W. GALLMAN, T. Y. YANG (Purdue University, West Lafayette, IN), and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2, p. 314-324) Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 263-270. Previously cited in issue 18, p. 2604, Accession no. A86-38913. refs
(Contract NAG1-372)

A88-45706
MULTI-CELL VORTICES COMPUTED IN LARGE-SCALE DIFFERENCE SOLUTION TO THE INCOMPRESSIBLE EULER EQUATIONS
ARTHUR RIZZI (Flygtekniska Forsoksanstalten, Bromma; Kungliga Tekniska Hogskolan, Stockholm, Sweden) Journal of Computational Physics (ISSN 0021-9991), vol. 77, July 1988, p. 207-220. refs

Computational results conducted on a large scale are obtained for a three-dimensional flow that encompasses a delta wing-shed vortex sheet; mesh-refinement results are compared with those from a vortex-element solution tracking the vortex sheet as a nondiffusing continuity. Analytical attention is given to the position of vortex features captured in the Euler flowfield, as well as the vortex-sheet diffusion and the pressure-field accuracy. The nonaxisymmetric disturbance generated by the wing trailing edge establishes a torsional wave on the vortex core, in turn producing a multiple vorticity cell structure that is judged to be real rather than numerical, and not merely a form of vortex-bursting. The phenomenon is suggested to be due to vortex instability. O.C.

N88-23731# Royal Aircraft Establishment, Farnborough (England).
AN ASSESSMENT OF THE DRAG REDUCTION PROPERTIES OF RIBLETS AND THE PENALTIES OF OFF-DESIGN CONDITIONS
L. GAUDET Aug. 1987 23 p
(RAE-TM-AERO-2113; BR104824; ETN-88-92510) Avail: NTIS HC A03/MF A01

The performance of riblets in reducing skin friction in turbulent flow was assessed. The data of Sawyer and Winter is used to develop skin-friction relationships derived from the velocity profile for a turbulent boundary layer as modified by a riblet surface. The maximum percentage drag reduction is shown to vary with Reynolds number, Rx. At large values of the nondimensional riblet height the riblet surface acts as a uniform roughness and a value for the equivalent sand-grain roughness height is given. The skin-friction relationships derived from the velocity profile as modified by the riblet surface show that for an optimum riblet size, reductions in skin friction of 7 percent may be achieved at Rx = 10 million, but at Rx = 1 billion the reduction is 5 percent. Applied to the BAe 125 and the A300, for example, the analysis implies maximum possible reductions in the drag coefficient of 0.00065 and 0.00047 respectively. These savings decrease if it is not feasible to apply the riblets in regions which are surface-flow sensitive. ESA

N88-23733 New South Wales Univ., Sydney (Australia). School of Mechanical and Industrial Engineering.
PROPULSIVE PERFORMANCE OF A LIFTING FLAPPING WING Ph.D. Thesis Abstract Only
JEREMY BLACKWELL Dec. 1986 418 p
Avail: Issuing Activity

A mathematical model of a lifting, flapping wing was created. Both a 3-dimensional wavy wake and a 2-dimensional flat wake approximation were examined. The flat wake solution was adequate only for small flapping amplitudes. Results show that horizontal flapping flight, requiring lift as well as thrust, whether for maximum thrust or propulsive efficiency, is likely to occur at low advance ratio. In addition, it is necessary that the wing be allowed to twist. Increased net lift results in a reduction of net thrust and propulsive efficiency. However, if the steady state component of drag (induced and profile) is debited to the body drag (the equivalent propeller condition), high thrusts and propulsive efficiencies are possible for a flapping wing, whether lifting or not. The effect of varying the wing chord during the flapping cycle and the fraction of cycle time spent on the downstroke were examined. It was found that for micro not equal to 0.5 and sigma less than one (where micro is the fraction of cycle time spent on the downstroke and sigma is the upstroke:downstroke wing chord ratio), thrust and propulsive efficiency could be significatly raised above the symmetric case micro equals 0.5 and sigma equals one. Author

N88-23734*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HIGH REYNOLDS NUMBER TESTS OF A DOUGLAS DLBA 032 AIRFOIL IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
CHARLES B. JOHNSON, DAVID A. DRESS, ACQUILLA S. HILL, PETER A. WILCOX, and MINH H. BUI (Douglas Aircraft Co., Inc., Long Beach, Calif.) May 1986 126 p
(NASA-TM-87663; L-16083; NAS 1.15:87663) Avail: NTIS HC A07/MF A01 CSCL 01A

A wind-tunnel investigation of a Douglas advanced-technology airfoil was conducted in the Langley 0.3-Meter Transonic Cryogenic Tunnel (0.3-m TCT). The temperature was varied from 227 K (409 R) to 100 K (180 R) at pressures ranging from about 159 kPa (1.57 atm) to about 514 kPa (5.07 atm). Mach number was varied from 0.50 to 0.78. These variables provided a Reynolds number range (based on airfoil chord) from 6.0 to 30.0 x 10 to the 6th power. This investigation was specifically designed to: (1) test a Douglas airfoil from moderately low to flight-equivalent Reynolds numbers, and (2) evaluate sidewall-boundary-layer effects on transonic airfoil performance characteristics by a systematic variation of Mach number, Reynolds number, and sidewall-boundary-layer removal. Data are included which demonstrate the effects of fixing transition, Mach number, Reynolds number, and sidewall-boundary-layer removal on the aerodynamic characteristics of the airfoil. Also included are remarks on model design and model structural integrity. Author

N88-23736*# Rockwell International Corp., Los Angeles, Calif.
FULL POTENTIAL METHODS FOR ANALYSIS/DESIGN OF COMPLEX AEROSPACE CONFIGURATIONS
VIJAYA SHANKAR, KUO-YEN SZEMA, and ELLWOOD BONNER Washington NASA May 1986 157 p
(Contract NAS1-15820)

(NASA-CR-3982; NAS 1.26:3982) Avail: NTIS HC A08/MF A01 CSCL 01A

The steady form of the full potential equation, in conservative form, is employed to analyze and design a wide variety of complex aerodynamic shapes. The nonlinear method is based on the theory of characteristic signal propagation coupled with novel flux biasing concepts and body-fitted mapping procedures. The resulting codes are vectorized for the CRAY XMP and the VPS-32 supercomputers. Use of the full potential nonlinear theory is demonstrated for a single-point supersonic wing design and a multipoint design for transonic maneuver/supersonic cruise/maneuver conditions. Achievement of high aerodynamic efficiency through numerical design is verified by wind tunnel tests. Other studies reported include analyses of a canard/wing/nacelle fighter geometry.

Author

N88-23737*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

LAMINAR FLOW AIRCRAFT CERTIFICATION

LOUIS J. WILLIAMS, comp. May 1986 325 p Workshop held in Wichita, Kans., 15-16 Apr. 1985; sponsored by NASA, AIAA, SAE and FAA Sponsored by NASA, Washington

(NASA-CP-2413; L-16111; NAS 1.55:2413) Avail: NTIS HC A14/MF A01 CSCL 01A

Various topics telative to laminar flow aircraft certification are discussed. Boundary layer stability, flaps for laminar flow airfoils, computational wing design studies, manufacturing requirements, windtunnel tests, and flow visualization are among the topics covered.

N88-23738*# Engineering and Science Consultants, Grafton, Va.

BOUNDARY-LAYER STABILITY AND AIRFOIL DESIGN

JEFFREY K. VIKEN *In* NASA, Langley Research Center, Laminar Flow Aircraft Certification p 1-30 May 1986

(Contract NAS1-17670)

Avail: NTIS HC A14/MF A01 CSCL 01A

Several different natural laminar flow (NLF) airfoils have been analyzed for stability of the laminar boundary layer using linear stability codes. The NLF airfoils analyzed come from three different design conditions: incompressible; compressible with no sweep; and compressible with sweep. Some of the design problems are discussed, concentrating on those problems associated with keeping the boundary layer laminar. Also, there is a discussion on how a linear stability analysis was effectively used to improve the design for some of the airfoils. Author

N88-23739*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

HIGH-FLAPS FOR NATURAL LAMINAR FLOW AIRFOILS

HARRY L. MORGAN *In its* Laminar Flow Aircraft Certification p 31-65 May 1986

Avail: NTIS HC A14/MF A01 CSCL 01A

A review of the NACA and NASA low-drag airfoil research is presented with particular emphasis given to the development of mechanical high-lift flap systems and their application to general aviation aircraft. These flap systems include split, plain, single-slotted, and double-slotted trailing-edge flaps plus slat and Krueger leading-edge devices. The recently developed continuous variable-camber high-lift mechanism is also described. The state-of-the-art of theoretical methods for the design and analysis of multi-component airfoils in two-dimensional subsonic flow is discussed, and a detailed description of the Langley MCARF (Multi-Component Airfoil Analysis Program) computer code is presented. The results of a recent effort to design a single- and double-slotted flap system for the NASA high speed natural laminar flow (HSNLF) (1)-0213 airfoil using the MCARF code are presented to demonstrate the capabilities and limitations of the code.

Author

N88-23740*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

COMPUTATIONAL WING DESIGN STUDIES RELATING TO NATURAL LAMINAR FLOW

EDGAR G. WAGGONER *In its* Laminar Flow Aircraft Certification p 67-87 May 1986

Avail: NTIS HC A14/MF A01 CSCL 01A

Two research studies are described which directly relate to the application of natural laminar flow (NLF) technology to transonic transport-type wing planforms. Each involved using state-of-the-art computational methods to design three-dimensional wing contours which generate significant runs of favorable pressure gradients. The first study supported the Variable Sweep Transition Flight Experiment and involves design of a full-span glove which extends from the leading edge to the spoiler hinge line on the upper surface of an F-14 outer wing panel. A wing was designed computationally for a corporate transport aircraft in the second study. The resulting wing design generated favorable pressure gradients from the leading edge aft to the mid-chord on both upper and lower surfaces at the cruise design point. Detailed descriptions of the computational design approach are presented along with the various constraints imposed on each of the designs. Author

N88-23741*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

WIND TUNNEL TESTING OF LOW-DRAG AIRFOILS

W. DONALD HARVEY, R. J. MCGHEE, and C. D. HARRIS *In its* Laminar Flow Aircraft Certification p 89-128 May 1986

Avail: NTIS HC A14/MF A01 CSCL 01A

Results are presented for the measured performance recently obtained on several airfoil concepts designed to achieve low drag by maintaining extensive regions of laminar flow without compromising high-lift performance. The wind tunnel results extend from subsonic to transonic speeds and include boundary-layer control through shaping and suction. The research was conducted in the NASA Langley 8-Ft Transonic Pressure Tunnel (TPT) and Low Turbulence Pressure Tunnel (LTPT) which have been developed for testing such low-drag airfoils. Emphasis is placed on identifying some of the major factors influencing the anticipated performance of low-drag airfoils. Author

N88-23750*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

PAN AIR ANALYSIS OF THE NASA/MCAIR 279-3: AN ADVANCED SUPERSONIC V/STOL FIGHTER/ATTACK AIRCRAFT

MICHAEL D. MADSON and LARRY L. ERICKSON Apr. 1986 40 p

(NASA-TM-86838; A-85414; NAS 1.15:86838) Avail: NTIS HC A03/MF A01 CSCL 01A

PAN AIR is a computer program for predicting subsonic or supersonic linear potential flow about arbitrary configurations. The program was applied to a highly complex single-engine-cruise V/STOL fighter/attack aircraft. Complexities include a close-coupled canard/wing, large inlets, and four exhaust nozzles mounted directly under the wing and against the fuselage. Modeling uncertainties involving canard wake location and flow-through approximation through the inlet and the exhaust nozzles were investigated. The recently added streamline capability of the program was utilized to evaluate visually the predicted flow over the model. PAN AIR results for Mach numbers of 0.6, 0.9, and angles of attack of 0, 5, and 10 deg. were compared with data obtained in the Ames 11- by 11-Foot Transonic Wind tunnel, at a Reynolds number of 3.69 x 10 to the 6th power based on c bar.

Author

N88-23754# George Washington Univ., Washington, D.C. Graduate School of Engineering and Applied Science.

WIND-TUNNEL INVESTIGATION OF ACTUATED FOREBODY STRAKES FOR YAW CONTROL AT HIGH ANGLES OF ATTACK

DANIEL G. MURRI May 1987 95 p
Avail: NTIS HC A05/MF A01

Wind-tunnel studies are conducted to evaluate the potential of actuated forebody strakes to provide increased levels of yaw control on fighter aircraft at stall and post-stall angles of attack where conventional aerodynamic controls are ineffective. The studies involved low-speed wind-tunnel tests of actuated forebody strake concepts applied to a generic fighter model and included circumferential pressure and flow visualization surveys on an isolated forebody. Results showed that the actuated forebody strake concept can provide high levels of yaw control over wide angle-of-attack and sideslip ranges. However, significant interaction effects that reduced the yaw control effectiveness of the strakes or induced coupled rolling and pitching moments occurred when lifting surfaces were placed in close proximity to the forebody/strake combination. Two fundamentally different flow mechanisms were identified that were responsible for the yawing moments generated by the strakes. Author

N88-23755*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INFLOW MEASUREMENT MADE WITH A LASER VELOCIMETER ON A HELICOPTER MODEL IN FORWARD FLIGHT. VOLUME 5: TAPERED PLANFORM BLADES AT AN ADVANCE RATIO OF 0.23
SUSAN L. ALTHOFF, JOE W. ELLIOTT, and RICHARD H. SAILEY (PRC Kentron, Inc., Hampton, Va.) Apr. 1988 355 p
(NASA-TM-100545; NAS 1.15:100545; AVSCOM-TM-88-B-008-VOL-5) Avail: NTIS HC A16/MF A01 CSCL 01A

An experimental investigation was conducted in the 14- by 22-Foot Subsonic tunnel at NASA Langley Research Center to measure the inflow into a scale model helicopter rotor in forward flight (mu sub inf = 0.23). The measurements were made with a two component Laser Velocimeter (LV) one chord above the plane formed by the path of the blade tips. A conditional sampling technique was employed to determine the position of the rotor at the time that each velocity measurement was made so that the azimuthal fluctuations in velocity could be determined. Measurements were made at a total of 168 separate locations in order to clearly define the inflow character. This data is presented without analysis. In order to increase the availability of the resulting data, both the mean and azimuthally dependenet values are included as part of this report on two 5.25 inch floppy disks in Microsoft Corporation MS-DOS format. Author

N88-23756*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNSTEADY PRESSURE AND STRUCTURAL RESPONSE MEASUREMENTS OF AN ELASTIC SUPERCRITICAL WING
CLINTON V. ECKSTROM, DAVID A. SEIDEL, and MAYNARD C. SANDFORD May 1988 13 p Presented at the AIAA/ASME/ASCE/AHS/ASC 29th Structures, Structural Dynamics, and Materials Conference, Williamsburg, Va., 18-20 Apr. 1988 Previously announced in IAA as A88-32231
(NASA-TM-100591; NAS 1.15:100591; AIAA-PAPER-88-2277) Avail: NTIS HC A03/MF A01 CSCL 01A

Results are presented which define unsteady flow conditions associated with high dynamic response experienced on a high aspect ratio elastic supercritical wing at transonic test conditions while being tested in the NASA Langley Transonic Dynamics Tunnel. The supercritical wing, designed for a cruise Mach number of 0.80, experienced the high dynamic response in the Mach number range from 0.90 to 0.94 with the maximum response occurring at a Mach number of approximately 0.92. At the maximum wing response condition the forcing function appears to be the oscillatory chordwise movement of strong shocks located on both the wing upper and lower surfaces in conjunction with the flow separating and reattaching in the trailing edge region. Author

N88-23757*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AEROPROPULSIVE CHARACTERISTICS OF ISOLATED COMBINED TURBOJET/RAMJET NOZZLES AT MACH NUMBERS FROM 0 TO 1.20
GEORGE T. CARSON, JR. and MILTON LAMB Jun. 1988 174 p
(NASA-TP-2814; L-16390; NAS 1.60:2814) Avail: NTIS HC A08/MF A01 CSCL 01A

An investigation was conducted in the Langley 16-Foot Transonic Tunnel to determine the aeropropulsive performance characteristics (the aerodynamic quantities affected by propulsion) of 13 isolated combined turbojet/ramjet nozzle configurations. These configurations simulated the variable-geometry features of two nozzle designs designated as the multiple-expansion ramp nozzle (MERN) and the composite contour nozzle (CCN). Test data were obtained at static conditions and at Mach numbers of 0.60, 0.90, and 1.20 with jet exhaust simulated by high-pressure air. The results showed that the CCN had the higher performance over the Mach number range than the MERN, as indicated by the difference of thrust minus drag divided by ideal thrust. Increasing the ramjet throat area for the MERN resulted in an increase in performance that increased with Mach number. For the CCN at Mach numbers less than 1.20, increasing the ramjet throat area resulted in a loss in performance. Author

N88-23758*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRESSURE DISTRIBUTIONS FROM SUBSONIC TESTS OF AN ADVANCED LAMINAR-FLOW-CONTROL WING WITH LEADING- AND TRAILING-EDGE FLAPS
ZACHARY T. APPLIN and GARL L. GENTRY, JR. Jul. 1988 32 p
(NASA-TM-4040-PT-1; L-16405; NAS 1.15:4040-PT-1) Avail: NTIS HC A03/MF A01 CSCL 01A

An unswept, semispan wing model equipped with full-span leading- and trailing-edge flaps was tested in the Langley 14- by 22-Foot Subsonic Tunnel to determine the effect of high-lift components on the aerodynamics of an advanced laminar-flow-control (LFC) airfoil section. Chordwise pressure distributions near the midsemispan were measured for four configurations: cruise, trailing-edge flap only, and trailing-edge flap with a leading edge Kreuger flap of either 0.10 or 0.12 chord. Part 1 of this report presents a representative sample of the plotted pressure distribution data for each configuration tested. Part 2 (under separate cover) presents the entire set of plotted and tabulated pressure distribution data. The data are presented without analysis. Author

N88-23759* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CROSSFLOW VORTICITY SENSOR Patent
BRUCE J. HOLMES, inventor (to NASA), DEBRA L. CARRAWAY, inventor (to NASA) (Old Dominion Univ., Hampton, Va.), HARLAN K. HOLMES, inventor (to NASA), and THOMAS C. MOORE, inventor (to NASA) 1 Mar. 1988 9 p Filed 15 Jan. 1987 Supersedes N87-23587 (25 - 19, p 2616)
(NASA-CASE-LAR-13436-1-CU; US-PATENT-4,727,751; US-PATENT-APPL-SN-003676; US-PATENT-CLASS-73-147; US-PATENT-CLASS-73-178-R) Avail: US Patent and Trademark Office CSCL 01A

A crossflow vorticity sensor for the detection of crossflow vorticity characteristics is described. The sensor is comprised of crossflow sensors which are noninvasively adhered to a swept wing laminar surface either singularly, in multi-element strips, in polar patterns, or in orthogonal patterns. These crossflow sensors are comprised of hot-film sensor elements which operate as a constant temperature anemometer circuit to detect heat transfer rate changes. Accordingly, crossflow vorticity characteristics are determined via cross-correlation. In addition, the crossflow sensors have a thickness which does not exceed a maximum value h in order to avoid contamination of downstream crossflow sensors.
Official Gazette of the U.S. Patent and Trademark Office

N88-23760*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SENSITIVITY OF F-106B LEADING-EDGE-VORTEX IMAGES TO FLIGHT AND VAPOR-SCREEN PARAMETERS
JOHN E. LAMAR and THOMAS D. JOHNSON, JR. (Planning Research Corp., Hampton, Va.) Jun. 1988 80 p Original contains color illustrations
(NASA-TP-2818; L-16395; NAS 1.60:2818) Avail: NTIS HC A05/MF A01 CSCL 01A

A flight test was undertaken at NASA Langley Research Center with vapor-screen and image-enhancement techniques to obtain qualitative and quantitative information about near-field vortex flows above the wings of fighter aircraft. In particular, the effects of Reynolds and Mach numbers on the vortex system over an angle-of-attack range were sought. The relevance of these flows stems from their present and future use at many points in the flight envelope, especially during transonic maneuvers. The aircraft used in this flight program was the F-106B because it was available and had sufficient wing sweep (60 deg) to generate a significant leading-edge vortex system. The sensitivity of the visual results to vapor screen hardware and to onset flow changes is discussed. Author

N88-24580*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AERODYNAMIC PERFORMANCE AND PRESSURE DISTRIBUTIONS FOR A NASA SC(2)-0714 AIRFOIL TESTED IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
RENALDO V. JENKINS, ACQUILLA S. HILL, and EDWARD J. RAY Jul. 1988 300 p Sponsored by NASA, Washington
(NASA-TM-4044; L-16384; NAS 1.15:4044) Avail: NTIS HC A13/MF A01 CSCL 01A

This report presents in graphic and tabular forms the aerodynamic coefficient and surface pressure distribution data for a NASA SC(2)-0714 airfoil tested in the Langley 0.3-Meter Transonic Cryogenic Tunnel. The test was another in a series of tests involved in the joint NASA/U.S. Industry Advanced Technology Airfoil Tests program. This 14% thick supercritical airfoil was tested at Mach numbers from 0.6 to 0.76 and angles of attack from -2.0 to 6.0 degrees. The test Reynolds numbers were 4 million, 6 million, 10 million, 15 million, 30 million, 40 million, and 45 million. Author

N88-24582# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
EXPERIMENT INVESTIGATION ON LONGITUDINAL CHARACTERISTICS OF THE FORWARD SWEPT WING
YAOBIN GUO, XUEJIAN WANG, and BINJIANG ZHANG 10 Mar. 1988 29 p Transl. into ENGLISH from Hangkong Xuebao (Peoples Republic of China), v. 8, no. 6, Jun. 1987 p 227-238 Original language document was announced in IAA as A88-16336
(AD-A191553; FTD-ID(RS)T-1364-87) Avail: NTIS HC A03/MF A01 CSCL 01C

Based on testing results of aerodynamic forces and pressures from a wind tunnel, the longitudinal aerodynamics characteristics of a forward swept wing are discussed in this paper. The results are also compared with the data of an associated aft swept wing. Measures of improving the inboard flowfield of a forward swept wing are also investigated, and the results are discussed. Under a low speed situation, an appropriate sweptback of the root section can improve the flow consequently obtaining higher aerodynamic performances. GRA

N88-24584# Purdue Univ., West Lafayette, Ind. Sciences and Propulsion Center.
RESEARCH ON AERO-THERMODYNAMIC DISTORTION INDUCED STRUCTURAL DYNAMIC RESPONSE OF MULTI-STAGE COMPRESSOR BLADING Final Technical Report, Apr. 1983 - Nov. 1987
SANFORD FLEETER 15 Jan. 1988 237 p
(Contract F49620-83-K-0029)
(AD-A192169; ME-TSPC-TR-88-10; AFOSR-88-0045TR) Avail: NTIS HC A11/MF A01 CSCL 01A

The overall objective of this research program was to quantitatively investigate the fundamental phenomena relevant to aero-thermodynamic distortion induced structural dynamic blade responses in multi-stage gas turbine engine components. The technical approach involved both experiment and analysis. The flow physics of multi-stage blade row interactions has been experimently investigated, with unique high reduced frequency unsteady aerodynamic data obtained to understand, quantify, and discriminate the fundamental flow phenomena as well as to direct the modeling of advanced analyses. The development of an unsteady viscous flow analysis appropriate for aerodynamic forced response predictions was initiated. A structural dynamics model based on an energy balance techniques coupled with the unsteady aerodynamic analyses under development is being utilized to investigate aerodynamically forced response of turbomachine blade rows. GRA

N88-24588 Rensselaer Polytechnic Inst., Troy, N.Y.
PASSIVE SHOCK WAVE-BOUNDARY LAYER CONTROL FOR THE BELL FX69-H-098 AIRFOIL Ph.D. Thesis
TIMOTHY JOHN BIDLACK 1987 269 p
Avail: Univ. Microfilms Order No. DA8729296

Passive shock wave-boundary layer control involves using a porous surface for the portion of an airfoil in the region of a sufficiently strong shock wave and positioning a cavity beneath it. Such a combination allows for some of the flow compressed by the shock waves to recirculate upstream. The suction created downstream of the shock wave by the difference in pressure accross it and the removal of flow in this region helps thin the boundary layer and reduces the possiblity of flow separation. In addition, the injection of flow upstream of the normal shock wave results in the formation of a lambda shock wave. This reduces the strength of the normal shock wave and its corresponding effects. As cruise speeds of helicopters increase, the transonic flow effects experienced by rotor blades becomes more pronounced. To determine the feasibility of applying passive shock wave-boundary layer control to a typical rotor blade, this research was conducted. The effects of varying the depth of the cavity was also investigated. The Bell FX69-H-098 airfoil was selected as a representative helicopter rotor blade. Its profile is typical of airfoils designed for high lift-to-drag ratios in hover, high maximum lift coefficients at retreating blade Mach numbers, and has favorable drag divergence characteristics. Dissert. Abstr.

N88-24589 Iowa Univ., Iowa City.
PREDICTION OF LAMINAR AND TURBULENT FLOWS PAST SINGLE AND TWIN AIRFOILS Ph.D. Thesis
KEMAKOLAM M. OBASIH 1987 366 p
Avail: Univ. Microfilms Order No. DA8729497

A numerical solution of the incompressible, two dimensional, constant property, ensemble averaged Navier Stokes equations, including a transition to turbulence model, is obtained for a single and twin airfoil in a nearly orthogonal boundary-fitted coordinate system. The Navier Stokes equations are solved by the finite analytic method. The turbulent transport properties are determined by a k-epsilon-E turbulence model and the Reynolds stresses are modelled by the algebraic eddy viscosity model. The transition from laminar to turbulent flow is determined from an empirical correlation based on the growth of the momentum thickness Reynolds number of the flow as it develops. A numerical computer program called FANS-2DEF is developed. For verification, finite analytic solutions are first obtained for laminar and turbulent flows over a finite flat plate at Reynolds numbers of 10,000 and 1,700,000 respectively. Results are verified by experimental data. Then results were obtained for laminar flow over a NACA 0012 airfoil at various angles of attack and Reynolds numbers. Good agreement with experimental results was obtained. Laminar and turbulent flow past a twin airfoil were also obtained. Predicted results agree well with the expected physical flow situation. Dissert. Abstr.

N88-24590# George Washington Univ., Washington, D.C. School of Engineering and Applied Science.
A TRANSONIC SMALL DISTURBANCE WING DESIGN METHODOLOGY M.S. Thesis
PAMELA SUSAN PHILLIPS May 1987 70 p
Avail: NTIS HC A04/MF A01

A predictor-corrector wing/airfoil design code was developed that predicts surface contour modifications to achieve a specified pressure distribution. The design code is comprised of an existing small distrubance wing-body-pod-pylon-winglet code and a version of existing design algorithm. Several two-and three-dimensional design test cases were successfully run demonstrating the subject code. Included in these cases are two design tasks previously completed by using a cut and try approach. These results and a description of the formulation of the design code are presented. Also included is background information on optimization, fictitious gas, predictor-correlator, and inverse methods. Author

N88-24593# Direction des Armements Terrestres, Toulouse (France).
PARACHUTE FOR IN-FLIGHT TRAINING ON PARACHUTE EJECTION [PARACHUTE POUR L'INSTRUCTION EN VOL A LA LIBERATION DE VOILURE]
M. CAROL Sep. 1987 239 p In FRENCH
(REPT-87-11; ETN-88-91996) Avail: NTIS HC A11/MF A01

A parachute was designed for ejection training in conditions close to reality in a military environment. The design is implemented with known components from operating parachutes and selected control components. The in-flight tests show that the functional specifications are respected both for the training qualities and for the safety aspects. ESA

N88-24596# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Aerothermodynamique.
SUPPLEMENTS TO THE STUDY OF THE WAKE OF A MIRAGE G8 MODEL AT F2 [COMPLEMENTS A L'ETUDE DU SILLAGE DE LA MAQUETTE DU MIRAGE G8 A F2]
C. GLEYZES and G. PAILHAS Nov. 1987 52 p In FRENCH
(Contract STPA-85-95-004)
(CERT-RT-OA-20/5025-AYD; ETN-88-92547) Avail: NTIS HC A04/MF A01

Two dimensional laser velocimeter and hot-wire probe measurements were made on a wind tunnel model of a Mirage G8 aircraft. Wake and drag results are obtained in spite of the wide spacing of measuring points. The results show that the relative contributions to drag are: fuselage 58 percent; wings 24 percent; tailplane 12 percent; and 6 percent drift. For turbulent drag (11 percent of the total) the figures are 6, 74, 15, and 5 percent respectively. ESA

N88-24597*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUMMARY OF LOW-SPEED WIND TUNNEL RESULTS OF SEVERAL HIGH-SPEED COUNTERROTATION PROPELLER CONFIGURATIONS
CHRISTOPHER E. HUGHES and JOHN A. GAZZANIGA (Sverdrup Technology, Inc., Cleveland, Ohio.) 1988 35 p Presented at the 24th Joint Propulsion Conferences, Boston, Mass., 11-13 Jul. 1988; sponsored by AIAA, ASME, SAE and ASEE
(NASA-TM-100945; E-4234; NAS 1.15:100945; AIAA-88-3149)
Avail: NTIS HC A03/MF A01 CSCL 01A

The low speed aerodynamic performance characteristics of several advanced counterrotation pusher propeller configurations with cruise design Mach numbers of 0.72 and 0.80 were investigated in the NASA Low Speed Wind Tunnel. The tests were conducted at Mach numbers representative of the takeoff and landing flight regime. The investigation included: (1) the propeller performance characteristics over a range of blade angle settings and rotational speeds at a Mach number of 0.20; (2) the effect on the propeller performance of varying the axial rotor spacing and mismatching the power and rotational speeds on the propeller rotors; (3) determining the reverse thrust performance characteristics at Mach numbers of 0.0, 0.10, 0.15 and 0.20. The results of the investigation indicated that the overall low speed performance of the counterrotation propeller configurations was reasonable. Author

N88-24598*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AIRCRAFT AEROELASTICITY AND STRUCTURAL DYNAMICS RESEARCH AT THE NASA LANGLEY RESEARCH CENTER: SOME ILLUSTRATIVE RESULTS
ROBERT V. DOGGETT, JR. and F. W. CAZIER, JR. May 1988 13 p Proposed for presentation at the 16th Congress of the International Council of the Aeronautical Sciences (ICAS), Jerusalem, Israel, 28 Aug. - 2 Sep. 1988
(NASA-TM-100627; NAS 1.15:100627) Avail: NTIS HC A03/MF A01 CSCL 01A

Highlights of nine different research studies are described. Five of these topics relate directly to fixed-wing aircraft and range from flutter studies using relatively simple and inexpensive wind-tunnel models to buffet studies of the vertical tails of an advanced high performance configuration. The other four topics relate directly to rotary-wing aircraft and range from studies of the performance and vibration characteristics of an advanced rotor design to optimization of airframe structures for vibration attenuation. Author

N88-24601*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SOME ROTORCRAFT APPLICATIONS OF COMPUTATIONAL FLUID DYNAMICS
W. J. MCCROSKEY Mar. 1988 25 p Presented at the 2nd International Conference on Basic Rotorcraft Research, College Park, Md., Feb. 1988 Prepared in cooperation with Army Aviation Research and Development Command, Moffett Field, Calif.
(NASA-TM-100066; A-88094; NAS 1.15:100066;
USAAVSCOM-TR-88-A-001) Avail: NTIS HC A03/MF A01
CSCL 01A

The growing application of computational aerodynamics to nonlinear rotorcraft problems is outlined, with particular emphasis on the development of new methods based on the Euler and thin-layer Navier-Stokes equations. Rotor airfoil characteristics can now be calculated accurately over a wide range of transonic flow conditions. However, unsteady 3-D viscous codes remain in the research stage, and a numerical simulation of the complete flow field about a helicopter in forward flight is not now feasible. Nevertheless, impressive progress is being made in preparation for future supercomputers that will enable meaningful calculations to be made for arbitrary rotorcraft configurations. Author

N88-24602*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
APPLICATIONS OF THE NAVIER-STOKES EQUATIONS TO WINGS AND COMPLEX CONFIGURATIONS USING A ZONAL APPROACH
JOLEN FLORES Jun. 1988 12 p
(NASA-TM-100080; A-88115; NAS 1.15:100080) Avail: NTIS HC A03/MF A01 CSCL 01A

The simulation of a transonic viscous flow over a series of 3-D configurations, ranging from isolated wings to relatively complete aircraft, is presented. A fast, diagonalized Beam-Warming algorithm is used in conjunction with a zonal approach to solve the Euler/Navier-Stokes equations for these applications. The computer code, called Transonic Navier-Stokes, uses four zones for wing configurations and up to 19 zones for more complete aircraft configurations. For the inner zones adjacent to no-slip surfaces, the thin-layer Navier-Stokes equations are solved, while in the outer zones the Euler equations are solved. Numerical results are presented and compared with experiment (when available) for wing calculations and a more complete configuration based on the F-16A aircraft. Author

N88-24605 Michigan Univ., Ann Arbor.
UNSTEADY FLOW IN A SUPERCRITICAL SUPERSONIC INLET Ph.D. Thesis
ROBERT THOMAS BIEDRON 1987 160 p
Avail: Univ. Microfilms Order no. DA8801282 CSCL 01A

Unsteady flow through a two dimensional supersonic inlet diffuser, with a normal shock wave in the diffuser is analyzed using asymptotic methods. Two time regimes are considered, the first corresponding to fundamentally unsteady flow, the second to quasisteady flow; a unified solution containing both time regimes is also presented. An ordinary differential equation describing the shock wave motion is found. Examples show the motion of a shock wave resulting from impressed back pressure oscillations and from changes in flow area due to a separated flow region. For cases involving separated flow, additional numerical solutions are employed to give typical wall shapes as functions of time. Unstarts and self sustained oscillations are considered.
Dissert. Abstr.

N88-24607*# Army Aviation Systems Command, Hampton, Va.
INFLOW MEASUREMENTS MADE WITH A LASER VELOCIMETER ON A HELICOPTER MODEL IN FORWARD FLIGHT. VOLUME 1: RECTANGULAR PLANFORM BLADES AT AN ADVANCE RATION OF 0.15
JOE W. ELLIOTT, SUSAN L. ALTHOFF, and RICHARD H. SAILEY (PRC Kentron, Inc., Hampton, Va.) Apr. 1988 323 p
(NASA-TM-100541; AVSCOM-TM-88-B-004; NAS 1.15:100541)
Avail: NTIS HC A14/MF A01 CSCL 01A

An experimental investigation was conducted in the 14- by 22-Foot Subsonic Tunnel at NASA Langley to measure the inflow into a scale model helicopter rotor in forward flight (microinf = 0.15). The measurements were made with a two component Laser Velocimeter (LV) one chord above the plane formed by the path of the rotor tips (tip path plane). A conditional sampling technique was employed to determine the azimuthal position of the rotor at the time each velocity measurement was made so that the azimuthal fluctuations in velocity could be determined. Measurements were made at a total of 147 separate locations in order to clearly define the inflow character. This data is presented without analysis. In order to increase the availability of the resulting data, both the mean and azimuthally dependent values are included as part of this report on two 5.25 inch floppy disks in Microsoft Corporation MS-DOS format. Author

03

AIR TRANSPORTATION AND SAFETY

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

A88-42111#
INITIAL VALIDATION OF GEMACS FOR AIRCRAFT LIGHTNING INTERACTION ANALYSIS
RANDY J. JOST, FRANK G. TOMKO (USAF, Institute of Technology, Wright-Patterson AFB, OH), and JAMES L. HEBERT (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: 1987 IEEE International Symposium on Electromagnetic Compatibility, Atlanta, GA, Aug. 25-27, 1987, Symposium Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 379-387. refs

Initial validation of a US Air-Force-owned general-purpose electromagnetic code, the General Electromagnetic Model for the Analysis of Complex Systems (GEMACS), for the analysis of aircraft-lightning interaction is presented. Results from this analysis are compared with those of previous studies performed with a time-domain three-dimensional finite-difference (T3DFD) code and with data recorded on a specially instrumented FAA CV-580 aircraft during a lightning strike. Results show that GEMACS adequately predicts the electromagnetic interaction of lightning with the aircraft and in some cases provides more information, more efficiently, than the T3DFD code. I.E.

A88-42388
DEVELOPMENT OF FIRE RESISTANT INTERIORS FOR COMMERCIAL AIRCRAFT
DENNIS A. NOLLEN (Du Pont de Nemours and Co., Fibers and Composites Development Center, Wilmington, DE) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 990-1003. refs

The FAA has issued new regulations which enhance the fireworthiness of commercial aircraft interiors. Starting in August of 1988, large interior panels will have to meet specified rates of heat release as measured by the Ohio State University Heat Release Calorimeter. The intent of this regulation is to delay the spread of fire in a post-crash scenario allowing passengers more egress time before the nonsurvivable flash-over occurs. This paper describes the development of new interior panel systems which meet the FAA requirements. Author

A88-42425
DEVELOPMENT OF FIRE RESISTANT CARGO LINERS FOR COMMERCIAL AIRCRAFT
DENNIS A. NOLLEN (Du Pont de Nemours Fibers and Composites Development Center, Wilmington, DE), GEORGE T. GEISENDORFER (Fiberite Corp., Tempe, AZ), and THOMAS J. GALVIN (ICI Americas, Inc., Wilmington, DE) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1519-1530. refs

Novel cargo liners fabricated from prepregs of Kevlar fiber-reinforced 'Fortiglas' fireblocks have been designed to meet the FAA's updated fireworthiness requirements for commercial transport aircraft. The new cargo liner panels do not break open during the FAA test, and display low backside temperature; these are important features in fire containment. The Fortiglas fireblock, in particular, furnishes an efficient flame barrier. The new-generation resins used allow excellent translation of aramid fiber damage tolerance, while being self-extinguishing and contributing little by way of smoke. O.C.

A88-42867#
HEIGHT KEEPING RELIABILITY OF AIRCRAFT AT HIGH ALTITUDE
W. P. CANNELL (Civil Aviation Authority, Directorate of Research, London, England) IN: Reliability '87; Proceedings of the Sixth Conference, Birmingham, England, Apr. 14-16, 1987. Volume 2. London, Institute of Quality Assurance, 1987, p. 4C/1/1 to 4C/1/11. refs

Techniques for collecting data on height-keeping (HK) error for commercial transport aircraft operating at high altitudes and assessing the results in terms of risk management are described and demonstrated, summarizing the results of recent European investigations. Topics addressed include the target level of safety for vertical separation (estimated as 1-5 x 10 to the -9th/flight h for the year 2000), the risk associated with loss of vertical separation, theoretical models of HK reliability, altimetry error models, and HK reliability measurement using single-aircraft and aircraft-pair methods. Diagrams, graphs, and histograms are provided, and a typical data set (3445 aircraft on North Atlantic routes) is shown to have a mean HK error of 16 ft and a standard deviation of 84 ft. Particular attention is given to the eight aircraft which had HK errors of 300 ft or more. T.K.

A88-42914#
TRAINING CAN REDUCE HELICOPTER MISHAPS
B. G. VAUGHN (Aerospatiale Helicopter Corp., Grand Prairie, TX) IN: Vertical flight training needs and solutions; Proceedings of the

AHS National Specialists' Meeting, Arlington, TX, Sept. 17, 18, 1987. Alexandria, VA, American Helicopter Society, Inc., 1987, p. 3-10. refs

Training methodologies are examined, discussing how helicopter accidents could have been prevented and making recommendations for lowering accident rates through added emphasis on training. National Traffic Safety Bureau rotary wing accident investigation summaries for a period of three years are reviewed, highlighting the human causal factors. It is shown that 85.6 percent of accidents in the study were due to human error. Simulator, judgment/decision, and cockpit management training are discussed and accident scenarios are presented, showing how the accidents could have been avoided. It is concluded that government agencies, training organizations, manufacturers, operators, and individuals must work together to make improvements in training. R.B.

A88-42915#
HELICOPTER ACCIDENT TRENDS
ROY G. FOX (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: Vertical flight training needs and solutions; Proceedings of the AHS National Specialists' Meeting, Arlington, TX, Sept. 17, 18, 1987. Alexandria, VA, American Helicopter Society, Inc., 1987, p. 13-19.

Safety in helicopters has been improving since their start in the 1940's. Historically, the major safety improvements have been the reduction of the frequency of material failures. Generally, two-thirds of all helicopter accidents are caused by human error and thus establish the most potentially productive area for safety improvement. This paper provides accident trend analysis of accident causes, human error contributions, and aircraft configuration effects. The relative risk due to human error is identified. Some of the root causes of human error are discussed, as well as the direction needed for helicopter pilot training. Author

A88-42917#
FAA ROLES AND OUTLOOK FOR SAFETY
JOHN J. SHAPLEY (FAA, Fort Worth, TX) IN: Vertical flight training needs and solutions; Proceedings of the AHS National Specialists' Meeting, Arlington, TX, Sept. 17, 18, 1987. Alexandria, VA, American Helicopter Society, Inc., 1987, p. 35-38.

Rotorcraft certification and research and development conducted by the FAA are discussed. Certification rules and aspects of minimum safety standards and the development of power-lift standards for tilt-rotor aircraft are examined. Accident investigations, pilot workload scenarios, and workload requirements exceeding capabilities of the crew are incorporated into the certification process. Specific workload scenarios are presented, discussing their use in the development of certification requirements. R.B.

A88-42921#
TRAINING OF TECHNICAL PERSONNEL FOR QUALITY MAINTENANCE
TRYGVE EIDEM (Helikopter Service A/S, Stavanger, Norway) IN: Vertical flight training needs and solutions; Proceedings of the AHS National Specialists' Meeting, Arlington, TX, Sept. 17, 18, 1987. Alexandria, VA, American Helicopter Society, Inc., 1987, p. 73-76.

The training of technical personnel involved in manufacturing and maintaining rotorcraft is discussed. It is suggested that aircraft manufacturers follow ICAO standards and recommendations for training. Training programs should be evaluated according to goal achievement, cost/benefit analysis, and development of working relatioships. Aspects of training to be evaluated include the knowledge, skills, and attitude towards the job of those involved, the company training methods and techniques, the student's study technique and attitude towards training. It is proposed that requirements in basic and specialized training and competence level definitions should be developed. Maintenance organizations and their performance are also examined. R.B.

A88-42923#
'FILM AT ELEVEN' - SAFETY AND THE TV NEWS HELICOPTER
BRUCE F. ERION (WXIA-TV, Atlanta, GA) and LEO GALANIS (KWTV, Oklahoma City, OK) IN: Vertical flight training needs and solutions; Proceedings of the AHS National Specialists' Meeting, Arlington, TX, Sept. 17, 18, 1987. Alexandria, VA, American Helicopter Society, Inc., 1987, p. 91-94.

The operation, equipment, maintenance, and training aspects of TV news helicopters are discussed, focusing on safety concerns. Important safety measures include a pilot who understands the needs of the newsroom operation, a full-time aerial photographer who understands the aircraft and can act as a crew chief, and communication between news helicopter operators performing the same mission. Equipment which increase the safety of the aircraft include a second VHF radio, specially designed camera windows, navigational radios, high skid gear, maintenance-free broadcast equipment, hydraulic door openers, sun visors, and wedge windows. The importance of annual training to ensure safe flying is also examined. R.B.

A88-43484
WIND SHEAR - CORRECTIVE MEASURES HAVE PROVEN SUCCESSFUL
GORDON CORPS (Airbus Industrie, Blagnac, France) ICAO Bulletin (ISSN 0018-8778), vol. 43, April 1988, p. 11-13.

Ways of predicting wind shear and reducing the dangers it causes are discussed, stressing the Alpha-Floor and the speed reference system (SRS). The Alpha-Floor, which is triggered by the angle of attack between the wing and the air through which the aircraft is flying can potentially initiate corrective action, even before the pilot has perceived that there is a problem. The SRS guides pilots in achieving the best conversion of kinetic energy to potential energy and vice versa by using the pitch command bars on the attitude director indicator or through the autopilot pitch channel to prevent the aircraft losing height until the lowest safe flying speed is achieved. The representation of data including speed trend, stalling speed, and flight path vector on the primary flight display offers additional pilot guidance. R.B.

A88-43485
WAKE TURBULENCE - THE INVISIBLE ENEMY
GIORA NAGID (International Civil Aviation Organization, Air Navigation Bureau, Montreal, Canada) ICAO Bulletin (ISSN 0018-8778), vol. 43, April 1988, p. 14, 15.

Studies to reduce the danger of wake turbulence, especially to following aircraft, and guidelines for wake turbulence classification of aircraft are discussed. An ICAO conference created three categories of aircraft based on maximum certified take-off mass, with heavy craft being those over 136,000 kg, light craft being less than 7,000 kg and medium craft being those in between. The radar separation minima for light aircraft following medium aircraft has been increased from 7.4 km to 9.3 km. Further guidance material is being developed based on wake turbulence research. R.B.

A88-43487
ICING BEFORE TAKE-OFF - AT ABOVE 0 C?
O. K. TRUNOV (Gosudatstvennyi Nauchno-Issledovatel'skii Institut Grazhdanskogo Vozdushnogo Flota, Moscow, USSR) ICAO Bulletin (ISSN 0018-8778), vol. 43, April 1988, p. 18-20.

The problem of icing on aircraft at temperatures above freezing is discussed, giving specific examples of icing occurence and discussing prevention and development of a solution to the problem. Fuel stored at temperatures below freezing can cause ice formation on parts of the aircraft near the fuel tanks. At typical cruising altitude, the fuel temperature drops by 10 to 15 C per hour, increasing the chance of ice formation. The only preventive measure available is close monitoring of the plane's surface before takeoff. Tank insulation and the creation of a stationary, computer-controled system consisting of a gantry and a system of sprayers through which deicing fluid flows are considered as possible solutions to the problem. R.B.

A88-43624
SELECTION OF A CRITERION FOR THE COMPARATIVE EVALUATION OF THE CARRYING EFFICIENCY OF COMMERCIAL AIRCRAFT [O VYBORE KRITERIIA SRAVNITEL'NOI OTSENKI TRANSPORTNOI EFFEKTIVNOSTI PASSAZHIRSKIKH SAMOLETOV]
IU. A. GARKUSHA and B. T. EROKHIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 92, 93. In Russian.

The well-known criterion for the comparative evaluation of the carrying efficiency of commercial aircraft is analyzed, and it is shown that the use of this criterion produces a certain systematic error. A modified criterion is proposed whereby the weight of the commercial load carried by the aircraft is subtracted from the total take-off weight in estimating the carrying efficiency. It is shown that, in many cases, the use of the modified criterion introduces a noticeable correction to the results of a comparative evaluation. V.L.

A88-44911
ENGINEERING AND ORGANIZATIONAL PRINCIPLES OF FLIGHT SAFETY ASSURANCE IN CIVIL AVIATION [INZHENERNO-ORGANIZATSIONNYE OSNOVY OBESPECHENIIA BEZOPASNOSTI POLETOV V GRAZHDANSKOI AVIATSII]
ZINOVII TREFIL'EVICH KROKHIN, FELIKS IVANOVICH SKRIPNIK, and VLADIMIR ZAKHAROVICH SHESTAKOV Moscow, Izdatel'stvo Transport, 1987, 176 p. In Russian. refs

The criteria and methods of flight safety evaluation, airworthiness characteristics, and certification are discussed. In particular, attention is given to the principal concepts and definitions of flight safety and causes of flight accidents; comprehensive flight safety assurance programs; criteria and methods for the quantitative evaluation of flight safety; and light accident prevention measures and safety equipment. The discussion also covers the role of human operator in ensuring flight safety, investigation of flight accidents, conduction of search and rescue operations, and antiterrorist measures. V.L.

N88-23716*# Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 1986
ROBERT W. SIMPSON *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1986 p 3-6 Apr. 1988
Avail: NTIS HC A06/MF A01 CSCL 01C

There were three areas of research sponsored in the Flight Transportation Lab. at MIT under the Joint University Research Program during 1986. The first was the completion of efforts investigating the possibility of using Loran-C for final approach guidance to a runway; the second is a preliminary exploration of the application of automated speech recognition in Air Traffic Control; the third is a continuation of a series of research topics into aircraft icing problems. Author

N88-23717*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IN-FLIGHT MEASUREMENT OF ICE GROWTH ON AN AIRFOIL USING AN ARRAY OF ULTRASONIC TRANSDUCERS
R. JOHN HANSMAN, JR., MARK S. KIRBY, ROBERT C. MCKNIGHT, and ROBERT L. HUMES (Calspan Corp., Arnold AFS, Tenn.) *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1986 p 7-15 Apr. 1988 Sponsored in cooperation with FAA
(Contract NGL-22-009-640; NAG3-666)
(AIAA-PAPER-87-0178) Avail: NTIS HC A06/MF A01 CSCL 01C

Results of preliminary tests to measure ice growth on an airfoil during flight icing conditions are presented. Ultrasonic pulse echo measurements of ice thickness are obtained from an array of eight ultrasonic transducers mounted flush with the leading edge of the airfoil. These thickness measurements are used to document the evolution of the ice shape during the encounter in the form of successive ice profiles. Results from 3 research flights are presented and discussed. The accuracy of the ultrasonic measurements is found to be within 0.5 mm of mechanical and stereo photograph measurements of the ice accretion. Author

N88-23719*# Ohio Univ., Athens. Dept. of Electrical Engineering.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT OHIO UNIVERSITY, 1986
RICHARD H. MCFARLAND *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1986 p 29-31 Apr. 1988
Avail: NTIS HC A06/MF A01 CSCL 01C

Several important goals were achieved with the work supported by the Joint University Program. Among these goals is the first DC-3 flight with a Navstar Global Positioning System (GPS) receiver collecting positional data and allowing comparisons with simultaneous collected data from the Long Range Navigation system Loran C. The principle purpose for this instrumentation was to learn of the detailed characteristics evident in the Doppler frequency shift from signals being received onboard an aircraft in flight. Author

N88-23724*# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT PRINCETON UNIVERSITY, 1986
ROBERT F. STENGEL *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1986 p 61-69 Apr. 1988
Avail: NTIS HC A06/MF A01 CSCL 01F

The Air Transportation Technology Program at Princeton proceeded along four avenues: Guidance and control strategies for penetration of microbursts and wind shear; Application of artificial intelligence in flight control systems; Computer aided control system design; and Effects of control saturation on closed loop stability and response of open loop unstable aircraft. Areas of investigation relate to guidance and control of commercial transports as well as general aviation aircraft. Interaction between the flight crew and automatic systems is a subject of prime concern. Author

N88-23727*# Princeton Univ., N. J.
FLIGHT PENETRATION OF WIND SHEAR: CONTROL STRATEGIES
AMIT S. JOSHI *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1986 p 107-117 Apr. 1988
Avail: NTIS HC A06/MF A01 CSCL 01F

Wind shear is a dangerous condition where there is a sharp change in the direction and magnitude of the wind velocity over a short distance or time. This condition is especially dangerous to aircraft during landing and takeoff and can cause a sudden loss of lift and thereby height at a critical time. A numerical simulation showed the effective performance of the Linear Quadratic Regulator and the Nonlinear Inverse Dynamics controllers. The major conclusions are listed and discussed. Author

N88-23761 Civil Aviation Authority, London (England).
UK AIRMISS STATISTICS
1987 9 p
(CAA-1/87; CAP-526; ISBN-0-86-039302-X; ISSN-0951-6301; ETN-88-92503) Avail: Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, England 1 pound

Airmiss statistics from 1976 to April 1986 for United Kingdom airspace are presented. ESA

N88-24609# General Accounting Office, Washington, D. C. Information Management and Technology Div.
FAA (FEDERAL AVIATION ADMINISTRATION) TECHNICAL CENTER: MISSION AND ROLE IN NATINAL AIRSPACE SYSTEM PLAN IMPLEMENTATION

Jan. 1988 45 p
(PB88-169818; GAO/IMTEC-88-6BR) Avail: NTIS HC A03/MF A01 CSCL 01C

A survey was conducted of the mission and operations of the Federal Aviation Administration's (FAA) Technical Center located in Pomona, New Jersey. The review notes that the FAA has proceeded to production with several high cost systems in its $15 billion National Airspace System plan without adequately testing and validating their operational capability. It also investigates the overall mission of the Center, its role in modernizing the air traffic control system (implementing the National Airspace System plan), and the way in which the Center allocates and uses resources. Author

N88-24610# Federal Aviation Agency, Atlantic City, N.J.
STUDY OF BENEFITS OF PASSENGER PROTECTIVE BREATHING EQUIPMENT FROM ANALYSIS OF PAST ACCIDENTS Final Report
LOUISE SPEITEL and RICHARD G. HILL Mar. 1988 246 p
(DOT/FAA/CT-88/03) Avail: NTIS HC A11/MF A01

A computer model was developed and utilized for calculating the benefits of passenger protective breathing devices and other fire safety improvements based on an analysis of accidents involving fire occurring from 1966 to 1986. The results of exercising this model on 20 past accidents indicate that the lives saved is very sensitive to assumptions. It was determined that seat cushion fire blocking (FB) would have saved almost half the lives. Floor proximity lighting (FPL) is much less effective than FB, saving 3 to 4 percent of fire deaths. Protective breathing equipment (PBE), assuming no donning delay and 100 percent usage by passengers is more effective than FPL. However, a 15 second donning delay of PBE may have resulted in a net disbenefit. Author

N88-24611# Anco Engineers, Inc., Culver City, Calif.
PEAK ACCELERATION DEVICE (PAD) Final Report, 1 Apr. 1985 - 19 Dec. 1986
PAUL IBANEZ and JOHN F. GRAY Oct. 1987 146 p
(Contract DAAK51-85-C-0009; DA PROJ. 1L6-65502-MM-40)
(AD-A191639; AD-F800025; ANCO-1663.11;
USAAVSCOM-TM-87-D-3) Avail: NTIS HC A07/MF A01 CSCL 01D

Each year a number of aircraft are involved in incidents/accidents of varying ground impact severity. The object of this project was to develop a small, passive, low-cost triaxial indicator that in the event of an incident/accident would record the magnitude of the acceleration experienced at their location in the aircraft. Analysis of this data would provide an insight into the performance of crashworthy structures and vehicles, thereby contributing to efforts to reduce loss of life, injury and equipment damage. Three basic concepts for the design of the Peak Acceleration Device (PAD) were examined. Initially, the use of foam that would crush predictably under the action of a metal rod was explored. Unfortunately, this arrangement was found to be impracticable as was a variation of the same concept where metal foils were to be pierced by pointed rods. The drawback in each case being primarily related to material characteristics. The third approach utilized a filament under tensile stress as a g-force indicator. Testing showed that this mechanism provided predictable and repeatable measure of impact levels and therefore it was this concept that was developed into the PAD. The final configuration of the Peak g indicator conforms to the target criteria established for the device. It has the capability to measure impacts of 15-100 g in each of three axes, will fit within a 2-1/4-in. cube, has a mechanical filter system that isolates the indicators from energy at frequencies above 100 Hz, and is housed in a rugged aluminum casing that provides high resistance to mechanical damage. GRA

N88-24612# National Transportation Safety Board, Washington, D. C.
AIRCRAFT ACCIDENT/INCIDENT, COPPERHILL, TENNESSEE, FEBRUARY 22, 1986 Summary Report, 1986
30 Mar. 1988 9 p
(PB88-910407; NTSB/AAR-88/02/SUM) Avail: NTIS HC A02/MF A01 CSCL 01C

This is the report of an aircraft accident investigated by the National Transportation Safety Board. The accident occurred at Copperhill, Tennessee, 22 February, 1986. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A88-42112
ANALYSIS AND MEASUREMENT OF EMI COUPLING FOR AIRCRAFT MOUNTED ANTENNAS AT THE SHF/EHF
TIMOTHY E. DURHAM (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: 1987 IEEE International Symposium on Electromagnetic Compatibility, Atlanta, GA, Aug. 25-27, 1987, Symposium Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 420-427. refs
(Contract F30602-85-C-0114)

The electromagnetic interference (EMI) between electronic systems on advanced aircraft due to mutual coupling between antennas is studied. There are several systems-level computer codes which can analyze coupling between aircraft-mounted antennas, but these are inadequate for EMI analysis at frequencies above 2 GHz for many of the complex geometries encountered in modern aircraft. In order to develop improved coupling-analysis models, an evaluation of all existing analysis techniques and computer programs has been carried out. Coupling measurements have been performed to assess the accuracy of the different analysis techniques. The author describes these evaluations and measurements and compares the theoretical and experimental results. I.E.

A88-42789
AN RCS ANALYSIS OF GENERIC AIRBORNE VEHICLES DEPENDENCE ON FREQUENCY AND BISTATIC ANGLE
CHUNG-CHI CHA (Syracuse Research Corp., NY), J. MICHELS, and E. STARCZEWSKI (USAF, Rome Air Development Center, Griffiss AFB, NY) IN: IEEE National Radar Conference, 3rd, Ann Arbor, MI, Apr. 20, 21, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 214-219.

A radar cross section (RCS) prediction program (SRCRCS), developed to assist in corroboration of RCS measurements and theoretical treatments used to verify airborne vehicle signatures, is reviewed. Emphasis was placed on the use of the first-order, high-frequency asymptotic techniques of physical optics and an equivalent current formulation of the physical theory of diffraction (PTD). The code has been utilized to provide both narrowband and wideband signatures of airborne vehicles in the frequency range from upper UHF to C-bands. The prediction capability includes bistatic geometries from monostatic to forward scattering. Recently, the code has been extended to include a moment-method solution to the electric field integral equation (EFIE). This capability enabled the considertion of electrically small bodies, extending the analytical capability to lower frequencies for the targets of interest. Results that demonstrate a few of the capabilities of the software program are discussed. I.E.

A88-42792
CALIBRATION CONSIDERATIONS IN A LARGE BISTATIC ANGLE AIRBORNE RADAR SYSTEM FOR GROUND CLUTTER MEASUREMENTS
STEPHEN ANTHONY (Michigan, Environmental Research Institute, Ann Arbor), FERREL STREMLER (Wisconsin, University, Madison), and MICHAEL WICKS (USAF, Rome Air Development Center,

Griffiss AFB, NY) IN: IEEE National Radar Conference, 3rd, Ann Arbor, MI, Apr. 20, 21, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 230-234. refs

Calibration considerations and the performance analysis of an L-band airborne clutter measurement system are discussed. The measurement system is designed to collect simultaneous bistatic and monostatic clutter measurements in support of the hybrid bistatic radar (HBR) system. The analysis techniques used to define the experiment geometry and resulting resolution cells, calibration considerations, and the impact on the ability to determine clutter radar cross sections are described. The calibration techniques selected involved the transfer of calibration data from optimal geometries for calibration, to the geometries of interest in this program. I.E.

A88-43185
THE ROLE OF FIBER OPTICS ON COMMERCIAL AIRCRAFT
JOHN R. TODD (Douglas Aircraft Co., Long Beach, CA) IN: Fiber optic systems for mobile platforms; Proceedings of the Meeting, San Diego, CA, Aug. 20, 21, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 157-162.

The role of fiber optics in next-generation commercial aircraft is considered. The economic benefits to be gained by using fiber optics in this way are reviewed, and the problems associated with this use are summarized. The fiber research and development effort of one aircraft company is examined, indicating the aims of different program phases and the applications of fiber optics in various company programs. The role of fiber optics in various aircraft systems is illustrated by diagrams and described. C.D.

A88-43243
CIVIL AVIATION INTEGRITY REQUIREMENTS FOR THE GLOBAL POSITIONING SYSTEM
ALISON K. BROWN (Navstar Systems Development, Monument, CO) Navigation (ISSN 0028-1522), vol. 35, Spring 1988, p. 23-40. refs

A report on the findings of the Integrity Working Group which was formed to study civil integrity problems relating to the use of the GPS by civil aviation is given. The group defines integrity as the ability of a system to provide timely warnings to users when the system should not be used for navigation. Because more stringent safety requirements must be met to receive FAA approval of GPS use in the National Airspace System, requirements already established for other navigation systems are examined to establish integrity alarm limits and time-to-alarm requirements. Integrity monitoring techniques are discussed, including receiver autonomous integrity monitoring, integration of GPS with other navigation systems, a GPS integrity channel, and differential GPS. The group's recommendations include expansion of GPS to 24 satellites, reduction in the effect of selective availability, and the formation of a GPS Integrity Channel Working Group. R.B.

A88-44904
DOPPLER DEVICES AND NAVIGATION SYSTEMS [DOPLEROVSKIE USTROISTVA I SISTEMY NAVIGATSII]
ANDREI GENNADIEVICH FLEROV and VALENTIN TROFIMOVICH TIMOFEEV Moscow, Izdatel'stvo Transport, 1987, 192 p. In Russian. refs

The physical principles, general design, and applications of the existing and future Doppler devices and navigation systems are discussed. In particular, attention is given to the classification and structure of Doppler navigation systems, navigational applications of Doppler systems, the design and characteristics of Doppler measurement devices, and measurements of the mean frequency of the Doppler spectrum. The discussion also covers the functional description, operation, and performance characteristics of several specific on-board Doppler navigation systems. V.L.

A88-44908
OPERATION AND MAINTENANCE OF AVIATION RADIO-ELECTRONIC EQUIPMENT [TEKHNICHESKAIA EKSPLUATATSIIA AVIATSIONNOGO RADIOELEKTRONNOGO OBORUDOVANIIA]
VLADIMIR STEFANOVICH NOVIKOV Moscow, Izdatel'stvo Transport, 1987, 264 p. In Russian. refs

The book deals with a variety of problems related to the operation and maintenance of airport and air route radio-electronic equipment. Topics discussed include the theory of the operation and maintenance of radio-electronic equipment, maintenance strategies, monitoring and prediction of the condition of the radio-electronic equipment of airports and air routes, and the organization of the maintenance service. The discussion also covers collection and analysis of equipment failure data, metrological support of equipment maintenance, repair of radio-electronic equipment, and the main types of repair and maintenance systems and equipment. V.L.

A88-44910
MEANS OF RADIO COMMUNICATION FOR AIR TRAFFIC CONTROL [SREDSTVA RADIOSVIAZI UPRAVLENIIA VOZDUSHNYM DVIZHENIEM]
ALEKSANDR FEDOROVICH LOGACHEV and IURII VASIL'EVICH EFREMENKOV Moscow, Izdatel'stvo Transport, 1987, 216 p. In Russian. refs

The technical and performance characteristics, operation, and applications of three types of commercial radio stations designed for air traffic control (Iasen-50, Baklan-RN, and Polet) are examined. The discussion covers the functional design of the radio stations, their principal components, power supply, and technical descriptions of the microcircuits. The book also contains reference data on the electronic components of the stations and recommendations concerning their operation and maintenance. V.L.

A88-45743
GENERALIZED LINEAR SOLUTION OF PROPORTIONAL NAVIGATION
UDAY S. SHUKLA and PRAVAS R. MAHAPATRA (Indian Institute of Science, Bangalore, India) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 24, May 1988, p. 231-238. refs

Proportional navigation (PN) equations are not solvable in closed form. Linearized solutions have been widely used for PN system analysis and design, but these are based on overly restrictive assumptions regarding the initial geometry, and are valid only for near-tail-chase pursuits. A generalization of the linearized approach is presented which yields more-accurate estimates of pursuer lateral acceleration than the classical linear solutions as verified by comparison with 'exact' numerical solutions. Further, the solution is applicable over a much wider range of engagement geometries. The treatment is based on a closed-form quasi-linearized solution of the PN equations followed by the small-angle approximation only to line-of-sight (LOS) angle rate. I.E.

N88-23722*# Ohio Univ., Athens.
INTEGRATED MULTISENSOR NAVIGATION SYSTEMS
FRANK VANGRAAS *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1986 p 45-50 Apr. 1988
Avail: NTIS HC A06/MF A01 CSCL 17G

The multisensor navigation systems research evolved from the availability of several stand alone navigation systems and the growing concern for aircraft navigation reliability and safety. The intent is to develop a multisensor navigation system during the next decade that will be capable of providing reliable aircraft position data. These data will then be transmitted directly, or by satellite, to surveillance centers to aid the process of air traffic flow control. In order to satisfy the requirements for such a system, the following issues need to be examined: performance, coverage, reliability, availability, and integrity. The presence of a multisensor

navigation system in all aircraft will improve safety for the aviation community and allow for more economical operation. Author

N88-24262# General Electric Co., Philadelphia, Pa. Space Systems Div.
SPACE BASED RADAR APPLICATION TO AIR TRAFFIC CONTROL
WILLIAM J. CAIME *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 31-33 1987
(Contract JPL-956969)
Avail: NTIS HC A22/MF A01

Space based radar offers an incomparable technique for broad area surveillance and rapid aircraft target detection and track. Directly derived, real time images can assist in achieving future goals for more effective control in an environment of increasing air traffic. Realization of the full capability of the technique will require continued development of high spacecraft power systems in excess of 100 kW as well as that for space radar subsystems. Optimization of the concept requires further analysis to consider spacecraft constellation and scan/dwell strategies to mitigate limitations such as coverage gaps in various traffic scenarios. Cooperating transponders will assist in dense traffic environments, and their application to SBR will have little impact on planned systems. Other improvements such as sophisticated tracking algorithms must be pursued. The integration and fusion of available SBR data with other planned improvements also must be addressed in a long term phased approach to future ATC, keyed to the availability of the emerging technologies. Author

N88-24613# Federal Aviation Administration, Washington, D.C.
CESSNA 172 MLS (MICROWAVE LANDING SYSTEM) TERMINAL INSTRUMENT PROCEDURES (TERPS) APPROACH DATA COLLECTION AND PROCESSING DATA REPORT
Technical Note, Jun. 1986 - Jun. 1987
EDWARD J. PUGACZ Oct. 1987 207 p
(AD-A191241; DOT/FAA/CT-TN87/36) Avail: NTIS HC A10/MF A01 CSCL 17G

This report documents the approaches portion of the Fixed Wing Microwave Landing System (MLS) Terminal Instrument Procedures (TERPS) data collection and processing project using a Cessna 172 (C-172) aircraft. This is one part of the Fixed Wing MLS TERPS data collection and processing program being performed at the Federal Aviation Administration (FAA) Technical Center. The program was undertaken to collect flight test data in various aircraft to establish a data base for development of MLS TERPS criteria. Data were collected during both missed approaches and landings using glideslopes of 3 deg, 4 deg, and 5 deg with all flights being tracked by ground based tracking systems. Statistical processing was performed on both the airborne and tracker data, and various graphical plots were produced. The processed data were delivered to AVN-120 for inclusion in the MLS TERPS criteria development data base. GRA

N88-24614# Federal Aviation Administration, Atlantic City, N.J.
ROTORCRAFT TCAS (TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM) EVALUATION: GROUP 3 RESULTS
Technical Note, Sep. - Dec. 1985
ALBERT J. REHMANN Oct. 1987 67 p
(AD-A191719; DOT/FAA/CT-TN87/21) Avail: NTIS HC A04/MF A01 CSCL 01D

This report documents the operational flight test of a prototype Traffic Alert and Collision Avoidance System (TCAS) installed in a Sikorsky S-76 helicopter. The prototype TCAS, programmed to encompass the functions of a TCAS 1, was flown to five east coast terminal cities, and operated along defined helicopter routes therein. The test results validated the minimum proposed TCAS 1 configuration. Further results recommend enhancements, to be included as options to improve the usefulness of TCAS 1. GRA

N88-24615# Federal Aviation Administration, Atlantic City, N.J.
OPTIMIZATION OF THE DILATION CHARACTERISTIC ON THE CONTROL JURISDICTION OF AN AREA CONTROL FACILITY
ROBERT G. MULHOLLAND Jan. 1988 65 p
(AD-A191720; DOT/FAA/CT-TN87/39) Avail: NTIS HC A04/MF A01 CSCL 17G

In an air traffic control environment such as the National Airspace System the control function is based on stereographic representations of aircraft positions in a plane tangent to a sphere with a center collocated with the center of an ellipsoidal model of the geoid. The variation of the dilation (i.e., the discrepancy between the length of an infinitesimal arc on the model surface and the image of the arc in the plane) over the control jurisdiction of an air traffic control facility is one of many factors that adversely affect the ability of the facility to maintain separation standards. Techniques are disclosed for selecting a tangency point and a radius for the spherical support of the stereographic plane that minimize the variation of the dilation over the control jurisdiction about a predetermined constant. The constant can be viewed as a specification of the scale of the map that is the stereographic image in the plane of the portion of the surface of the earth model underlying controlled airspace. GRA

N88-24616# Federal Aviation Administration, Atlantic City, N.J.
MICROWAVE LANDING SYSTEM MATHEMATICAL MODELING STUDY FOR MIDWAY AIRPORT RUNWAY 22L, CHICAGO, ILLINOIS Technical Note, Aug. - Oct. 1987
JESSE D. JONES and LINDA EPSTEIN Jan. 1988 65 p
(AD-A191721; DOT/FAA/CT-TN87/49) Avail: NTIS HC A04/MF A01 CSCL 17G

This technical note describes Microwave Landing System (MLS) mathematical modeling performed for runway 22L, Midway Airport, Chicago, Illinois. This study considered multipath and shadowing effects of buildings and aircraft. Results are provided as plots showing the multipath levels and separation angles and error plots showing the resultant errors. GRA

N88-24619*# *Charles River Analytics, Inc., Cambridge, Mass.*
USER'S GUIDE TO THE FAULT INFERRING NONLINEAR DETECTION SYSTEM (FINDS) COMPUTER PROGRAM
A. K. CAGLAYAN, P. M. GODIWALA, and H. S. SATZ Jun. 1988 89 p
(Contract NAS1-17719)
(NASA-CR-178410; R8801; NAS 1.26:178410) Avail: NTIS HC A05/MF A01 CSCL 14B

Described are the operation and internal structure of the computer program FINDS (Fault Inferring Nonlinear Detection System). The FINDS algorithm is designed to provide reliable estimates for aircraft position, velocity, attitude, and horizontal winds to be used for guidance and control laws in the presence of possible failures in the avionics sensors. The FINDS algorithm was developed with the use of a digital simulation of a commercial transport aircraft and tested with flight recorded data. The algorithm was then modified to meet the size constraints and real-time execution requirements on a flight computer. For the real-time operation, a multi-rate implementation of the FINDS algorithm has been partitioned to execute on a dual parallel processor configuration: one based on the translational dynamics and the other on the rotational kinematics. The report presents an overview of the FINDS algorithm, the implemented equations, the flow charts for the key subprograms, the input and output files, program variable indexing convention, subprogram descriptions, and the common block descriptions used in the program. Author

N88-24621*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AIRPLANE RUNWAY PERFORMANCE MONITORING SYSTEM
Patent Application
DAVID B. MIDDLETON, inventor (to NASA), RAGHAVACHARI SRIVATSAN, inventor (to NASA) (Kansas Univ., Lawrence.), and LEE H. PERSON, JR., inventor (to NASA) 11 May 1988 43 p
(NASA-CASE-LAR-13854-1-CU; NAS 1.71:LAR-13854-1-CU; US-PATENT-APPL-SN-192562) Avail: NTIS HC A03/MF A01 CSCL 17G

The invention is a real-time takeoff and landing performance monitoring system for an aircraft which provides a pilot with graphic

and metric information to assist in decisions related to achieving rotation speed within the safe zone of a runway, or stopping the aircraft on the runway after landing or takeoff abort. By comparing the present performance of the aircraft with a predicted nominal performance based upon given conditions, performance deficiencies are detected by the system. The system provides a head-down display and a head-up display. The head-up display is projected onto a partially reflective transparent surface through which the pilot views the runway. Hence, the system supplies the pilot with critical status information while allowing the pilot to continue to view the runway. NASA

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A88-42100*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IN-FLIGHT FLOW VISUALIZATION USING INFRARED IMAGING
J. M. BRANDON, G. S. MANUEL, R. E. WRIGHT, JR., and B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) AIAA, Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988. 10 p. refs
(AIAA PAPER 88-2111)

A flight test investigation was conducted to evaluate infrared (IR) flow imaging techniques for boundary-layer flow visualization. The flight tests used a single-engine turboprop aircraft with a fiberglass-skinned natural laminar flow glove mounted on the left wing and an infrared imaging system to obtain flow visualization data. Data were compared to results obtained from other more conventional boundary-layer flow visualization methods and found to agree well. Test flights were conducted to determine the effect of test surface color on IR flow visualization results. In addition, flights were made during both night and daylight hours to assess the effect of solar radiation on the results. The investigation included an effort to visualize a vortex passing over the wing glove, but the tests provided only limited results. Author

A88-42106
MEASURED ELECTROMAGNETIC PERFORMANCE OF HARDENING ELEMENTS FOR AIRCRAFT WINDOWS AND DOORS
LOTHAR O. HOEFT (BDM Corp., Albuquerque, NM), C. HERRMANN (TRW, Inc., TRW Defense Systems Group, Albuquerque, NM), and WILLIAM D. PRATHER (USAF, Weapons Laboratory, Kirtland AFB, NM) IN: 1987 IEEE International Symposium on Electromagnetic Compatibility, Atlanta, GA, Aug. 25-27, 1987, Symposium Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 168-171.

The electromagnetic coupling through the doors and windows of a Boeing 707 aircraft was determined by measuring the open circuit voltage developed in a resistively terminated wire placed across the inside of the aperture when a transverse electromagnetic wave was injected on the outside surface of the aircraft using a special test fixture. Measurements were made with and without electromagnetic control devices such as window screens, metal blanks and conductive gaskets. Window screen reduced the coupling by about 20 dB while metal window blanks with circumferential conductive gaskets were much more effective (45 dB). Conductive gaskets reduced the coupling through the cargo door by about 28 dB. The performance for a personnel door was only 10 dB due to differences in construction of the door and its latching mechanism. However, when the aircraft was pressurized, the shielding increased to 22 dB. I.E.

A88-42391
C-5B MATERIALS AND PROCESSES ENHANCEMENTS
GUY E. KNOWLES, JR. (Lockheed Aeronautical Systems Co., Georgia Div., Marietta) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1053-1067.

Specific changes in materials and processes introduced into the design of the C-5B Galaxy Airlifter aircraft are discussed in terms of improved structures, design configurations, adhesively bonded structure durability, sealing systems, finish protection, corrosion prevention and control, and reduced flammability and toxicity potential. As a result of all the improvements made, the C-5B has demonstrated significantly enhanced utilization, readiness, and supportabilitly of the aircraft, compared to the C-5A, with decreased maintenance and operational costs. In addition, an assessment of future risk potential in terms of materials and processes showed a high degree of integrity with no inherent areas of weakness. I.S.

A88-42852#
A RELIABILITY AND MAINTAINABILITY PREDICTION METHODOLOGY FOR THE CONCEPTUAL AIRCRAFT DESIGN PROCESS
V. C. SERGHIDES and J. P. FIELDING (Cranfield Institute of Technology, England) IN: Reliability '87; Proceedings of the Sixth Conference, Birmingham, England, Apr. 14-16, 1987. Volume 1. London, Institute of Quality Assurance, 1987, p. 2A/1/1 to 2A/1/11. refs

A quantitative reliability and maintainability methodology for the conceptual design of both combat and civil transport aircraft is presented. The methodology is based on a number of statistically derived empirical equations which predict the reliability and maintainability of each main aircraft system from one or two of the aircraft design parameters that are readily available at this early design stage. The application of the equations to a sample of aircraft has yielded predictions that are strongly correlated with actual reliability and maintainability rates. V.L.

A88-43197
PROPELLER-DRIVEN TRANSPORT AIRCRAFT - NEW IDEAS AND PROJECTS [AVIONS DE TRANSPORT A HELICES - NOUVEAUTES ET PROJETS]
LEONARD ROSENTHAL L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 129, 1988, p. 68-80. In French.

The advantages of propfan transport aircraft are discussed, and the performance and design characteristics of various propeller-driven transport aircraft are reviewed. A new 6-blade design is used on the PW 124 turboprop of the ATP regional transport aircraft. Other new designs, such as a curved 4-blade propfan and an 8-blade propfan, are also considered. Descriptions are given for 25-30-passenger aircraft, for 17-19-passenger aircraft, for 8-11-passenger aircraft, and for 4-6-passenger bussiness and pleasure aircraft. R.R.

A88-43519#
AT3 AND V-22
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 26, June 1988, p. 28-31.

Aspects of the Advanced Technology Tactical Transport (AT3) and the V-22 Osprey tiltrotor are discussed, including configuration, structure and performance. The AT3 configuration has tandem high-aspect-ratio wings with a conventional horizontal tail to achieve high-lift and low drag for long range. Design goals include flying below 3,000 ft at 326 knots with a radius of 1,200 n. mi, maintaining fuel reserves while getting in and out of 1,000 ft strips, and a full payload of 12,500 lb. The V-22 is composed of all-carbon composites to reduce weight for long-range hovering efficiency while offering ballistic damage tolerance. Expected performance is a radius of 520 n. mi. cruising at 250 knots while carrying a payload of about 3,200 lb at sea level on a 103 F day at 55,000

lb gross weight. Included in the mission profile is hovering at the objective in 95 F heat at 4,000 ft while out of lift-boosting ground effect. R.B.

A88-43631
A STUDY OF THE PERFORMANCE OF A HYDROACOUSTIC FILTER IN THE LINES OF A FLIGHT VEHICLE [ISSLEDOVANIE RABOTOSPOSOBNOSTI GIDROAKUSTICHESKOGO FIL'TRA V MAGISTRALIAKH LETATEL'NYKH APPARATOV]
IU. S. MIKHEEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 106-108. In Russian. refs

Hydroacoustic filters with an insert having the shape of sylphon bellows have been developed in an attempt to reduce the filter weight and size, eliminate transmission of vibrations from tanks. and to achieve automatic tuning to the frequency of the wave being damped. Analytical expressions for the calculation of such filter are presented. To verify these expressions experimentally, they are applied to specially fabricated test filters with sylphons of Kh18N10T steel. The test filters have demonstrated good performance. V.L.

A88-44567
PILOT REPORT - AFTI F-111
SCOTT E. PARKS (USAF, Wright-Patterson AFB, OH) Air Force Magazine (ISSN 0730-6784), vol. 71, July 1988, p. 82-84, 87, 88, 91.

NASA's Advanced Fighter Technology Integration F-111 incorporates a Mission Adaptive Wing (MAW) which optimizes performance for cruise in various altitude/speed regimes throughout the F-111's envelope, as well as during maneuvering, by simultaneously and continuously changing both wing sweep and camber. The gust-alleviation mode that MAW's control system can assume is especially important for aircraft cruising at high speed and low altitude, as must be the case for military aircraft penetrating enemy defenses. This mode has its basis in the ability of MAW's digital control system to continuously compute wing root loads and change the camber of the outboard section of the wing as required to control those loads. O.C.

A88-44571
THE DYNAMIC RESPONSE OF AN AIRCRAFT WHEEL TO VARIATIONS IN RUNWAY FRICTION
A. G. WATTLING (Bristol, University, England) Aeronautical Journal (ISSN 0001-9240), vol. 92, May 1988, p. 169-178. Sponsorship: Ministry of Defence of England. refs
(Contract MOD-A6B/841)

Experimental and analytical techniques are presented for the determination of the response characteristics of a scale-model aircraft wheel to changes in runway friction. Results obtained from tests using these techniques are given. The wheel spinup acceleration is shown to be proportional to wheel load and to the magnitude of the surface friction coefficient after surface change. It is also found to be inversely proportional to brake torque, but is largely independent of speed. An increase of speed is shown to increase the distance required for spinup of a locked wheel as it encounters surfaces of higher friction coefficient. Good correlation of these trends is obtained analytically. The effects of tire flexibility are indicated by the results of both the experimental tests and the analytical simulations. These effects may degrade the performance of aircraft antiskid braking systems. It is recommended, therefore, that simulations used in the development of such systems take proper account of tire flexibility when modeling the dynamics of the wheel and tire. Author

A88-44659#
COMPARISON STUDY OF SUPERSONIC STOVL PROPULSION SYSTEMS
D. F. BERG, D. W. ELLIOTT, and J. R. SIMMONS (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 14 p.
(AIAA PAPER 88-2808)

Three powered-lift propulsion systems are evaluated using a common aircraft design. The powered lift systems are: remote augmentor; lift plus lift cruise; and remote exhaust. The aircraft/engine systems are sized to a common mission and set of maneuver requirements for the technology IOC date of 2005. The figure-of-merit in comparing the concepts is the take-off gross weight, which relates to the life cycle cost of the system. The following items are considered and evaluated in making this comparison: (1) airframe integration (emphasis on propulsion system weight and volume); (2) propulsion selection (dependent upon thrust split, available control bleed capacity, the mission and maneuvering thrust required; (3) exhaust gas temperature footprint in the vertical mode; (4) trim and control requirements, system definition and complexity assessment; and (5) maintenance and procurement costs. Author

A88-44665#
MODELING OF SOLID-LIQUID CIRCULATION IN THE NATIONAL AEROSPACE PLANE'S SLUSH HYDROGEN TANKS
J. NAVICKAS, E. C. CADY, and T. L. FLASKA (McDonnell Douglas Astronautics Co., Advanced Technology Center, Huntington Beach, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 6 p.
(AIAA PAPER 88-2824)

Slush hydrogen, or solid hydrogen particles suspended in liquid hydrogen, is considered as fuel for the National Aerospace Plane (NASP). In such a system the particles must be suspended in the liquid to prevent them from settling at the tank bottom and fusing into chunks of solid hydrogen. This can be accomplished by a closed-loop circulation system. The FLOW-3D program, a general three-dimensional fluid flow program, was modified to include solid particles in the liquid stream. A closed-loop circulation system, consisting of solid particles in a liquid-alcohol mixture, was studied experimentally and the test results compared with those obtained using the modified program. No computational difficulties were encountered in carrying out the calculations. Although some differences between test and computed results were observed, the technique can serve as a valuable tool in the NASP design. Author

A88-44897
DESIGN AND FLIGHT OPERATION OF AN-26 AIRCRAFT [USTROISTVO I LETNAIA EKSPLUATATSIIA SAMOLETA AN-26]
ANDREI ALEKSANDROVIC KOMAROV, VLADIMIR PROKHOROVIC RYCHKA, and PETR NILOVICH MAMOSHIN Moscow, Izdatel'stvo Transport, 1987, 192 p. In Russian.

The general design, the principal systems and components, performance characteristics, and flight operation of An-26, a turboprop transport aircraft, are discussed. In particular, attention is given to the design and technical characteristics of the airframe, operation of the control surfaces, and pre-flight preparation of the control system. The discussion also covers the hydraulic power system, the fuel system, the powerplant, fire prevention equipment, high-altitude and deicing systems, and various kinds of cargo-handling, sanitary, and support equipment. V.L.

A88-44909
AERODYNAMICS OF THE TU-134A-3(B-3) [AERODINAMIKA SAMOLETA TU-134A-3/B-3/]
TEVEL' IOSIFOVICH LIGUM Moscow, Izdatel'stvo Transport, 1987, 264 p. In Russian.

Aerodynamic data and performance characteristics are given for Tu-134A-3 and Tu-134B-3 with D-30 III series engines, modified versions of the standard Tu-134A and Tu-134B aircraft with D-30 II series engines. Particular attention is given to the aerodynamic basis for the recommended flight regimes under normal and special conditions. The discussion covers cruising flight, takeoff and landing, and climb characteristics; longitudinal and lateral stability, static stability, and controllability; characteristics of the aircraft at large angles of attack; characteristics of perturbed motion; and operation under extreme and emergency conditions. V.L.

A88-45283#
MODELING OF SURFACE BLOWING AS AN ANTI-ICING TECHNIQUE FOR AIRCRAFT SURFACES
A. H. TABRIZI (Indiana Institute of Technology, Fort Wayne) and E. G. KESHOCK (Tennessee, University, Knoxville) Journal of Aircraft (ISSN 0021-8669), vol. 25, April 1988, p. 343-348. Previously cited in issue 08, p. 1047, Accession no. A87-22365. refs

A88-45286#
GENERAL FORMULATION FOR THE AEROELASTIC DIVERGENCE OF COMPOSITE SWEPT-FORWARD WING STRUCTURES
L. LIBRESCU (Virginia Polytechnic Institute and State University, Blacksburg) and J. SIMOVICH (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 1129-1140) Journal of Aircraft (ISSN 0021-8669), vol. 25, April 1988, p. 364-371. Previously cited in issue 24, p. 3542, Accession no. A86-49095. refs

A88-45302#
THE INFLUENCE OF HELICOPTER FUSELAGE ON ITS ROTOR
MAO SUN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, March 1988, p. A108-A112. In Chinese, with abstract in English. refs

The effect of helicopter fuselage on its rotor is studied using a simplified free-wake model. The results show that the rotor near-wake is distorted because of the flow field of the fuselage, resulting in large variation on the induced velocity distribution at the rotor plane. The variation of the induced velocity distribution at the rotor plane caused by the fuselage through distorting the rotor near-wake is much larger than that induced by the fuselage directly. Author

A88-45375*# Akron Univ., Ohio.
A FINITE ELEMENT STUDY OF THE EIDI SYSTEM
A. A. KHATKHATE, R. J. SCAVUZZO, and M. L. CHU (Akron, University, OH) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 9 p. NASA-supported research. refs (AIAA PAPER 88-0022)

This paper presents a method for modeling the structural dynamics of an Electro-Impulse De-Icing System, using finite element analyses procedures. A guideline for building a representative finite element model is discussed. Modeling was done initially using four noded cubic elements, four noded isoparametric plate elements and eight noded isoparametric shell elements. Due to the size of the problem and due to the underestimation of shear stress results when compared to previous analytical work an approximate model was created to predict possible areas of shedding of ice. There appears to be good agreement with the test data provided by The Boeing Commercial Airplane Company. Thus these initial results of this method were found to be encouraging. Additional analytical work and comparison with experiment is needed in order to completely evaluate this approach. Author

A88-45679#
F-16XL DEMONSTRATES NEW CAPABILITIES IN FLIGHT TEST AT EDWARDS AIR FORCE BASE
PATRICK K. TALTY and DONALD J. CAUGHLIN (USAF, Flight Test Center, Edwards AFB, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 206-215. refs

The F-16XL was an evolutionary aircraft developed by building on the proved capabilities of the F-16's fly-by-wire flight control system, relaxed static stability, and vortex flow control. Two F-16 fuselages were stretched and modified with a new cranked arrow wing that included a low-drag conformal weapon carriage. The goal was to provide improved operational effectiveness of the F-16 in the air-to-ground role without degrading the F-16's air-to-air capabilities. Design goals also included survivability enhancement through increased speed, maneuverability, and reduced radar signature along with retention of the F-16's reliability and maintainability through 80-percent commonality with the F-16. The F-16XL successfully met most of these goals. Improvements in air-to-ground effectiveness were a 35-65-percent increase in mission radius, an increased external weapons payload capability of 15,000 lb, increased speed, and outstanding high-angle-of-attack flying qualities with air-to-ground weapons. Areas identified for improvement were primarily related to the low thrust-to-weight ratio of the XL during heavyweight takeoff and sustained maneuvering. The concepts demonstrated by the F-16XL will impact all future fighter aircraft design programs. Author

A88-45688#
AEROELASTIC TAILORING OF A COMPOSITE WING WITH A DECOUPLER PYLON AS A WING/STORE FLUTTER SUPPRESSOR
I. LOTTATI (Technion - Israel Institute of Technology, Haifa) Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 271-280. refs

An analytical investigation was conducted to determine the influence of the decoupler pylon on the aeroelastic behavior of a composite, rectangular wing. It is assumed that the wing is carrying a fuselage at its semispan and an external store attached to a decoupler pylon at a various station along the wing's span and that the aircraft is in a free-flight condition (unrestrained vehicle). Passive soft-spring/damper elements are used to decouple wing modes from store pitch modes. The effect of some parameters on the ability of the decoupler pylon to suppress flutter are analyzed. It is shown by analysis that the decoupler pylon provides substantial increase in flutter speed and that the ability of the decoupler pylon to suppress flutter is influenced mainly by the spanwise and chordwise pivot point location of the external attached store. Furthermore, it is shown that the aeroelastic tailoring of the wing and angle of sweep have a major influence on the flutter instability of the configuration. Author

A88-45691#
COMMENT ON 'THE ROLE OF STRUCTURAL AND AERODYNAMIC DAMPING ON THE AEROELASTIC BEHAVIOR OF WINGS'
WILLIAM P. RODDEN Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 286-288; Author's Reply, p. 288. refs

N88-23726*# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
IT'S TIME TO REINVENT THE GENERAL AVIATION AIRPLANE
ROBERT F. STENGEL *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1986 p 81-105 Apr. 1988
Avail: NTIS HC A06/MF A01 CSCL 01C

Current designs for general aviation airplanes have become obsolete, and avenues for major redesign must be considered. New designs should incorporate recent advances in electronics, aerodynamics, structures, materials, and propulsion. Future airplanes should be optimized to operate satisfactorily in a positive air traffic control environment, to afford safety and comfort for point-to-point transportation, and to take advantage of automated manufacturing techniques and high production rates. These requirements have broad implications for airplane design and flying qualities, leading to a concept for the Modern Equipment General Aviation (MEGA) airplane. Synergistic improvements in design, production, and operation can provide a much needed fresh start for the general aviation industry and the traveling public. In this investigation a small four place airplane is taken as the reference, although the proposed philosophy applies across the entire spectrum of general aviation. Author

N88-23744*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLIGHT EXPERIENCES WITH LAMINAR FLOW
BRUCE J. HOLMES *In its* Laminar Flow Aircraft Certification p 155-169 May 1986
Avail: NTIS HC A14/MF A01 CSCL 01C

A review of natural laminar flow (NLF) flight experiences over the period from the 1930's to the present has been given to provide information on the achievability and maintainability of NLF in typical airplane operating environments. Significant effects of loss of laminar flow on airplane performance have been observed for several airplanes, indicating the importance of providing information on these changes to laminar flow airplane operators. Significant changes in airplane stability and control and maximum lift were observed in flight experiments with the loss of laminar flow. However, these effects can be avoided by proper selection of airfoils. Conservative laminar flow airfoil designs should be employed which do not experience significant loss of lift (caused by flow separation) upon the loss of laminar flow. Mechanisms have been observed for the effects of insect accumulation, flight through clouds and precipitation, and propeller slipstreams on laminar flow behavior. Fixed transition testing, in addition to free transition testing, is recommended as a new standard procedure for airplanes with surfaces designed to support laminar flow.
Author

N88-23746*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRELIMINARY AERODYNAMIC DESIGN CONSIDERATIONS FOR ADVANCED LAMINAR FLOW AIRCRAFT CONFIGURATIONS
JOSEPH L. JOHNSON, JR., LONG P. YIP, and FRANK L. JORDAN, JR. *In its* Laminar Flow Aircraft Certification p 185-225 May 1986
Avail: NTIS HC A14/MF A01 CSCL 01C

Modern composite manufacturing methods have provided the opportunity for smooth surfaces that can sustain large regions of natural laminar flow (NLF) boundary layer behavior and have stimulated interest in developing advanced NLF airfoils and improved aircraft designs. Some of the preliminary results obtained in exploratory research investigations on advanced aircraft configurations at the NASA Langley Research Center are discussed. Results of the initial studies have shown that the aerodynamic effects of configuration variables such as canard/wing arrangements, airfoils, and pusher-type and tractor-type propeller installations can be particularly significant at high angles of attack. Flow field interactions between aircraft components were shown to produce undesirable aerodynamic effects on a wing behind a heavily loaded canard, and the use of properly designed wing leading-edge modifications, such as a leading-edge droop, offset the undesirable aerodynamic effects by delaying wing stall and providing increased stall/spin resistance with minimum degradation of laminar flow behavior.
Author

N88-23748*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPERATIONAL CONSIDERATIONS FOR LAMINAR FLOW AIRCRAFT
DAL V. MADDALON and RICHARD D. WAGNER *In its* Laminar Flow Aircraft Certification p 247-268 May 1986
Avail: NTIS HC A14/MF A01 CSCL 01C

Considerable progress has been made in the development of laminar flow technology for commercial transports during the NASA Aircraft Energy Efficiency (ACEE) laminar flow program. Practical, operational laminar flow control (LFC) systems have been designed, fabricated, and are undergoing flight testing. New materials, fabrication methods, analysis techniques, and design concepts were developed and show much promise. The laminar flow control systems now being flight tested on the NASA Jetstar aircraft are complemented by natural laminar flow flight tests to be accomplished with the F-14 variable-sweep transition flight experiment. An overview of some operational aspects of this exciting program is given.
Author

N88-23749*# Federal Aviation Administration, Kansas City, Mo. Small Airplane Certification Directorate.
CERTIFICATION ASPECTS OF AIRPLANES WHICH MAY OPERATE WITH SIGNIFICANT NATURAL LAMINAR FLOW
EDWARD A. GABRIEL and EARSA L. TANKESLEY *In* NASA, Langley Research Center, Laminar Flow Aircraft Certification p 269-277 May 1986
Avail: NTIS HC A14/MF A01 CSCL 01C

Recent research by NASA indicates that extensive natural laminar flow (NLF) is attainable on modern high performance airplanes currently under development. Modern airframe construction methods and materials, such as milled aluminum skins, bonded aluminum skins, and composite materials, offer the potential for production of aerodynamic surfaces having waviness and roughness below the values which are critical for boundary layer transition. Areas of concern with the certification aspects of Natural Laminar Flow (NLF) are identified to stimulate thought and discussion of the possible problems. During its development, consideration has been given to the recent research information available on several small business and experimental airplanes and the certification and operating rules for general aviation airplanes. The certification considerations discussed are generally applicable to both large and small airplanes. However, from the information available at this time, researchers expect more extensive NLF on small airplanes because of their lower operating Reynolds numbers and cleaner leading edges (due to lack of leading-edge high lift devices). Further, the use of composite materials for aerodynamic surfaces, which will permit incorporation of NLF technology, is currently beginning to appear in small airplanes.
Author

N88-23762*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
FLIGHT TESTING A V/STOL AIRCRAFT TO IDENTIFY A FULL-ENVELOPE AERODYNAMIC MODEL
B. DAVID MCNALLY and RALPH E. BACH, JR. May 1988
16 p
(NASA-TM-100996; A-88139; NAS 1.15:100996) Avail: NTIS HC A03/MF A01 CSCL 01C

Flight-test techniques are being used to generate a data base for identification of a full-envelope aerodynamic model of a V/STOL fighter aircraft, the YAV-8B Harrier. The flight envelope to be modeled includes hover, transition to conventional flight and back to hover, STOL operation, and normal cruise. Standard V/STOL procedures such as vertical takeoff and landings, and short takeoff and landings are used to gather data in the powered-lift flight regime. Long (3 to 5 min) maneuvers which include a variety of input types are used to obtain large-amplitude control and response excitations. The aircraft is under continuous radar tracking; a laser tracker is used for V/STOL operations near the ground. Tracking data are used with state-estimation techniques to check data consistency and to derive unmeasured variables, for example, angular accelerations. A propulsion model of the YAV-8B's engine and reaction control system is used to isolate aerodynamic forces and moments for model identification. Representative V/STOL flight data are presented. The processing of a typical short takeoff and slow landing maneuver is illustrated.
Author

N88-23763*# Boeing Commercial Airplane Co., Seattle, Wash.
INTEGRATED APPLICATION OF ACTIVE CONTROLS (IAAC) TECHNOLOGY TO AN ADVANCED SUBSONIC TRANSPORT PROJECT: PROGRAM REVIEW Contractor Report, Oct. 1978 - Nov. 1984
Washington NASA Mar. 1986 111 p
(Contract NAS1-15325)
(NASA-CR-3880; NAS 1.26:3880; D6-52151) Avail: NTIS HC A06/MF A01 CSCL 01C

This report summarizes the Integrated Application of Active Controls (IAAC) Technology to an Advanced Subsonic Transport Project, established as one element of the NASA/Boeing Energy Efficient Transport Technology Program. The performance assessment showed that incorporating ACT into an airplane designed to fly approximately 200 passengers approximately 2,000 nmi could yield block fuel savings from 6 to 10 percent at the design range. The principal risks associated with incorporating these active control functions into a commercial airplane are those involved with the ACT system implementation. The Test and Evaluation phase of the IAAC Project focused on the design,

fabrication, and test of a system that implemented pitch axis fly-by-wire, pitch axis augmentation, and wing load alleviation. The system was built to be flight worthy, and was planned to be experimentally flown on the 757. The system was installed in the Boeing Digital Avionics Flight Controls Laboratory (DAFCL), where open loop hardware and software tests, and a brief examination of a direct drive valve (DDV) actuation concept were accomplished. The IAAC Project has shown that ACT can be beneficially incorporated into a commercial transport airplane. Based on the results achieved during the testing phase, there appears to be no fundamental reason(s) that would preclude the commercial application of ACT, assuming an appropriate development effort is included. Author

N88-23764# General Accounting Office, Washington, D. C.
NATIONAL AERO-SPACE PLANE: A TECHNOLOGY DEVELOPMENT AND DEMONSTRATION PROGRAM TO BUILD THE X-30
Apr. 1988 80 p
(GAO/NSIAD-88-122) Avail: NTIS HC A05/MF A01

The National Aero-Space Plane (NASP) Program is a joint DOD/NASA technology development and demonstration program to build and test the X-30 experimental flight vehicle. The X-30 is designed to take off horizontally from a conventional runway, reach hypersonic speeds up to Mach 25, attain low Earth orbit, and return to land on a conventional runway. The X-30 would fly 10 times faster and higher than existing air-breathing aircraft. The NASP Program is described and a status report of X-30 development provided, including the following: (1) goals and objectives; (2) program costs and schedule estimates; (3) key technological developments, integration, and risks; (4) potential military, space, and commercial mission applications; (5) program management and acquisition; and (6) alternatives and international aerospace development efforts. Author

N88-23765* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MULTI-BODY AIRCRAFT WITH AN ALL-MOVABLE CENTER FUSELAGE ACTIVELY CONTROLLING FUSELAGE PRESSURE DRAG Patent
RICHARD M. WOOD, inventor (to NASA) 5 Apr. 1988 7 p
Filed 12 Feb. 1987 Supersedes N87-25320 (25 - 19, p 2571)
(NASA-CASE-LAR-13511-1; US-PATENT-4,735,381;
US-PATENT-APPL-SN-013801; US-PATENT-CLASS-244-130;
US-PATENT-CLASS-244-119; US-PATENT-CLASS-244-120;
US-PATENT-CLASS-244-15) Avail: US Patent and Trademark Office CSCL 01C

A multi-body aircraft with an all-movable center fuselage which translates relative to two side fuselages is described. At subsonic and transonic flight the center fuselage is in a forward position. At supersonic speeds the center fuselage moves aft so as to ensure optimum aerodynamic interference at particular Mach numbers. This provides an increased shock strength and greater surface areas so the significant reductions in zero-lift wave drag can be achieved. This concept allows for a significant increase in the wing aspect ratio which would improve high-lift performance at all speeds without incurring a significant supersonic zero-lift wave drag penalty. In addition to an improved low-fineness ratio, high-speed performance is achieved at all speeds and for all flight conditions.
Official Gazette of the U.S. Patent and Trademark Office

N88-23766*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SENSITIVITY ANALYSIS AND MULTIDISCIPLINARY OPTIMIZATION FOR AIRCRAFT DESIGN: RECENT ADVANCES AND RESULTS
JAROSLAW SOBIESZCZANSKI-SOBIESKI Jul. 1988 14 p
Presented at the 16th Congress of the International Council of the Aeronautical Sciences, Jerusalem, Israel, 28 Aug. - 2 Sep. 1988
(NASA-TM-100630; NAS 1.15:100630) Avail: NTIS HC A03/MF A01 CSCL 01C

Optimization by decomposition, complex system sensitivity analysis, and a rapid growth of disciplinary sensitivity analysis are some of the recent developments that hold promise of a quantum jump in the support engineers receive from computers in the quantitative aspects of design. Review of the salient points of these techniques is given and illustrated by examples from aircraft design as a process that combines the best of human intellect and computer power to manipulate data. Author

N88-24623*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NONLINEAR PROGRAMMING EXTENSIONS TO RATIONAL FUNCTION APPROXIMATION METHODS FOR UNSTEADY AERODYNAMIC FORCES
SHERWOOD H. TIFFANY and WILLIAM M. ADAMS, JR. Jul. 1988 55 p Previously announced in IAA as A87-33694 Sponsored by NASA, Washington
(NASA-TP-2776; L-16205; NAS 1.60:2776) Avail: NTIS HC A04/MF A01 CSCL 01C

The approximation of unsteady generalized aerodynamic forces in the equations of motion of a flexible aircraft are discussed. Two methods of formulating these approximations are extended to include the same flexibility in constraining the approximations and the same methodology in optimizing nonlinear parameters as another currently used extended least-squares method. Optimal selection of nonlinear parameters is made in each of the three methods by use of the same nonlinear, nongradient optimizer. The objective of the nonlinear optimization is to obtain rational approximations to the unsteady aerodynamics whose state-space realization is lower order than that required when no optimization of the nonlinear terms is performed. The free linear parameters are determined using the least-squares matrix techniques of a Lagrange multiplier formulation of an objective function which incorporates selected linear equality constraints. State-space mathematical models resulting from different approaches are described and results are presented that show comparative evaluations from application of each of the extended methods to a numerical example. Author

N88-24626# Naval Air Test Center, Patuxent River, Md.
METHOD FOR PREDICTION AND DETERMINATION OF TAKEOFF PERFORMANCE FOR VECTORED THRUST VEHICLES
J. F. CALVERT 5 Jan. 1988 18 p
(AD-A191809; NATC-TM-87-171-SA) Avail: NTIS HC A03/MF A01 CSCL 01B

YAV-8B and AV-8B Short Takeoff(STO) test results had indicated that STO techniques for the Harrier 2 could be further optimized, particularly for operations at higher hover weight ratios (1.3 and above). This paper documents a method to predicte and determine optimum land-based STO performance with minimum flight testing required. The method was applied during the determination of the optimum STO performance of the AV-8B, and is tailored generally toward thrust vectored vehicles with rapid thrust vectoring capability. With certain assumptions accounted for this approach can also be used in less restricted cases. Emphasis was placed on developing a repeatable task terminating with sufficient flight path acceleration at 50 ft AGL. STO tests conducted using the revised STO procedures validated the improvement in STO performance. Changes to the AV-8B flight operations manual were recommended in order to implement the revised STO task. GRA

N88-24627# Honeywell Systems and Research Center, Minneapolis, Minn.
NONLINEAR FLYING QUALITY PARAMETERS BASED ON DYNAMIC INVERSION Final Report, Jun. 1986 - Jun. 1987
B. G. MORTON, M. R. ELGERSMA, C. A. HARVEY, and G. HINES 30 Oct. 1987 169 p
(Contract F33615-86-C-3612)
(AD-A192146; F0231-FR; AFWAL-TR-87-3079) Avail: NTIS HC A08/MF A01 CSCL 01A

This report documents the results of efforts to develop that

can be used for the computation of nonlinear flying quality parameters. A variety of candidate nonlinear flying quality parameters and candidate specifications for them were developed. These parameters are genuinely different from expressions derived from linearized models. They depend on the nonlinear aerodynamic functions themselves and not their derivatives, and these parameters can be computed directly from preliminary nonlinear aircraft models. GRA

N88-24628*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ACTUATED FOREBODY STRAKES Patent Application
DANIEL G. MURRI, inventor (to NASA) 11 May 1988 22 p
(NASA-CASE-LAR-13983-1; NAS 1.71:LAR-13983-1; US-PATENT-APPL-SN-192563) Avail: NTIS HC A03/MF A01 CSCL 01C

Actuated forebody strakes provide yaw control at high angles of attack. In one embodiment, the strakes are axially slidable in the forebody to be deployed out of slots provided for the strakes in the forebody. In another embodiment, the strakes are pivotally connected at the tip of the strakes to pivot radially outwardly out of the slots provided in the forebody. In another embodiment, the forebody is provided with either a single strake or two strakes and the forebody is rotatable to vary the radial location of the strake or strakes. All embodiments achieve significant yaw control capability over a wide angle of attack and sideslip ranges. NASA

N88-24629*# Kansas Univ., Lawrence. Design Team.
CLASS 2 DESIGN UPDATE FOR THE FAMILY OF COMMUTER AIRPLANES
THOMAS R. CREIGHTON and LOUIS J. HENDRICH May 1987 284 p
(Contract NGT-8001)
(NASA-CR-182681; NAS 1.26:182681) Avail: NTIS HC A13/MF A01 CSCL 01C

This is the final report of seven on the design of a family of commuter airplanes. This design effort was performed in fulfillment of NASA/USRA grant NGT-8001. Its contents are as follows: (1) the class 1 baseline designs for the commuter airplane family; (2) a study of takeoff weight penalties imposed on the commuter family due to implementing commonality objectives; (3) component structural designs common to the commuter family; (4) details of the acquisition and operating economics of the commuter family, i.e., savings due to production commonality and handling qualities commonality are determined; (5) discussion of the selection of an advanced turboprop propulsion system for the family of commuter airplanes, and (6) a proposed design for an SSSA controller design to achieve similar handling for all airplanes. Final class 2 commuter airplane designs are also presented. Author

N88-24630*# West Virginia Univ., Morgantown. Dept. of Mechanical and Aerospace Engineering.
COMPUTATIONAL DESIGN OF LOW ASPECT RATIO WING-WINGLET CONFIGURATIONS FOR TRANSONIC WIND-TUNNEL TESTS Progress Report, 1 Jan. - 30 Jun. 1988
JOHN M. KUHLMAN and CHRISTOPHER K. BROWN 6 Jul. 1988 64 p
(Contract NAG1-625)
(NASA-CR-183021; NAS 1.26:183021) Avail: NTIS HC A04/MF A01 CSCL 01C

A computational design has been performed for three different low aspect ratio wing planforms fitted with nonplanar winglets; one of the three planforms has been selected to be constructed as a wind tunnel model for testing in the NASA LaRC 7 x 10 High Speed Wind Tunnel. A design point of M = 0.8, CL approx = 0.3 was selected, for wings of aspect ratio equal to 2.2, and leading edge sweep angles of 45 and 50 deg. Winglet length is 15 percent of the wing semispan, with a cant angle of 15 deg, and a leading edge sweep of 50 deg. Winglet total area equals 2.25 percent of the wing reference area. This report summarizes the design process and the predicted transonic performance for each configuration. Author

N88-24631 Virginia Polytechnic Inst. and State Univ., Blacksburg.
PERIODIC SOLUTIONS IN AIRCRAFT CRUISE-DASH OPTIMIZATION Ph.D. Thesis
UDAY J. SHANKAR 1987 171 p
Avail: Univ. Microfilms Order No. DA8802734

The problem of obtaining optimal cruise-dash trajectories for atmospheric aircraft flight is investigated. Periodic solutions are sought. The problem amounts to finding the trajectories that give the best range performance while achieving a specified average velocity. The cost functional is the weighted sum of the fuel spent and the time taken averaged over the range traversed. The aircraft model is quite complex and all solutions are obtained numerically. It is known that the nonconvexity of the energy hodograph results in a relaxed steady state solution for the energy model, chattering cruise dash. This solution has limited practical application. More realistic solutions in terms of an averaging model are sought. The fast dynamics are modeled as oscillatory solutions with ripples that do not die out, but move along with the progression of the slow motions. These are unsuccessful for the particular aircraft example worked out. A better approximation, relaxation oscillations, which encompasses slow energy changes alternating with fast altitude transitions is proposed. Numerical solutions is obtained. Finally optimal periodic solutions for the point-mass-model are obtained for some values of the cost weighting parameter. Dissert. Abstr.

N88-24633*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
CURRENT FLIGHT TEST EXPERIENCE RELATED TO STRUCTURAL DIVERGENCE OF FORWARD-SWEPT WINGS
LAWRENCE S. SCHUSTER and WILLIAM A. LOKOS Aug. 1988 15 p Presented at the 1988 International Symposium of Flight Test Engineers, Arlington, Tex., 14-18 Aug. 1988
(NASA-TM-100445; H-1500; NAS 1.15:100445) Avail: NTIS HC A03/MF A01 CSCL 01C

Flight testing the X-29A forward-swept wing aircraft has required development of new flight test techniques to accomplish subcritical extrapolations to the actual structural divergence dynamic pressure of the aircraft. This paper provides current experience related to applying these techniques to analysis of flight data from the forward-swept wing in order to assess the applicability of these techniques to flight test data. The measurements required, maneuvers flown, and flight test conditions are described. Supporting analytical predictions for the techniques are described and the results using flight data are compared to these predictions. Use of the results during envelope expansion and the resulting modifications to the techniques are discussed. Some of the analysis challenges that occurred are addressed and some preliminary conclusions and recommendations are made relative to the usefulness of these techniques in the flight test environment. Author

N88-24634*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ANALYSIS PROCEDURES AND SUBJECTIVE FLIGHT RESULTS OF A SIMULATOR VALIDATION AND CUE FIDELITY EXPERIMENT
PETER C. CARR and BURNELL T. MCKISSICK (National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.) Jul. 1988 31 p
(NASA-TM-88270; H-1371; NAS 1.15:88270) Avail: NTIS HC A03/MF A01 CSCL 01C

A joint experiment to investigate simulator validation and cue fidelity was conducted by the Dryden Flight Research Facility of NASA Ames Research Center (Ames-Dryden) and NASA Langley Research Center. The primary objective was to validate the use of a closed-loop pilot-vehicle mathematical model as an analytical tool for optimizing the tradeoff between simulator fidelity requirements and simulator cost. The validation process includes comparing model predictions with simulation and flight test results to evaluate various hypotheses for differences in motion and visual cues and information transfer. A group of five pilots flew air-to-air

tracking maneuvers in the Langley differential maneuvering simulator and visual motion simulator and in an F-14 aircraft at Ames-Dryden. The simulators used motion and visual cueing devices including a g-seat, a helmet loader, wide field-of-view horizon, and a motion base platform. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A88-41424
AIRBORNE MONITORING SYSTEM IMPROVES MAINTAINABILITY
Aerospace Engineering (ISSN 0736-2536), vol. 8, June 1988, p. 28-32.

The Vibration, Structural Life, and Engine Diagnostics (VSLED) monitoring system developed for the V-22 tiltrotor is examined. VSLED supports the collection and processing of data relating to flight performance, engine performance, and navigation and processes information on the functioning and condition of system components. Monitoring functions integrated into the system include vibration diagnostic algorithms for the drivetrain, rotors, and engines, onboard analysis for rotor track and balance and generation of instructions for adjustment, structural life monitoring for the airframe, rotor system, and associated dynamic components, and an engine monitoring system. The system is designed to perform seven functions: operating limit exceedance detection, performance degradation trending, vibration trending, fault detection and isolation, power assurance checks, recording of post-flight maintenance data, and parts life usage monitoring. R.B.

A88-42780* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AIRCRAFT ON-BOARD SAR PROCESSING USING A FREQUENCY-DOMAIN FAST CORRELATION TECHNIQUE
KUANG Y. LIU (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: IEEE National Radar Conference, 3rd, Ann Arbor, MI, Apr. 20, 21, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 165-170. refs

The design of a frequency-domain fast correlation processor for aircraft onboard synthetic-aperture radar (SAR) applications is described. The design uses the fast Fourier transform (FFT) fast correlation technique to perform both range and azimuth pulse compression functions for the NASA/JPL L-band, quad-polarization airborne SAR. The subject processor is computationally efficient and requires a simple control unit. It is capable of producing single-look, 8-m (slant range) by 10-m (azimuth) resolution, SAR images of a selected polarization over a swath width of up to 15 km in real time onboard the aircraft. I.E.

A88-42935#
TECHNIQUES TO PROCESS, ENHANCE, AND DISPLAY MULTISENSOR FUSED IMAGERY
TOM STINNETT and CHERYL YOUNG (Westinghouse Defense and Electronics Center, Baltimore, MD) IN: International Symposium on Aviation Psychology, 4th, Columbus, OH, Apr. 27-30, 1987, Proceedings. Columbus, OH, Ohio State University, 1987, p. 58-64. refs

In this paper, the value of fusing the SAR and tactical map imagery in real time is evaluated using results of experiments and demonstrations, and the necessary display processing and enhancement requirements are defined. It is concluded that SAR data are more effective if supplemented with stored digital map images containing both topographical and cultural features along with tactical annotated data, and that this combination of display information is even more efficient if it is displayed in color. However, it is emphasized that the use of color encoding and the allocation of colors must be carefully selected and applied. It is suggested that no more than four colors should be used, the color encoding scheme must be based on mission requirements and the type of information displayed, and any specific color/luminance requirements have to be experimentally verified to assure an improved operator performance. I.S.

A88-43180
FIBER-OPTIC CIRCUITS FOR AIRCRAFT ENGINE CONTROLS
WALTER L. GLOMB, JR. (United Technologies Research Center, East Hartford, CT) IN: Fiber optic systems for mobile platforms; Proceedings of the Meeting, San Diego, CA, Aug. 20, 21, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 122-127. Research supported by United Technologies Corp. refs

This paper describes environmental effects which impact the design of interfaces to fiber-optic sensors and data buses in aircraft engine controls. Emphasis is placed on selection of components and designs which maintain their performance and reliability in the harsh environment of an electronics enclosure mounted on a modern aircraft turbine engine. Particular attention is given to the effects of temperature on electro-optical component and system performance. The main conclusion is that electro-optical interfaces to a variety of fiber-optic systems can be installed in an engine-mounted control if the designs and components are selected after careful analysis of the effects of the engine environment. Author

A88-43181
LINEAR FIBER OPTIC DATA BUS FOR AIRCRAFT APPLICATIONS
MICHAEL B. MILLER (Litton Industries, Inc., Blacksburg, VA) IN: Fiber optic systems for mobile platforms; Proceedings of the Meeting, San Diego, CA, Aug. 20, 21, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 128-135.

In this paper, the advantages of a linear data bus over star and ring topologies based on the introduction of a different type of access coupler technology are demonstrated. The new couplers are nonreciprocal or asymmetric in function and so can circumvent many of the power budget problems usually encountered in linear topologies. Environmental tests of the couplers which show them to be rugged enough for military and commercial aircraft applications are described. The transmitter and receiver requirements for various data bus applications are given. Two examples of linear data buses based on actual or planned aircraft systems are presented which indicate the immediate feasibility of the fiber optic linear data bus. C.D.

A88-44325* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
COMPUTER VISION TECHNIQUES FOR ROTORCRAFT LOW-ALTITUDE FLIGHT
BANAVAR SRIDHAR and VICTOR H. L. CHENG (NASA, Ames Research Center, Moffett Field, CA) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 8, June 1988, p. 59-61. refs

A description is given of research that applies techniques from computer vision to automation of rotorcraft navigation. The effort emphasizes the development of a methodology for detecting the ranges to obstacles in the region of interest based on the maximum utilization of passive sensors. The range map derived from the obstacle detection approach can be used as obstacle data for the obstacle avoidance in an automataic guidance system and as advisory display to the pilot. The lack of suitable flight imagery data, however, presents a problem in the verification of concepts for obstacle detection. This problem is being addressed by the development of an adequate flight database and by preprocessing of currently available flight imagery. Some comments are made on future work and how research in this area relates to the guidance of other autonomous vehicles. I.E.

A88-45288#
STALL MARGIN INDICATION

ARTHUR W. HOADLEY (Western Michigan University, Kalamazoo) and RAYMOND S. VANDERBOK (Electronic Systems Development Co., Canton, MI) Journal of Aircraft (ISSN 0021-8669), vol. 25, April 1988, p. 380-383. Research supported by Western Michigan University. Previously cited in issue 03, p. 298, Accession no. A87-14030.

N88-23723*# Ohio Univ., Athens.
INTEGRATED AVIONICS RELIABILITY
DIMITRI ALIKIOTIS *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1986 p 51-59 Apr. 1988
Avail: NTIS HC A06/MF A01 CSCL 01D

The integrated avionics reliability task is an effort to build credible reliability and/or performability models for multisensor integrated navigation and flight control. The research was initiated by the reliability analysis of a multisensor navigation system consisting of the Global Positioning System (GPS), the Long Range Navigation system (Loran C), and an inertial measurement unit (IMU). Markov reliability models were developed based on system failure rates and mission time. Author

N88-23767# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Avionics Panel.
THE DESIGN, DEVELOPMENT AND TESTING OF COMPLEX AVIONICS SYSTEMS
Dec. 1987 408 p In ENGLISH and FRENCH Symposium held in Las Vegas, Nev., 27 Apr. - 1 May 1987
(AGARD-CP-417; ISBN-92-835-0437-2) Avail: NTIS HC A18/MF A01

The design, development and testing of complex avionics systems are discussed. Design aspects for future avionics systems, managing the future system design process, and system design tools and integration are among the topics covered.

N88-23769# Naval Air Development Center, Warminster, Pa.
SYSTEMS FOR THE 21ST CENTURY
RICHARD G. DESIPIO *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 7 p Dec. 1987
Avail: NTIS HC A18/MF A01

An avionic system index is proposed which allows for the definition of each function of the avionics system. The results of two demonstrations relative to the exploitation of on-board avionics built-in-test and diagnostics are presented. Author

N88-23771# Aeritalia S.p.A., Caselle Torinese (Italy). Gruppo Sistemi Avionici ed Equipaggiamenti.
RAPID PROTOTYPING OF COMPLEX AVIONIC SYSTEM ARCHITECTURES
L. BERARDI, N. GIORGI, W. MELLANO, A. VALENTE, and E. ZUCCO *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 13 p Dec. 1987 Sponsored in part by Unisys, Italy
Avail: NTIS HC A18/MF A01

A design tool called Expert Consultant for Avionics system Transformation Exploration (ECATE) is described. ECATE, rapidly prototyping different alternatives, helps the designer in establishing the information flow architecture of the avionics system, that is, the organization of the internal data handling. The tool provides the user with an interface to assist him in describing the avionics from the point of view of the data handling and presents the results in a suitable format. It performs consistency checks and advises the user on possible architectural problems by means of expert system techniques. Author

N88-23772# British Aerospace Public Ltd. Co., Woodford (England). Civil Aircraft Div.
THE SPECIFICATION AND DESIGN OF A FUTURE MARITIME RECONNAISSANCE AIRCRAFT
J. SHEPARD *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 11 p Dec. 1987
Avail: NTIS HC A18/MF A01

The problems of providing specifications for system components of the highly integrated avionic systems of the future are discussed in the context of the avionics systems of a Future Maritime Reconnaissance Aircraft (FMRA). The need and extent of the integration of the avionic systems are discussed, as are the consequences for system definition and specification. Potential techniques for addressing these problems are reviewed. These are brought together to describe an approach which could provide the tools required. The implication of this approach for vendors and integrators is addressed. Author

N88-23775# Agusta Sistemi S.p.A., Varese (Italy).
TEST PHILOSOPHY OF THE EH101 INTEGRATED AVIONIC
E. GALLI *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 5 p Dec. 1987
Avail: NTIS HC A18/MF A01

The philosophy employed during the development and testing of the EH101 integrated avionic Navel helicopter is outlined. The avionics architecture is given in graphic form. Overall avionic integration, the aircraft management computer test, the sensor interface units test, and the aircraft management system test are described. Author

N88-23776# International Business Machines Corp., Owego, N.Y. Federal Systems Div.
SYSTEMS ENGINEERING TECHNIQUE
LEONARD KARAS and DONNA RHODES *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 9 p Dec. 1987
Avail: NTIS HC A18/MF A01

An overview is given of the Systems Engineering Technique (SET). SET was developed to effect an improvement in quality and productivity aspects in the development of avionics systems. The methodology synthesizes the best features of existing development methodologies into a single core procedure which is equally applicable throughout the systems development phases of complex systems. Six key areas emphasized by SET are discussed, and the concept of systems engineering measurements is introduced as the means to evaluate system quality and productivity. SET is being applied to the development of avionics systems at IBM Owego and has been effective in improving specification quality. Author

N88-23777# Avions Marcel Dassault, Saint-Cloud (France).
MODELING OF FUNCTIONAL SPECIFICATIONS FOR ONBOARD SOFTWARE: EXPERIENCE WITH THE RAFALE AVIONICS SYSTEM [MAQUETTAGE DES SPECIFICATIONS FONCTIONNELLES DU LOGICIEL EMBARQUE EXPERIENCE DU SYSTEME AVIONIQUE RAFALE]
PATRICK SCHIRLE *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 12 p Dec. 1987 In FRENCH
Avail: NTIS HC A18/MF A01

The avionics system of the Rafale aircraft entailed innovations such as the integration of aircraft systems and the acquisition of control information. These new functions resulted in a notable increase in, and qualitative evolution of, onboard computer software. For the improvement of quality and response characteristics of software, development was supported by an integral methodology for modeling software functional specifications. The model was constructed around a SEL computer supporting a FORTRAN listing of 3500 pages of system functional specifications. The model allows the direct validation of each individual specification and the whole ensemble of specifications. The model was used to support the analysis of the system failures, provide a base for the assessment of modifications, generate acceptance rules, and prepare a functional reference for integration. Author

N88-23778# International Business Machines Corp., Owego, N.Y.
THE AVIONICS SOFTWARE ARCHITECTURE IMPACT ON SYSTEM ARCHITECTURE

C. DOUGLASS LOCKE *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 5 p Dec. 1987
Avail: NTIS HC A18/MF A01

Technology developments that led to the problem of system vulnerability to software errors resulting from increased avionic system complexity and the impact of these developments on the functionality and design of new systems are considered. The current sequence for performing the physical and software architectural design, including a definition of the software architecture is discussed. The likely consequences of using these methods for designing new avionics systems are also discussed. Author

N88-23779# Litton Technische Werke, Freiburg (West Germany).
A COMPARISON OF INTEGRATED AND SEPARATE SYSTEMS FOR FLIGHT CONTROL AND NAVIGATION
H. BUITKAMP *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 10 p Dec. 1987
Avail: NTIS HC A18/MF A01

Two steps for the integration of flight control sensors, the Altitude and Heading Reference System (AHRS) and the Inertial Navigation System (INS) are discussed. It has been shown that the use of the same sensors for flight control and AHRS functions, as for example in the Aircraft Motion Sensor Unit (AMSU) system, yield excellent results. The AMSU system has demonstrated its performance capability in the Experimental Aircraft Program (EAP) inherently unstable aircraft. These aircraft, as opposed to conventional aircraft, require inertial sensor data with an extremely high bandwidth and very small data latency for flight control purposes. Author

N88-23780# Textron Bell Helicopter, Fort Worth, Tex. Advanced Human Factors System Design.
DEVELOPMENT AND TESTING OF A PREDICTIVE METHODOLOGY FOR OPTIMIZATION OF MAN-MACHINE INTERFACE IN FUTURE AVIONICS SYSTEMS
ROGER E. PARKS *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 9 p Dec. 1987
Avail: NTIS HC A18/MF A01

The trend toward increasing complexity and cost in emerging avionics systems, driven by requirements for increased functional capability, has created a need for a predictive analytical methodology which accurately forecasts system performance early in the design process, and treats the human operator and the equipment as a fully integrated man-machine system. A methodology that meets these needs has been developed and validated by Bell Helicopter Textron. The process is being used to provide early, accurate avionics system characterization, thereby reducing design costs. Author

N88-23781# Boeing Military Airplane Development, Wichita, Kans.
CREWSTATION INFORMATION AND DEVELOPMENT SYSTEM (CIDS)
M. E. ROWLAND and W. R. WAGONER *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 11 p Dec. 1987
Avail: NTIS HC A18/MF A01

The process by which requirements for an avionics system are translated into an integrated crewstation design is discussed. The Crewstation Information Development System (CIDS) was divided into three phases of activity. In Phase 1, methodology development, a comprehensive set of requirements, resource allocation, and an information utilization assessment is derived. Phase 2, crewstation development, focuses on deriving the most effective methods of utilizing required crewstation information, taking into consideration the impact of the operational environment. The final phase, design application, concerns the details of crewstation design and the development of a crewstation information manager. Author

N88-23783# Northrop Corp., Hawthorne, Calif. ASET Development.
MANAGING ADVANCED AVIONIC SYSTEM DESIGN
PHILIP H. SIMONS *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 8 p Dec. 1987
Avail: NTIS HC A18/MF A01

The critical requirements of advanced avionic system design are overall system requirements, configuration item requirements, interface requirements, and design process management requirements. These requirements can be met through the design process of abstract requirements definition, requirements/functional decomposition, functional recomposition, and detailed interface definition. This process can be greatly aided by computer automation, resulting in the design of more complex avionics systems in far less time than would be possible using older tools. Author

N88-23784# Centre d'Etudes et de Recherches de Medecine Aerospatiale, Paris (France). Lab. Central de Biologie Aerospatiale.
PSYCHOSENSORY COCKPIT ERGONOMICS, ADVANTAGES OF INTELLIGENT INFORMATION SYSTEMS [ERGONOMIE PSYCHOSENSORIELLE DES COCKPITS, INTERET DES SYSTEMES INFORMATIQUES INTELLIGENTS]
R. AMALBERTI, F. DEBLON, and J. P. MENU *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 12 p Dec. 1987 In FRENCH; ENGLISH summary
Avail: NTIS HC A18/MF A01

Psychosensory cockpit ergonomics consists of a pluridisciplinary approach focused on global consideration of man-machine interface issues. Knowledge supplied by each research field (sensory physiology, cognitive psychology, design of intelligent systems) is used in every concrete approach, taking into consideration aviation requirements and technological advances. Requirements that must be met to build such systems and computer system goals are discussed. Author

N88-23785# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
ADVANCED DEVELOPMENT OF A COCKPIT AUTOMATION DESIGN SUPPORT SYSTEM
PHILIP V. KULWICKI, JOE W. MCDANIEL, and LISA M. GUADAGNA *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 15 p Dec. 1987
Avail: NTIS HC A18/MF A01

A highly disciplined and structured crew system design process is being developed to improve the efficiency and effectiveness by which advanced cockpits can be fielded. As an initial implementation of the CAT design process, a Cockpit Automation Design Support System (CADSS) is being developed to provide a computer aided design environment, including the software design tools amd the simulation utilities that can facilitate the development of the crew system in synchrony with the development of the avionics and weapon system. The rationale underlying the CADSS is described in terms of the system components, which include a Designer's Computer Aided Design System (DCADS) processor, new software tools and a breadboard cockpit simulator which are envisioned to complement, but not replace, existing development facilities. This implementation of the cockpit design support system is described in relation to the overall CAT program activities and schedule. Author

N88-23786# Societe Nationale Industrielle Aerospatiale, Marignane (France). Div. Helicopteres.
DESIGN AND DEVELOPMENT OF AN AVIONICS SYSTEM ADAPTED TO HELICOPTER MISSIONS [CONCEPTION ET DEVELOPPEMENT D'UN SYSTEME AVIONIQUE ADAPTE AUX MISSIONS DES HELICOPTERES]
DANIEL BOUHERET and JEAN LOUIS ROCH (Crouzet Aerospace and Systems, Valence, France) *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 16 p Dec. 1987 In FRENCH
Avail: NTIS HC A18/MF A01

The development of the avionics system for the Dauphin 365 F configured for search and rescue operations is discussed. A general description of flight missions and system architecture is presented with particular emphasis being given to the navigation and mission management subsystems. The system is based on a Nadir Mk2 microprogrammable computer capable of an execution rate of 1 MOPS. The interactive relationship between the system designers and integrators is described along with the design support tools that aid in achieving successful interaction. Author

N88-23787# Hughes Aircraft Co., Fullerton, Calif.
OPERATION AND PERFORMANCE OF AN INTEGRATED HELICOPTER COMMUNICATION SYSTEM
WALTER R. FRIED *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 8 p Dec. 1987 Previously announced in IAA as A87-31469
Avail: NTIS HC A18/MF A01

The unique operational and performance requirements of the communication system for modern tactical Army helicopters are described. An integrated system architecture is described which satisfies these requirements and incorporates very high levels of automation, thereby reducing pilot workload. The automation concepts include the use of a preloaded communication data base and a centralized communication processor containing advanced control, reconfiguration and message formatting software. Link analysis and simulation results are presented to show the performance capabilities of the system with respect to the projected mission requirements. Author

N88-23788# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. Human Engineering Div.
DESIGNING FOR DESIGN EFFECTIVENESS OF COMPLEX AVIONICS SYSTEMS
KENNETH R. BOFF *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 9 p Dec. 1987
Avail: NTIS HC A18/MF A01

The Integrated Perceptual Information for Designers (IPID) Project is a multiagency supported effort to aid the accessibility and use of human performance data in system design. It is formulated around five information management objectives: (1) identifying, collecting, and consolidating human performance data of potential value to system design; (2) human factoring these data to enable their direct use by system designers; (3) establishing an institute with responsibility for maintenance, update and analysis of these resources to support crew system design; (4) developing and sponsoring educational opportunities to train and sensitize system designers in the value and application of human performance data to crew system design; and (5) conducting exploratory research to define and evaluate requirements for an automated design support capability to aid engineers to access and tradeoff human performance data with other technical information germane to the effective design of crew systems. Author

N88-23789# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
DESIGN FOR INTEROPERABILITY (INTERCHANGEABILITY)
GEORGE KONOMOS *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 5 p Dec. 1987
Avail: NTIS HC A18/MF A01

Interoperability of the various elements used in a system is the design property which allows the intermixing of elements from various sources (manufactures) without any impact on the performance of the system or the operational hardware. Here, the line replaceable module approach is discussed. This is a new approach to avionics where a processor module is a 6 inch by 6 inch plug-in board with processing power many times higher than that of older line replaceable units. Author

N88-23790# Aeritalia S.p.A., Caselle Torinese (Italy). Gruppo Equipaggiamenti.
THE ELECTROMAGNETIC THREAT TO FUTURE AVIONIC SYSTEMS
BRUNO AUDONE *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 10 p Dec. 1987
Avail: NTIS HC A18/MF A01

The electromagnetic threat to future aircraft is studied and evaluated on the basis of the evolution of the avionic systems. The high level of integration of these systems combined with the increased number of electromagnetic sources which may interfere with the performance of the overall weapon system create the need to reexamine the usual design and testing approach in order to reach an adequate level of aircraft hardening. It is essential to design and test at system level rather than at hardware level. System design guidelines are discussed. Areas where basic research studies need to be undertaken are highlighted. Author

N88-23791# Thorn EMI, Hayes (England). Radar Div.
THE INTEGRATION, CHARACTERISATION AND TRIALLING OF A MODERN COMPLEX AIRBORNE RADAR
ROGER ROY HOGBEN and FRANK N. MORPHET *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 5 p Dec. 1987
Avail: NTIS HC A18/MF A01

The process of commissioning, testing and conducting trials of complex aircraft radar is discussed. An attempt is made to show how vital an informed and methodical approach is to achieving success. It is argued that it is essential to the approach that higher management understands and supports it. Author

N88-23793# Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario). Human Engineering Section.
EXPERIENCE IN THE INTEGRATION OF HUMAN ENGINEERING EFFORT WITH AVIONICS SYSTEMS DEVELOPMENT
D. BEEVIS *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 9 p Dec. 1987
Avail: NTIS HC A18/MF A01

Based on a review of human engineering activities in ten major acquisition projects, some conclusions aimed at facilitating the integration of human engineering activities with the development of advanced avionics are outlined. Conclusions are also drawn about the systems design and human engineering processes, and the role that mission, function, and task analysis can play in integrating human engineering and systems development activities. It is concluded that an approach that combines the interaction of hardware, software, and human functions is made especially necessary by the impact of advanced technology on the roles of human operators and maintainers, on the man-machine interface, and on the system development process itself. Finally, it is argued that there is a need to establish standardized approaches to the application of human engineering in avionics system design. Author

N88-23794# Electronique Serge Dassault, St. Cloud (France).
TESTING COMPLEX AVIONICS SOFTWARE: A PRACTICAL EXPERIENCE [LE TEST DE LOGICIELS AVIONIQUES COMPLEXES: UNE EXPERIENCE PRATIQUE]
M. MUENIER *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 16 p Dec. 1987 In FRENCH
Avail: NTIS HC A18/MF A01

The methods used at Dassault for testing avionics software, particularly the operational programs used on the Mirage F1 and Mirage 2000 aircraft, are presented. The MINERVE software development methodology is briefly described. The objective of MINERVE is to facilitate software production while ensuring control of quality, costs and development delays. The various software tools used to perform unitary, integration, functional and final software validation and testing are described. These tools provide hardware environment simulation, graphic output and various operational modes. A trend towards the integration of front-end tools (specification tools) and back-end tools (test tools) is noted and a natural progression from specification tool to semiformal specification, to prototype, to stimuli, to test tools is foreseen. Author

N88-23797# Air Force Test Pilot School, Edwards AFB, Calif.
A LOOK TOWARD THE FUTURE OF COMPLEX AVIONICS SYSTEMS DEVELOPMENT USING THE USAF TEST PILOT SCHOOL'S AVIONICS SYSTEMS TEST TRAINING AIRCRAFT
WILLIAM H. BROOME, JR. and MIKE PARRAG (Calspan Corp., Buffalo, N. Y.) *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 16 p Dec. 1987
Avail: NTIS HC A18/MF A01

The Avionics Systems Test Training Aircraft (ASTTA) is a special configuration of the NC-131H Total In-flight Simulator (TIFS), and was developed to fill a significant gap in the education and experience of the avionics systems test community. It provides a cost effective means of quickly exposing both designers and testers to the key issues of systems development and in-flight testing, especially the operator to systems interface human factors issues. Its benign flight environment is conducive to both initial and advanced training in flight test techniques. Author

N88-23799# Avions Marcel Dassault, Saint-Cloud (France).
AVIONICS SYSTEMS: DEVELOPMENT METHOD AND COMPUTER TOOLS [SYSTEME AVIONIQUE-METHODE DE DEVELOPPEMENT ET OUTILS INFORMATIQUES]
P. LAROCHE-LEVY *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 13 p Dec. 1987 In FRENCH
Avail: NTIS HC A18/MF A01

The avionics development system based on the use of computer automation tools is described. The problems posed in the development of avionics are defined and the various phases constituting the development life cycle for avionics systems are characterized. The capabilities of the computer tools and how they are used in various development stages are described. Finally, the benefits gained through the use of such a development methodology are discussed. Author

N88-23801# National Aerospace Lab., Amsterdam (Netherlands).
DEVELOPMENT OF AN AIRBORNE FACILITY FOR ADVANCED AVIONICS RESEARCH
N. VANDRIEL *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 14 p Dec. 1987
Avail: NTIS HC A18/MF A01

Based on its flight test and simulator experience, the Netherlands National Aerospace Laboratory (NLR) has started the development of an airborne avionics research facility. In the framework of the Avionics Research Testbed (ART) project, NLR's Metro research airplane is being equipped with a number of advanced avionics systems, including programmable electronic flight instrument system, flight management computer, microwave landing system, global positioning system and secondary surveillance radar. Author

N88-23802# Avions Marcel Dassault, Saint-Cloud (France). Aerospatiale Div. Helicopteres.
WORKSHOPS FOR THE DESIGN OF AVIONICS SYSTEMS AND THE DEVELOPMENT OF ONBOARD SOFTWARE [ATELIERS DE CONCEPTION DE SYSTEMES AVIONIQUES ET DE REALISATION DE LOGICIELS EMBARQUES]
MONIQUE SLISSA and PHILIPPE LAROCHE-LEVY *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 13 p Dec. 1987 In FRENCH
Avail: NTIS HC A18/MF A01

An avionics development system based on an open-ended suite of integrated computer tools is described. Additions and changes to the basic tool set can be implemented to suit the requirements of the specific project or individual contractor. A hosting structure tool that ties the whole system together is described along with three other basic tools: OCS, a system design aid; DLAO, a computer aided software definition tool; and SAO, a graphic, detailed specification aid. Author

N88-23804# Service Techniques des Programmes Aeronautiques, Paris (France).
DEVELOPMENT OF COMPLEX AVIONICS SYSTEMS: EXPERIENCE FROM FRENCH MILITARY PROGRAMS [DEVELOPPEMENT DES SYSTEMES AVIONIQUES COMPLEXES: EXPERIENCE ISSUE DES PROGRAMMES MILITAIRES FRANCAIS]
ANTOINE COURSIMAULT *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 15 p Dec. 1987 In FRENCH
Avail: NTIS HC A18/MF A01

The principles used to guide the development of the avionics systems for the Mirage 2000 and ATL2 aircraft are discussed. In addition, the anomalies discovered during these development experiences and improvements contributing to the current ACT program are examined. The various development, verification, and production stages are characterized. Emphasis is placed on the importance of requirements analysis and specifications development. Author

N88-24636# Aeronautical Systems Div., Wright-Patterson AFB, Ohio.
AN EVALUATION OF THREE LINEAR SCALE RADAR ALTIMETER DISPLAYS Final Report
LARRY A. CARR Jan. 1988 102 p
(AD-A192173; ASD-TR-87-5005) Avail: NTIS HC A06/MF A01 CSCL 17G

Twelve fighter pilots were used as subjects to fly six low altitude missions in a full mission F-16 simulator with a visual system projected on a head-up display. The subjects were required to accomplish three descents to one of two altitudes (300' or 1000') on each of the missions and to maintain that altitude before then climbing back to cruising altitude were used as measures of performance. A Modified Cooper Harper scale was used to assess workload and a questionnaire was also used to ascertain subjective opinion concerning each scale. The original scale was compared with two alternative scales that both had an expanded lower portion and one of the two had an expanded upper altitude range. The results indicated that none of the performance measures were significant with respect to the scales being used. Accuracy for reading and plotting altitudes was better using the original scale apparently due to its larger number of scale markings. Workload ratings showed lower workload associated with the expanded upper scale in transitioning into and out of low altitude. Questionnaire data was not significant, but did result in key comments that showed distinct preference for the two alternatives scales with the expanded low altitude regions. A separate alternative scale was recommended for further testing. GRA

N88-24637*# Research Triangle Inst., Research Triangle Park, N.C.
DEVELOPMENT OF A MULTIPURPOSE SMART RECORDER FOR GENERAL AVIATION AIRCRAFT
J. H. WHITE and J. F. FINGER Mar. 1988 93 p
(Contract NAS1-16098)
(NASA-CR-168353; NAS 1.26:168353) Avail: NTIS HC A05/MF A01 CSCL 01D

An intelligent flight recorder, called the Smart Recorder, was fabricated and installed on a King Air aircraft used in standard commercial charter service. This recorder was used for collection of data toward two objectives: (1) the characterization of the typical environment encountered by the aircraft; and (2) research in the area of trend monitoring. Data processing routines and data presentation formats were defined that are applicable to commuter size aircraft. The feasibility of a cost-effective, multipurpose recorder for general aviation aircraft was successfully demonstrated. Implementation of on-board environmental data processing increased the number of flight hours that could be stored on a single data cartridge and simplified the data management problem by reducing the volume of data to be processed in the laboratory. Trend monitoring algorithms showed less variability in the trend plots when compared against plots of manual data. J.P.B.

07

AIRCRAFT PROPULSION AND POWER

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

A88-41569#
THE NOISE-PRODUCING CHARACTERISTICS OF HIGHLY LOADED, VALVELESS, PULSE COMBUSTORS
J. A. C. KENTFIELD (Calgary, University, Canada) ASME, Transactions, Journal of Vibration, Acoustics, Stress, and Reliability in Design (ISSN 0739-3717), vol. 110, April 1988, p. 238-245. refs
(Contract ¢GR|NSERC-A-7928)
(ASME PAPER 86-WA/NCA-34)

An inherent problem of pulsating combustors is noise generation and the difficulty of predicting noise levels. Analytical data are presented which illustrate the transient velocity profiles prevailing at the open ends of the inlets and tailpipes of valveless pulse combustors. A comparison is made of measured sound pressure level spectra at these locations with corresponding predicted transient velocity profiles. It is shown that there is a correlation of the main characteristics of the noise spectra and velocity profiles. Consideration is also given to the problems of muffling valveless pulse combustors and the potential, from the noise suppression viewpoint, of twin-coupled units and relatively high frequency pulse combustors featuring multiple inlet passages. An indication is also given of how it may be possible to operate clusters, or arrays, of pulse combustors firing sequentially. Author

A88-41822
POWERPLANTS WITH IN-FLIGHT THRUST VECTOR DEFLECTION [SILOVYE USTANOVKI S POVOROTOM VEKTORA TIAGI V POLETE]
VIKTOR FEDOROVICH PAVLENKO Moscow, Izdatel'stvo Mashinostroenie, 1987, 200 p. In Russian. refs

Various types and schemes of powerplants with thrust vector deflection designed for VTOL, STOL, and STOVL aircraft and also for improving flight control characteristics are reviewed. The discussion includes the design and principle of operation of thrust vector deflecting devices and the aerogasdynamic effect of exhaust jets on the aircraft, powerplant, and airfield pavement. The performance characteristics of powerplants with thrust vector deflection are presented. V.L.

A88-42451#
CURRENT GAS TURBINE COMBUSTION AND FUELS RESEARCH AND DEVELOPMENT
J. E. PETERS (Illinois, University, Urbana) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, May-June 1988, p. 193-206. Previously cited in issue 01, p. 13, Accession no. A88-11039. refs

A88-42462#
ROTATION EFFECTS ON AXISYMMETRIC SUDDEN-EXPANSION FLOWS
RONALD M. C. SO and SAAD A. AHMED (Arizona State University, Tempe) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, May-June 1988, p. 270-276. DARPA-sponsored research. refs
(Contract N60530-85-C-0191)

A transparent tube has been used to simulate the flow in a ramjet dump combustor. Tube rotation effects on mixing in the dump combustor were examined by rotating the plexiglass tube about its own axis at a constant speed. Attention was given to two conditions: one in which the tube rotated at 840 rpm, and another with the tube stationary. Average inlet velocity was set at about 10.6 m/sec in all cases. The results obtained show that the primary reattachment length decreased with increasing rotation, due to the destabilizing effect of the large shear created by the rotating tube wall. O.C.

A88-42623
AIRCRAFT PROPULSION - PRESENT AND FUTURE [PROPULSION DE AVIONES - PRESENTE Y FUTURO]
MARTIN CUESTA ALVAREZ IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), May 1988, p. 16-33. In Spanish.

A comprehensive design configuration, development status, and performance capability evaluation is made for the variety of military, commercial, and private aircraft powerplants whose features' evolution derived from U.S. and West European research organizations' response to the 1973 energy crisis and its exorbitant increase of aircraft fuel prices. High and low bypass turbofans, turbojets, unducted fans, contrarotating propfans, shrouded propfans, reciprocating engines, and hypersonic airbreathing propulsion systems are treated, together with the commercial propspects and comparative advantages of such alternative fuels as liquid hydrogen and liquid natural gas. O.C.

A88-43123
USING THE FINITE ELEMENT METHOD FOR STUDYING THE STRESS-STRAIN STATE OF THE ROTORS OF GAS TURBINE ENGINES [PRIMENENIE METODA KONECHNYKH ELEMENTOV DLIA ISSLEDOVANIIA NAPRIAZHENNO-DEFORMIROVANNOGO SOSTOIANIIA ROTOROV GTD]
V. G. BAZHENOV and IU. I. TROSTENIUK (Kievskii Politekhnicheskii Institut, Zhitomir, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), May 1988, p. 88-92. In Russian. refs

A finite element algorithm designed for problems of high dimensionality is presented which makes it possible to determine the stress-strain state of the rotors of gas turbine engines and to evaluate their load-bearing capacity. Based on calculations for assembled rotors, it is possible to determine clearances in seals with sufficiently high reliability. It is shown that the flexural deformations of cantilever disks can be significantly reduced by using slanted disks and disks with a crown that is assymetric with respect to the hub. V.L.

A88-43607
CALCULATION OF THE TEMPERATURE PROFILE OF A WALL JET IN THE MIXING ZONE OF THE COMBUSTION CHAMBER OF A GAS-TURBINE ENGINE WITH ALLOWANCE FOR THE VARIABLE SPECIFIC HEAT OF THE GAS [RASCHET TEMPERATURNOGO PROFILIA PRISTENNOI STRUII V ZONE SMESHENIIA KAMERY SGORANIIA GTD S UCHETOM PEREMENNOI TEPLOEMKOSTI GAZA]
S. G. DEMENKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 26-31. In Russian. refs

A study is made of the effect of the variable specific heat of the gas on temperature distribution in a single wall jet of air propagating in a model of the mixing zone of an annular combustion chamber with a tangential slot. Numerical and analytical methods are proposed for calculating the temperature profile with allowance for the variable specific heat. It is shown that the analytical method combines the accuracy of the numerical method with the speed of a constant-specific-heat method. V.L.

A88-43611
MODAL SYNTHESIS IN THE STUDY OF THE DYNAMIC BEHAVIOR OF COMPLEX AIRCRAFT GAS-TURBINE ENGINE SYSTEMS [MODAL'NYI SINTEZ V ISSLEDOVANII DINAMICHESKOGO POVEDENIIA SLOZHNYKH SISTEM AVIATSIONNYKH GTD]
M. K. LEONT'EV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 44-48. In Russian.

The main concepts and the general equations of the methods of modal synthesis for determining the vibration characteristics of complex elastic-inertial systems of aircraft gas-turbine engines are presented. The equations are written in a form convenient for their direct implementation on a computer. Some problems associated with the use of modal synthesis for evaluating the dynamic behavior of complex elastic-inertial systems are identified. V.L.

A88-43612
A NUMERICAL METHOD FOR CALCULATING TURBULENT FLOWS AND HEAT TRANSFER IN THE ENGINES OF FLIGHT VEHICLES [CHISLENNYI METOD RASCHETA TURBULENTNYKH TECHENII I TEPLOOBMENA V DVIGATELIAKH LETATEL'NYKH APPARATOV]
A. M. LIPANOV, IU. F. KISAROV, and I. G. KLIUCHNIKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 49-53. In Russian.

A method is developed for the numerical modeling of turbulent flows of a viscous compressible gas and heat transfer in flight vehicle engines in the stationary operation region. The method, which uses finite difference calculations, makes it possible to evaluate the effect of the geometrical dimensions of the engine and rotation speed on the flow and heat transfer parameters. Results of calculations are presented for two engine configurations. V.L.

A88-43616
AN EXPERIMENTAL STUDY OF THE NOZZLE VANE CASCADES OF GAS TURBINES WITH COUNTERROTATING ROTORS [EKSPERIMENTAL'NOE ISSLEDOVANIE RESHETOK SOPLOVYKH APPARATOV TURBIN GTD S PROTIVOPOLOZHNYM VRASHCHENIEM ROTOROV]
B. A. PONOMAREV and IU. V. SOTSENKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 64-67. In Russian. refs

Experimental data are presented on the performance characteristics of guide vane cascades with large and small angles of flow deflection designed for turbines with corotating and counterrotating rotors, respectively. A comparison of three cascades shows that the transition to the counterrotating scheme reduces the number of vanes by 40 percent, with a total reduction in the vane surface area of 21 percent. This results in a reduction of the flow rate of the cooling air. V.L.

A88-44611
THE BIG TURBOFANS - HOLDING THE NEW PROPS AT BAY
BILL SWEETMAN Interavia (ISSN 0020-5168), vol. 43, June 1988, p. 561-565.

An account is given of the most significant design features, comparative performance advantages, and economic competitiveness of high-bypass and unducted-fan (UDF) airliner engines that are expected to supplant CFM56-family engines in coming years, in the interest of fleet component modernization and fuel consumption reductions. The next-generation engines discussed are the proof-of-concept prototype of the revolutionary UDF type, as well as the more conventionally configured turbofans designated V2500 and PW4000, and the state-of-the-art '-5A1' variant of the CFM56. O.C.

A88-44631
MODELING OF GAS TURBINE FUEL NOZZLES
N. K. RIZK, A. A. MOSTAFA, and H. C. MONGIA (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) Atomisation and Spray Technology (ISSN 0266-3481), vol. 3, no. 4, 1987, p. 241-260. refs

A fuel injection model approach that addresses airflow dynamics, atomization, and spray dynamics is developed. The airflow field of a production airblast atomizer is evaluated and compared with laser anemometer measurements. The injection model considers fuel filming and breakup processes in addition to secondary atomization. The model is validated against the spray measurements of the nozzle. The spray dispersion is modeled using a recently developed turbulent two-phase flow model. The predictions are compared with reported Phase/Doppler measurements for dropsize as well as axial and radial velocity components within the spray produced by a pressure atomizer. It is conlcuded that the present approach yields encouraging results, and may serve as a sound basis for the accurate representation of the various fuel injection processes, and the development of a design procedure for internal passages of fuel injectors. Author

A88-44656#
THE V-22 OSPREY - PROPULSION SYSTEM SUPPORTABILITY IN A JOINT DEVELOPMENT PROGRAM
LAUNA D. BARBOZA and ALAN W. MOFFATT (Bell Helicopter Textron, Inc., Fort Worth, TX) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p.
(AIAA PAPER 88-2797)

In order to better understand the V-22's operating environment and maximize its ability to support this VTOL aircraft's operations, the results of surveys obtained for the various support organizations were fed back into the design process, and logistics engineers were teamed with design engineers. Attention is presently given to the results of these measures in the case of the V-22 propulsion system's proprotor gearbox, tilt-rotor gearbox, midwing gearbox, engine interconnect shafting, proprotor blade-fold system, proprotor tilt conversion actuator, and exhaust nozzle IR suppressor. O.C.

A88-44658#
UHB TECHNOLOGY VALIDATION - THE FINAL STEP
JOHN E. DONELSON, WILLIAM T. LEWERENZ, and ROGER T. DURBIN (Douglas Aircraft Co., Long Beach, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p.
(AIAA PAPER 88-2807)

This paper summarizes a recently-completed flight test program to confirm the suitability of ultra-high bypass (UHB) ratio engine technology for commercial transport aircraft. A McDonnell Douglas MD-80 aircraft was modified to accommodate a General Electric Unducted Fan (UDF) engine and was flight tested for more than 165 hours during a 10-month period concluding in March, 1988. The flight test program addressed the technical challenges associated with UHB engine technology in the areas of acoustics, structural dynamics, aerodynamics, and engine/aircraft integration and also included demonstrations to airline and media personnel. The knowledge obtained from this program has allowed McDonnell Douglas to proceed confidently with the detail design of commercial transport aircraft utilizing UHB technology. Author

A88-44671#
A PARAMETRIC INVESTIGATION OF A MODEL GAS TURBINE CAN COMBUSTOR
J. BROUWER, C. D. CAMERON, and G. S. SAMUELSEN (California, University, Irvine) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p. refs
(Contract F08635-86-C-0309)
(AIAA PAPER 88-2839)

The performance of a model laboratory combustor, representative of a gas turbine can combustor featuring liquid fuel injection through a twin fluid atomizer, dome swirl, and two rows of discrete wall jets, was investigated through two parametric variations. Measurements were made under reacting conditions for a variation of mass flow through the wall jets and dome swirler size operating at an overall equivalence ratio of 0.3 with a petroleum derived JP-4 fuel. Non-intrusive, in situ measurements of droplet size and droplet velocity and two components of gas phase velocity, in addition to temperature, and exit plane species concentrations were obtained. The velocity fields reveal the containment created by the primary and dilution jets, and the role of the primary jets in effecting on-axis recirculation. Recirculation in the primary zone is induced primarily by swirl with the primary jets containing the recirculation. The droplet fields reflect the practical realities of full-scale systems by the revelation of an asymmetry in the distribution of spray that leads to an asymmetry in the thermal field. In general, the flowfield investigated in the present study is relatively insensitive to variations in the rate of flow through the wall jets, whereas the size and strength of the recirculation zone is strongly dependent on the swirl strength. The exit plane species concentrations reveal the downstream effects of dome region flowfield structure. Author

A88-44678#
FLOWFIELD MEASUREMENTS IN AN UNSTABLE RAMJET BURNER
D. M. REUTER, U. G. HEGDE, and B. T. ZINN (Georgia Institute of Technology, Atlanta) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p. refs
(AIAA PAPER 88-2855)

This paper investigates the flow field in the flame region of an unstable laboratory ramjet burner. The steady and unsteady components of the velocity field are obtained using a conditional sampling laser-Doppler velocimetry (LDV) technique. The vorticity field is also derived from the measured velocity field. It is shown that combustion instability in the ramjet burner is accompanied by unsteady vortex shedding at the flame holding region. The vortex shedding occurs at the frequency of instability and it periodically distorts the flame front causing a cyclic variation of the flame area. This variation in the flame area results in a strong unsteady heat release rate capable of driving the longitudinal instabilities in the system. Author

A88-44680#
EXPERIMENTAL AND THEORETICAL STUDIES IN THE CONTROLLED MIXING VARIABLE GEOMETRY COMBUSTOR
A. K. GUPTA, M. R. MODARRES-RAZAVI (Maryland, University, College Park), and N. MARCHIONNA (Avco Lycoming Textron, Stratford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 14 p. Research supported by Avco Lycoming Textron. refs
(AIAA PAPER 88-2857)

The controlled-mixing-sustaining variable geometry combustor (VGC) presented for gas turbine engine applications allows better control of flow aerodynamics and an improved distribution of reactants in the combustor. The experimental VGC consists of up to five concentric/telescoping annuli having independent control of flow rate in each annulus. Both numerical and experimental results are presented, with a view to examining the effects of systematic variation for such parameters as combustor geometry, fuel nozzle injector design, radial swirl distribution, swirl length, and air-fuel distribution in various annuli. Both the center fuel-rich and center fuel-lean arrangements can furnish low NO and NOx emission levels. O.C.

A88-44681#
A MODEL FOR OPTIMIZING EMISSIONS AND STABILITY OF A GAS-TURBINE COMBUSTOR
S. M. CORREA and K. S. OVERTON (GE Research and Development Center, Schenectady, NY) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p. refs
(AIAA PAPER 88-2858)

A network of stirred and plug-flow reactors is presently used in a scheme involving about 30 species and 90 reactions to simulate continuous flow gas turbine combustors. Combustor geometry and air and fuel flow scheduling are left as variables, and an external loop based on principles of unstructured optimization in multiparameter spaces is used to repeatedly run the analysis. The ability to generate such known solutions as staged combustion for minimizing prompt and thermal NO(x), as well as the ability to evolve unique solutions in view of other design objectives, are demonstrated. O.C.

A88-44685#
OPTIMIZATION OF SUPERCRITICAL ROTOR SYSTEM FOR THE T406 ENGINE
P. D. HYLTON, S. A. KLUSMAN, and R. J. TRIPPETT (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 6 p.
(AIAA PAPER 88-2890)

The T406 advanced turboprop gas turbine engine features a power turbine rotor designed to operate above its first two critical speeds. A full scale supercritical shaft rig was designed to demonstrate the acceptability of such a design. The rig was then used to optimize a squeeze film damper for control of the two supercritical modes. This paper discusses the rig testing and computer analysis, which supported the power turbine optimization. The effects of damper characteristics on the rotor system logarithmic decrement were examined using a finite element rotor dynamic analysis routine. The test rig was used to evaluate the effects of oil pressure and temperature and damper configuration on actual rotor response. An optimized rotor configuration was achieved using this process. Author

A88-44703#
PAYOFFS FOR SUPERSONIC THROUGH FLOW FAN ENGINES IN HIGH MACH TRANSPORTS AND FIGHTERS
G. A. CHAMPAGNE (Pratt and Whitney, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p. refs
(AIAA PAPER 88-2945)

A study was conducted to evaluate the potential of incorporating turbofan engines with supersonic through flow fans in a Mach 2.3 civil transport and a Mach 2.5 fighter. In the 762,000 lb commercial transport, the supersonic fan engine provides a 14 percent improvement in range from 5400 to 6140 n m relative to the conventional engine. This range increase is due to a 9 percent reduction in specific fuel consumption and a 31 percent lighter engine/inlet/nacelle. In the Mach 2.5 fighter, the supersonic fan propulsion system provides a 2 percent reduction in takeoff gross weight. Author

A88-44704#
AN INVESTIGATION OF VERY HIGH BYPASS RATIO ENGINES FOR SUBSONIC TRANSPORTS
R. A. ZIMBRICK and J. L. COLEHOUR AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. refs
(AIAA PAPER 88-2953)

A study of propulsion system performance for a family of high bypass ratio turbofan engines is presented in this paper. The bypass ratio range is from 5 to 17.5, and both bare engine performance and nacelle installation performance have been considered. Geared, variable pitch and variable nozzle engines with bypass ratios of 10.6, 14 and 17.5 have been studied parametrically, and the performance of a fixed pitch, gearless engine of bypass ratio 9.6 has been estimated to represent an advanced engine with conventional mechanical complexity. Nacelle performance data for a bypass 5 engine have also been included as a baseline. Thrust reverser design for these engines is also considered. Results of this study indicate that nacelle losses do not reverse the trend of improving fuel efficiency with bypass ratio, out to at least bypass ratio 17.5, if innovative nacelle design approaches are used. The bypass 9.6 engine shows a lower fuel burn benefit than the bypass 17.5 engine, but is offers the potential of reduced mechanical complexity and lower maintenance cost. Author

A88-44706*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SMALL ENGINE COMPONENTS TEST FACILITY TURBINE TESTING CELL
BRENT C. NOWLIN and VINCENT G. VERHOFF (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. Previously announced in STAR as N88-22037.
(AIAA PAPER 88-2962)

NASA Lewis Research Center has designed and constructed a new state-of-the-art test facility. This facility, called the Small Engine Components Test Facility (SECTF), is used to test gas turbines and compressors at conditions similar to actual engine conditions. The SECTF is comprised of two separate facilities - a turbine test cell and a compressor test cell. The paper will describe the turbine test cell. The capabilities of the facility make it unique - no other facility of its kind is capable of combining its pressure, speed, and temperature ranges. Turbine inlet air ranges up to 9 atm (125 psig). The turbine exhaust pressure ranges from 0.15

atm (2 psia) to atmospheric pressure. Turbine inlet air temperatures range from ambient to 700 K (1260 deg R). The controllable speed of the turbine rotor ranges from 4000 to 60,000 rpm and the maximum power absorbed by the facility dynamometer is 1250 hp. The data acquisition system scans up to 2000 channels/sec. This paper will discuss in detail the capabilities of the facility, overall facility design, instrumentation used in the facility, and the data acquisition system. Actual research data is not discussed. Author

A88-44712#
MODULAR COMPUTER CODES FOR THE TRAINING IN TURBINES DESIGN
G. TORELLA (Accademia Aeronautica, Pozzuoli, Italy) and P. DI MARTINO (Alfa Romeo Avio S.p.A., Pomigliano d'Arco, Italy) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p. refs
(AIAA PAPER 88-2973)

The paper deals with the development and the set-up of two modular computer codes for the training in turbines design. The systems are different owing to the computers used. The simplest one may use personal computers with 8-16 Mhz clock microprocessors. The most advanced uses a VAX 8300 and a Tektronix computer. The paper shows some results of turbine design calculations carried out with both systems. Author

A88-44718#
21ST CENTURY HIGH SPEED TRANSPORT PROPULSION
MARTIN G. SMITH, JR. (Pratt and Whitney, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. refs
(AIAA PAPER 88-2987)

The NASA-sponsored High Speed Commercial Transport (HSCT) program's marketing studies have given attention to 300-passenger 6000-n. mi. range supersonic transports operating in the Mach 2-5 range. A key factor in the feasibility of such aircraft is the propulsion system chosen, which in addition to being fuel efficient must be reliable and environmentally acceptable. These studies have recently progressed to the point where the speed regime for the HSCT has been narrowed to Mach 2-plus to Mach 3-plus, using a kerosene-type fuel. A subsequent, more advanced vehicle may use liquid natural gas to cruise at speeds of up to Mach 5. O.C.

A88-44721*# Rolls-Royce, Inc., Atlanta, Ga.
VECTORING SINGLE EXPANSION RAMP NOZZLE (VSERN) STATIC MODEL TEST PROGRAM
D. J. H. EAMES (Rolls-Royce, Inc., Atlanta, GA) and M. L. MASON (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. refs
(AIAA PAPER 88-3000)

A variable throat-area, side-vectoring single expansion ramp nozzle (VSERN) concept's internal performance characteristics are studied with a view to controlling the bypass flow of an unmixed turbofan engine. Static tests have been conducted on VSERN at NASA-Langley using a variety of parametric models giving attention to the effects of upstream bend angle, ramp geometry, area ratio, and nozzle pressure ratio on static thrust and flow performance. Advantages of VSERN over the conventional vectoring axisymmetric convergent side-nozzles typified by those of the Harrier's Pegasus engine. O.C.

A88-44727*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF SPATIAL INLET TEMPERATURE AND PRESSURE DISTORTION ON TURBOFAN ENGINE STABILITY
CHARLES M. MEHALIC (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 16 p. Previously announced in STAR as N88-21162. refs
(AIAA PAPER 88-3016)

The effects of circumferential and radial inlet temperature distortion, circumferential pressure distortion, and combined temperature and pressure distortion on the stability of an advanced turbofan engine were investigated experimentally at simulated altitude conditions. With circumferential and radial inlet temperature distortion, a flow instability generated by the fan operating near stall caused the high-pressure compressor to surge at, or near, the same time as the fan. The effect of combined distortion was dependent on the relative location of the high-temperature and low-pressure regions; high-pressure compressor stalls occurred when the regions coincided, and fan stalls occurred with the regions separated. Author

A88-44728#
ENDURANCE GROUND TESTING OF THE AR318 TURBOPROP ENGINE
G. TORELLA (Accademia Aeronautica, Pozzuoli, Italy), G. LIOTTI, and F. BRUNO (Alfa Romeo Avio S.p.A., Pomigliano d'Arco, Italy) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. refs
(AIAA PAPER 88-3018)

An endurance test of the AR318 single shaft turboprop engine has been carried out in order to verify the integrity of the engine and the degradation of performance for a more severe take-off rating with an increased Turbine Entry Temperature (T.E.T.). The paper deals with the activities performed and with the numerical computer codes developed and set up for processing the experimental data obtained by hangar test bed. Results of calculations for controlling the reliability of data, for engine simulation, for performance monitoring and for diagnostic are shown. Author

A88-44729#
COMPARABILITY TESTS IN THE INTERNATIONAL TURBINE ENGINE TEST FACILITIES
JAMES G. MITCHELL (Micro Craft, Inc., Tullahoma, TN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p.
(AIAA PAPER 88-3020)

This paper is an introduction to a lengthy investigation performed under the auspices of the AGARD Propulsion and Energetics Panel. Since 1980 technical personnel from the NATO countries have conducted a series of closely controlled tests on turbine engines. These tests were conducted in test facilities which simulate altitude flight conditions as well as in ground-level test beds which provide no ram air or altitude simulation. The test data were examined to determine differences in important measurements at common operating conditions. Studies were performed to determine the probable causes of the data variation as a function of test-facility influences and test techniques. Author

A88-44731#
TWO DIMENSIONAL NOZZLE THRUST REVERSER TESTS
SHARAD NAIK and CHARLIE CHIARELLI (Rohr Industries, Inc., Chula Vista, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p. refs
(AIAA PAPER 88-3028)

A scale model test of a two-dimensional nozzle with an integral thrust reverser was performed at the Rohr cold flow static airflow facility. A parametric evaluation of the reverser performance for different efflux angles, splay angles and nozzle pressure ratios was performed. Detailed total pressure surveys were made at the exit of the reverser and static pressures inside the reverser ducts and the transition duct were measured. Flow visualization iside of the reverser ducts was performed using oil film and smoke techniques. The efflux plume was made visible by carbon-dioxide gas introduced into the flow upstream of the model. The reverser was designed to achieve an axial thrust coefficient of 50 percent which was exceeded over the range of nozzle pressure ratios of 1.5 to 4.5. Author

A88-44738#
COMBUSTION OF POLYETHYLENE IN A SOLID FUEL RAMJET - A COMPARISON OF COMPUTATIONAL AND EXPERIMENTAL RESULTS
P. J. M. ELANDS, P. A. O. G. KORTING (Centrale Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek, Rijswijk, Netherlands), F. DIJKSTRA, and T. WIJCHERS (Delft, Technische Hogeschool, Netherlands) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. Research supported by the Stichting voor de Technische Wetenschappen and National Fund for Supercomputers. refs
(AIAA PAPER 88-3043)

A numerical simulation of flow and combustion processes in a solid-fuel ramjet's combustion chamber is presently validated in light of results from a test program employing polyethylene cylindrical fuel grains. The numerical simulation described two-dimensional, steady-state turbulent flows through channels with and without a sudden expansion. The validation gives attention to the comparison of regression rate data in relation to chamber pressure, air mass flow, inlet air temperature, and chamber step dimensions. The effective heat of gasification of the fuel is noted to be an important parameter. O.C.

A88-44739#
MEASUREMENT IN A SOLID FUEL RAMJET COMBUSTION WITH SWIRL
D. A. DUESTERHAUS and A. HOEGL (DFVLR, Institut fuer Chemische Antriebe und Verfahrenstechnik, Hardthausen am Kocher, Federal Republic of Germany) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. refs
(AIAA PAPER 88-3045)

A series of experiments of a directly connected solid fuel ramjet combustor were conducted with and without inlet flow swirl. The swirl number ranged from 0 to .55 with several swirl flow distributions for polyethylene and a modified hydroxyl terminated polybutadiene (HTPB) fuel. The effect of inlet temperature and air mass flow density on fuel regression and combustion efficiency were measured. Temperature and gas concentration profiles were also measured at two different locations. Author

A88-44750#
SIDE-DUMP SOLID FUEL RAMJET COMBUSTOR EVALUATION
JAMES NABITY and TONY WALLS (U.S. Naval Weapons Center, China Lake, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p.
(AIAA PAPER 88-3072)

In volume-limited applications, a side-dump configuration solid-fuel ramjet may yield a substantial performance improvement over the more conventional center-dump configuration. Attention is presently given to the problem of a lack of uniform fuel regression along the grain length, for the cases of various port area/injector area, port area/exit nozzle area, dome length and dump angle geometries. Fuel regression rates were found to be comparable to predictions by a coaxial combustor model; combustion efficiencies approached those of a coaxial dump combustor with bypass air. A correlation is developed which indicates the effect of important parameters on flameholding. O.C.

A88-44752#
ADVANCED TURBOPROP AND PROPFAN DEVELOPMENT AND TESTING
T. F. GEE and A. S. NOVICK (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p.
(AIAA PAPER 88-3080)

Allison Gas Turbine Division has recently completed development of two 'turboprop' engines. Specifically, the T56-A-427 for application in the Grumman E-2C and C-2A aircraft and the 501-M78 for the NASA Propfan Test Assessment program. The T56-A-427 is a fully qualified engine for prime aircraft power while the 501-M78 completed a PFRT program for research flight testing. This paper describes the two engines and their development programs. Author

A88-44765#
NOZZLE AIRFLOW INFLUENCES ON FUEL PATTERNATION
T. J. ROSFJORD (United Technologies Research Center, East Hartford, CT) and W. A. ECKERLE (Clarkson University, Potsdam, NY) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p.
(Contract F33615-85-C-2415)
(AIAA PAPER 88-3140)

The velocity and turbulence levels downstream of eight variations of a model gas turbine, aerating, fuel nozzle have been measured. The nozzle configurations were assemblies which purposefully altered the airflow through the nozzle by misaligning swirlers, changing the number of vanes in a swirler or contouring swirl vane trailing edges. Data were acquired by a traversing, two-component laser velocimeter in planes 0.060 in. (1.5 mm) or 2.50 in. (6.4 cm) downstream from the nozzle exit. Analyses of these data indicated that very symmetric flowfields can be produced. Such control was easier to achieve for the airflow than the fuel, supporting the position that nozzle patternation quality was more dependent on the fuel distribution in the nozzle. The presence of swirler wakes could always be discerned at the nozzle exit; the extreme variations imposed by coarse swirlers could dominate the flow. Such airflow influences were not apparent in the velocity profiles at downstream locations. However, their influence in convecting a higher fuel mass flux persisted from the nozzle exit and produced extreme variations in the spray pattern. Author

A88-44771*# Analytical Services and Materials, Inc., Hampton, Va.
THE EFFECTS OF FINITE RATE CHEMICAL PROCESSES ON HIGH ENTHALPY NOZZLE PERFORMANCE - A COMPARISON BETWEEN SPARK AND SEAGULL
M. H. CARPENTER (Analytical Services and Materials, Inc., Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 17 p. refs
(Contract NAS1-18599)
(AIAA PAPER 88-3157)

The generalized chemistry version of the computer code SPARK is extended to include two higher-order numerical schemes, yielding fourth-order spatial accuracy for the inviscid terms. The new and old formulations are used to study the influences of finite rate chemical processes on nozzle performance. A determination is made of the computationally optimum reaction scheme for use in high-enthalpy nozzles. Finite rate calculations are compared with the frozen and equilibrium limits to assess the validity of each formulation. In addition, the finite rate SPARK results are compared with the constant ratio of specific heats (gamma) SEAGULL code, to determine its accuracy in variable gamma flow situations. Finally, the higher-order SPARK code is used to calculate nozzle flows having species stratification. Flame quenching occurs at low nozzle pressures, while for high pressures, significant burning continues in the nozzle. Author

A88-44773#
OPTIMIZED SUPERSONIC EXHAUST NOZZLES FOR HYPERSONIC PROPULSION
G. R. NICKERSON, S. S. DUNN (Software and Engineering Associates, Inc., Carson City, NV), and D. MIGDAL (Pratt and Whitney, West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p.
(AIAA PAPER 88-3161)

A family of thrust optimized two-dimensional ramp nozzles is displayed. The nozzles are of the internal-external expansion type with variable length straight outer cowls, expanding on to variable shape internal contoured ramps. The ramp shapes are determined by using calculus of variations techniques in a method-of-characteristics flow solution. The effects of geometric

variables, such as area ratio, overall length, and nozzle inlet Mach number are used to examine their effect on contour shape, thrust coefficient, and moment coefficient. The range of variables which have significant impact on performance and moments are shown. Author

A88-44779#
ANALYTICAL REDUNDANCY DESIGN FOR IMPROVED ENGINE CONTROL RELIABILITY - FINAL REVIEW
J. A. SWAN (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) and R. W. VIZZINI (U.S. Navy, Naval Air Propulsion Test Center, Trenton, NJ) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. refs
(Contract N00140-83-C-9046)
(AIAA PAPER 88-3176)

The isolation of hard and soft control system failures and the provision of control system reconfiguration for all sensor and actuator failures are features of the Analytical Redundancy Technology for Engine Reliability Improvement (ARTERI) system of the GE23A. An account is presently given of the architecture of the system's real-time component-level model of the engine, which employs adjustable component performance levels, a component-tracking module, failure- detection and-isolation logic, and a reconfiguration logic. Also noted are the results of ARTERI simulation tests conducted against a series of simplified linear engine models, a simplified nonlinear engine model, and a detailed nonlinear aerothermo model of the GE23A engine. O.C.

A88-44781#
CONSTRAINED NONLINEAR OPTIMAL JET ENGINE ACCELERATION CONTROL
JUN-XIANG LIANG (China Aeronautical Research Institute of Technology and Economics, Beijing, People's Republic of China) and BRUCE K. WALKER (Cincinnati, University, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. refs
(AIAA PAPER 88-3178)

The problem of controlling turbojet engine accelerations such that the compressor stall boundary is not exceeded is examined. By converting the formulation of the engine dynamics for a typical turbojet engine to nondimensional variables, the problem is cast as a constrained nonlinear optimal control problem where the performance index is the time required for the acceleration. Efforts to find the optimal time history using the steepest descent method are shown to lead to nonconvergent results for this applicaiton. By further modifying the formulation of the problem to make the control a nondimensional function of other variables and adding a penalty on terminal rotor speed, the steepest descent solution is successful and the results indicate significant improvement in the time required for accelerations. These results show that optimal control theory can lead to faster accelerations when a specific bound is placed on the allowable stall margin. Author

A88-44799#
CORRELATION OF GAS TURBINE PERFORMANCE WITH CHARACTERISTIC TIME MODELS
W. S. DERR, K. FRITSKY, B. ROYDS, and A. M. MELLOR (Drexel University, Philadelphia, PA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p. Research supported by General Motors Corp. refs
(Contract NSF ENG-87-12997)
(AIAA PAPER 88-3225)

Characteristic time models are used to predict and correlate performance of an Allison Gas Turbine combustor, based on run data supplied by Allison. The limited success encountered in accurately predicting pollutant emissions, combustion efficiency, and the fuel flow at ignition and lean blowoff is mainly attributed to the lack of reliable emissions and efficiency measurements. Correlations of combustor performance, however, appeared just as good as correlations developed by Rizk and Mongia using a hybrid model consisting of Lefebvre's performance models and Allison's 3-D computer code. The simplicity of the characteristic time models and their good correlation ability offer advantages over Rizk and Mongia's hybrid model. Author

A88-44801#
CHARACTERISTICS OF AXISYMMETRIC CONFINED JET THRUST VECTOR CONTROL
P. G. LAMBERT and M. E. FRANKE (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 6 p. refs
(AIAA PAPER 88-3237)

Vector capability of a confined jet thrust vector control (CJTVC) nozzle is discussed. In a CJTVC nozzle, secondary injection is used to vector a highly over-expanded supersonic jet in a confined region. The effects of secondary pressure and flow rate as well as injection port area and shape on side force are described. Axial thrust penalty due to the confined region is presented. Nozzle performance is shown also in terms of dimensionless parameters. Incomplete vectoring and unstable operation are found under some conditions. Author

A88-44803#
AN OPERATING AND SUPPORT COST MODEL FOR AIRCRAFT ENGINES - SOSCM
THOMAS D. MEITZLER (USAF, Acquisition Logistics Center, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p.
(AIAA PAPER 88-3244)

The continuing requirement for the Aeronautical Systems Division, Deputy for Propulsion, Director of Acquisition Logistics (ASD/YZL), to analyze the impacts on life cycle costs caused by acquisition decisions generated the need for an operating and support cost model uniquely designed for, and identifiable to, aircraft engines. To fulfill this requirement for an analytical tool, two basic tasks were defined and accomplished. First, analysts defined the input/output requirements along with the model's algorithms. Second, they generated a simple-to-use, menu-driven program for a microcomputer. The model is deterministic in nature and provides the user with a capability to make support cost comparisons among engines. This paper is a brief description of the resulting model which has become known as SOSCM (Super Operating and Support Cost Model) and which has been used on several engine acquisition programs. The paper includes a discussion of the input/output requirements, the algorithms, and the analytical capabilities. Author

A88-44804#
DEVELOPMENT OF AN ENGINE FSED COMPUTER-AIDED DATA BASE
S. M. COTE (U.S. Navy, Naval Air Development Center, Warminster, PA) and M. C. DUFFLES (U.S. Navy, Naval Air Systems Command, Washington, DC) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 6 p. refs
(AIAA PAPER 88-3245)

In the 1970s, several new aircraft turbine engine full scale engineering development (FSED) programs were completed by the military services. The requirements and accomplishments of each engine qualification were very important to the Navy propulsion community. Past turbine engine technical data and program data were and are viewed as the essential ingredients to any new full scale engineering development plan. The planning for future propulsion system developments is predicated on the understanding of the successes or failures of past programs and being able to command a responsive and accurate data base for source-selection and evaluation. One hundred twenty-nine engine programs have been assembled, verified, and entered into a PC spread-sheet data base. This FSED data base has been exercised by the Navy in several new engine program evaluations. Author

A88-44806#
THE J402-CA-702 - A MODERN 1000 LB. THRUST RPV ENGINE

E. RAZINSKY (Teledyne CAE, Toledo, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p.
(AIAA PAPER 88-3248)

Design features and performance capabilities are presented for the J402-CA-702 RPV single-spool turbojet, which has achieved a sea level static thrust of 960 lb and is fully qualified for aerial target and RPV applications, with an envelope that encompasses altitudes of up to 55,000 ft and speeds of up to Mach 0.9. The spool carries a two-stage axial compressor section followed by a centrifugal stage; a single-stage turbine is employed. All three compressor stages are integrally cast from 17-4 PH stainless steel. O.C.

A88-44810*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INLET STARTING PREDICTIONS FOR SIDEWALL-COMPRESSION SCRAMJET INLETS
CARL A. TREXLER (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. refs
(AIAA PAPER 88-3257)

While inlet capture, total pressure recovery, and compression are important performance parameters in the design of scramjet inlets, the inlet must be capable of starting. An analytical, inviscid method has been developed that provides first order starting information for sidewall-compression scramjet inlets and trends have been established for some of the parameters that affect inlet starting. These parameters include sidewall contraction ratio, cowl position, Mach number, sweep angle, fuel injection struts, and sidewall and strut compression angles. Results from the parametric study are compared with data from both no-strut and two-strut inlet models. Author

A88-44812#
THE VERIFICATION OF INLET/ENGINE DISTORTION COMPATIBILITY
TATSUO ABE, MASAHIRO AKAGI (Japan Defense Agency, Technical Research and Development Institute, Tokyo), HIDEHIKO NISHIWAKI (Kawasaki Heavy Industries Co., Ltd., Gifu, Japan), SATOSHI YASHIMA, and JUNCHI SAKAKI (Ishikawajima-Harima Heavy Industries Co., Ltd., Aircraft Engine Div., Tokyo, Japan) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p. refs
(AIAA PAPER 88-3267)

An account is given of inlet/engine flow distortion and compatibility design considerations and test results for the F3-30 low bypass turbofan engine developed for a Japanese intermediate training aircraft. No engine surge or flame-out problems have been encountered during flight tests giving attention to higher-than-design value angles-of-attack and sideslip. Simulator tests have been conducted for high angle-of-attack, spin, and high (subsonic) speed conditions. O.C.

A88-44813#
METHODS OF INTEGRATED AIRCRAFT PROPULSION CONTROL PROGRAM DEFINITION
O. K. IUGOV, O. D. SELIVANOV, V. N. KARASEV, and P. L. POKOTILO (Tsentral'nyi Nauchno-Issledovatel'skii Institut Aviatsionnogo Motorostroeniia, Moscow, USSR) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p.
(AIAA PAPER 88-3268)

Methodology of study and synthesis of integrated aircraft propulsion control programs is described. Mathematic models of aircraft propulsion and control are developed. The up-to-date mathematic tooling is used for optimization and regression analysis. Examples of integrated propulsion control efficiency evaluation for a number of typical flight profiles of a modern multimission aircraft are given. Author

A88-44814#
FINITE ELEMENT SIMULATION OF JETS IN A CROSSFLOW WITH COMPLEX NOZZLE CONFIGURATIONS FOR V/STOL APPLICATIONS
TAE S. OH and JOSEPH A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. refs
(AIAA PAPER 88-3269)

A flowfield and surface pressure distribution prediction method is presented for the flow induced by three-dimensional jets injected from a flat surface into a crossflow, reflecting the first-order influence of the fluctuating character of the turbulent flow via axial turbulence intensity data. The performance of this prediction method is verified for a single circular jet in a crossflow at a jet/crossflow velocity ratio value of 4. The same methodology is then applied to single- and dual-rectangular jets in a crossflow at the same velocity ratio. Most of the important surface pressure distribution features are predicted. O.C.

A88-44816#
THE AERODYNAMIC PERFORMANCE OF A MODERN VAPORIZING COMBUSTOR DUMP DIFFUSER
S. J. STEVENS, A. P. WRAY (Loughborough University of Technology, England), and P. D. PRICE (Rolls-Royce, PLC, Bristol, England) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. Research supported by the Ministry of Defence Procurement Executive.
(AIAA PAPER 88-3273)

An experimental investigation has been conducted to ascertain the flow characteristics and primary pressure loss mechanism in a vaporizing combustor system, using a four-burner-sector plexiglass model of the system. Most of the overall pressure loss is noted to occur downstream of the prediffuser, and much of that is associated with flow separations from the cooling ring scoops; this yields poor flow distribution at the entry to both flame-tube feed annuli, with the outer flow being the most affected. O.C.

A88-44817#
EXPERIMENTAL STUDIES OF COMBUSTOR DILUTION ZONE AERODYNAMICS
S. J. STEVENS and J. F. CARROTTE (Loughborough University of Technology, England) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. Sponsorship: Ministry of Defence. refs
(Contract MOD-ER1/9/4/2170/113RAE)
(AIAA PAPER 88-3274)

An experimental investigation has been carried out to study circumferential irregularities in the temperature distribution downstream of a row of 16 heated jets injected into a confined annular crowsflow at a momentum flux ratio of 4. When the dilution air is supplied from a representative feed annulus, the resulting approach velocity produces a complex flow field which issues through the rear of each dilution hole and which varies from one jet to another. Measurements of both temperature and velocity in planes parallel and perpendicular to the injection wall have indicated the influence of the exit velocity profiles on the subsequent development of two jets. The structure of a jet is modified by the exit velocity profile causing distortions of the temperature distribution about the hole center-plane. Since each jet has its own mixing characteristics an irregular temperature pattern around the dilution annulus is produced. Mean vorticity values are calculated from the velocity data and are used to explain differences between the structures of the jets defined here and those of the well documented single jet issuing into a relatively unconfined crossflow. Author

A88-44818#
CASCADE PREDIFFUSER PERFORMANCE EVALUATION
T. J. MADDEN, B. C. SCHLEIN, and W. B. WAGNER (Pratt and Whitney, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint

Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p. refs
(AIAA PAPER 88-3275)

The influence of several annular cascade prediffusers in representative gas turbine engine combustors is experimentally investigated. Prediffusers deccelerate compressor discharge air flow to reduce total pressure losses as the flow reaches the combustor hood and shroud passages outside the combustor. A cascade prediffuser incorporates a multitude of struts, with one located circumferentially between each fuel injector, and all are placed closely enough to induce interaction among their wakes as the flow traverses the combustor hood. Attention is given to the results of a parametric study conducted for a variety of prediffuser area ratios, lengths, wall contours, and combustor shroud flow variations. O.C.

A88-44841#
E-2C T56-A-427 ENGINE MONITORING SYSTEM
JIM JACKSON (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p.
(AIAA PAPER 88-3414)

An engine monitoring system for the T56-A-427 engine was developed by Allison Gas Turbine under Navy contract for retrofit into the E-2C aircraft. The system, designated as T56-A-427 Engine Monitoring System (EMS), is designed to continuously monitor engine health, record pertinent information, and provide diagnostic information to operating personnel. In-house and flight testing are underway, and system completion is expected in late 1988. Advances in state-of-the-art computer and sensor technology have improved system cost and reliability over previous EMS systems. Author

A88-44842#
DAMAGE TOLERANCE CONCEPTS FOR ADVANCED ENGINES
T. E. FARMER (United Technologies Corp., Pratt and Whitney, West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 6 p. refs
(AIAA PAPER 88-3165)

Planned increases in thrust to weight for future gas turbine engines require dramatically higher operating temperatures and rotor speeds. This necessitates simpler design, improved materials and sophisticated fabrication techniques. Damage Tolerance Design (DTD) has been established as the basis for gas turbine engine design and maintenance in the United States. The advanced configurations, bonded structures, composites, anisotropic alloys and less ductile materials required to meet the advanced engine goals challenge the current DTD philosophy. Fortunately, interim plans for incremental increases in performance and engine configuration to meet long-term goals afford the opportunities for developing transition technologies to meet these objectives. Author

A88-44843#
ANALYSIS AND SOLUTION OF THE ROTOR INSTABILITY PROBLEM IN THE ADVANCED MODEL TF30 P111+ ENGINE
J. T. AKIN, V. S. FEHR (United Technologies Corp., Pratt and Whitney, East Hartford, CT), and D. L. EVANS (USAF, Air Logistics Center, Oklahoma City, OK) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p. refs
(AIAA PAPER 88-3166)

The TF30 P111+ engine developed a high pressure spool rotor dynamic instability when it went into production in mid 1986. Vibration rejection rates were as high as 50 percent until the instability was eliminated with the incorporation of an oil-film damper at the high pressure turbine (HPT) bearing. This paper focuses on the analytical treatment of the instability and includes a summary of engine testing that was done to help diagnose the problem. Correlation between test and analysis implicate the aerodynamic cross-coupled forces from the HPT system as the destabilizing mechanism. Results from the stability model are presented that show the damper completely suppressing the instability as later confirmed by ground level tests. This experience points out the subtle characteristic of rotor instability and the need for improved quantification of the destabilizing mechanisms that produce it. The predecessor engine model had been in service for years without the problem, yet it developed a rotor instability with the incorporation of a new HPT that had no obvious impact on engine rotor dynamics. Author

A88-44903
AIRCRAFT ENGINES [DVIGATELI LETATELNYKH APPARATOV]
ANATOLII ANDREEVICH GAR'KAVYI, AL'BERT VIKTOROVICH CHAIKOVSKII, and SEMEN ISAAKOVICH LOVINSKII Moscow, Izdatel'stvo Mashinostroenie, 1987, 288 p. In Russian. refs

The general design, principles of operation, and the main components of aircraft engines are discussed with emphasis of gas-turbine engines. In particular, attention is given to the fundamentals of thermodynamics, working processes in aircraft engines, the principal types of aircraft engines and their applications, and the performance characteristics and limitations of gas turbine engines. The discussion also covers the design and operation of air intakes, compressors, and combustion chambers; design and operation of turboramjets, bypass, turboprop, turbofan, and compressorless engines; and auxiliary systems. V.L.

A88-45010#
DESIGN AND TEST OF A LOW ASPECT RATIO FAN STAGE
T. L. CREASON and S. BAGHDADI (United Technologies Corp., Pratt and Whitney, West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p.
(AIAA PAPER 88-2816)

The first part of a plan aimed at quantifying the benefits of low aspect ratio and aerodynamic sweep on high speed compressor and fan stages has been completed. A low aspect ratio unswept fan stage having a pressure ratio of 2.2 at a tip speed of 1558 ft/sec has been designed and tested as part of the company's independent research and development effort. The fan has demonstrated performance well beyond the currently accepted state-of-the-art levels. Author

A88-45011*# General Motors Corp., Indianapolis, Ind.
THE DESIGN OF AN AIR-COOLED METALLIC HIGH TEMPERATURE RADIAL TURBINE
PHILIP H. SNYDER (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) and RICHARD J. ROELKE (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. refs
(AIAA PAPER 88-2872)

Recent trends in small advanced gas turbine engines call for higher turbine inlet temperatures. Advances in radial turbine technology have opened the way for a cooled metallic radial turbine capable of withstanding turbine inlet temperatures of 2500 F while meeting the challenge of high efficiency in this small flow size range. In response to this need, a small air-cooled radial turbine has been designed utilizing internal blade coolant passages. The coolant flow passage design is uniquely tailored to simultaneously meet rotor cooling needs and rotor fabrication constraints. The rotor flow-path design seeks to realize improved aerodynamic blade loading characteristics and high efficiency while satisfying rotor life requirements. An up-scaled version of the final engine rotor is currently under fabrication and, after instrumentation, will be tested in the warm turbine test facility at the NASA Lewis Research Center. Author

A88-45120#
A REPORT ON HIGH SPEED WIND TUNNEL TESTING OF THE LARGE SCALE ADVANCED PROP-FAN
W. A. CAMPBELL, H. S. WAINAUSKI, and P. R. BUSHNELL (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT)

AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 19 p. refs
(AIAA PAPER 88-2802)

This paper presents a summary of the High Speed Wind Tunnel Testing of the SR-7L Large Scale Advanced Prop-Fan (LAP). The LAP is a 9 foot diameter, 8 bladed tractor type rated for 6,000 SHP at 1698 RPM. It was designed and built by Hamilton Standard under contract to the NASA Lewis Research Center. The LAP employs thin swept blades to provide efficient propulsion and reduced noise at flight speeds up to Mach 0.85. Testing was conducted in the ONERA S1-MA Atmospheric Wind Tunnel in Modane, France. The test objectives were to confirm that the LAP was free from high speed classical flutter, determine the structural and aerodynamic response to angular inflow, measure blade surface pressures (steady and unsteady) and evaluate the aerodynamic performance at various blade angles, rotational speeds and flight Mach numbers. The results show that the measured structural and aerodynamic performance of the LAP correlated well with analytical predictions thereby providing confidence in the computer prediction codes utilized for this test and for current Pro-Fan product design activities. There were no signs of classical flutter throughout any phase of test up to and including the 0.84 maximum Mach number achieved. Steady and unsteady blade surface pressures were successfully measured for a wide range of Mach numbers, inflow angles, rotational speeds and blade angles. Samples of the data acquired and correlations with predictions are presented in this paper. Author

A88-45281#
FURTHER DEVELOPMENT OF PNEUMATIC THRUST-DEFLECTING POWERED-LIFT SYSTEMS
ROBERT J. ENGLAR (Lockheed-Georgia Co., Marietta) Journal of Aircraft (ISSN 0021-8669), vol. 25, April 1988, p. 324-333. *Previously cited in issue 08, p. 1050, Accession no. A87-22353.* refs

A88-45307#
IDENTIFICATION INVESTIGATION OF CLOSED-LOOP AEROENGINE CONTROL SYSTEM
SIQI FAN, JINWEN YU (Northwestern Polytechnical University, Xian, People's Republic of China), JINGYI CHU, and JINJING LI (Xian Aeroengine Co., People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, March 1988, p. A142-A147. In Chinese, with abstract in English. refs

An aeroengine model can be identified from actual closed-loop engine test data if a pseudorandom binary sequence as a test signal acts on the feedback circuit of the closed-loop control system. The fuel flow excited by PRBS is the input signal of the engine identification and the speed is the output. This paper presents the identification test method that has been applied to the Spey MK202 engine at the testbed and discusses the test signal analysis method that has been implemented at data processor. The model parameters of the engine have been identified by use of the Hsia method. The model examination shows that the result obtained with this method is satisfactory. Author

A88-45596
AIRCRAFT ELECTRICAL SYSTEMS (3RD REVISED AND ENLARGED EDITION)
E. H. J. PALLETT Harlow, England/New York, Longman Scientific and Technical/John Wiley and Sons, Inc., 1987, 239 p.

An introduction to aircraft electrical systems is presented in a textbook for maintenance engineers and pilots. Fundamental electrical principles on generation and conversion of power supplies are reviewed and applied to aircraft systems. Topics covered include ac and dc power supplies, power conversion equipment, external and auxiliary power supplies, and power distribution. Circuit controlling and protection devices, measuring instruments, and warning indication systems are examined. Power utilization by motors and systems, and electrical diagrams and identification schemes are discussed. R.B.

A88-45617#
INVESTIGATION OF COWL VENT SLOTS FOR STABILITY ENHANCEMENT IN MITS SCRAMJET INLETS
M. E. WHITE, J. R. STEVENS, D. M. VAN WIE, L. A. MATTES, and J. L. KEIRSEY (Johns Hopkins University, Laurel, MD) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p.
(AIAA PAPER 88-2956)

The supercritical stability characteristics of inward-turning scoop inlets applicable to dual-mode scramjet engines have been greatly enhanced by the incorporation of a series of cowl vent slots just downstream of the inlet throat. Data has been obtained over a range of Mach number, angle-of-attack and role angle using two single-scoop inlet models. A database has been established to characterize the effect of varying available slot spill area on the stable operating range of the inlet, and on the maximum inlet air capture and pressure recovery. Also inherent in this database is information isolator duct lengths required for stabilization of an inlet terminal shock system of near normal shock strength. The results presented herein cover a Mach number range from 3.0 to 4.75. Author

A88-45618*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A STATIC INVESTIGATION OF A SIMULTANEOUS PITCH AND YAW THRUST VECTORING 2-D C-D NOZZLE
JOHN G. TAYLOR (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 13 p. refs
(AIAA PAPER 88-2998)

An investigation has been conducted in the static test facility of the Langley 16-Foot Transonic Tunnel to determine the internal performance and flow-turning capability of a two-dimensional convergent-divergent nozzle. Thrust vectoring in the pitch plane was provided by rotation of the divergent flaps. The exhaust stream was turned in the yaw direction by deflection of yaw flaps hinged at the end of the nozzle sidewalls. The yaw flap hinge location was varied along the divergent region of the nozzle at four locations including the exit plane and the throat plane. The three hinge locations upstream of the nozzle exit plane required the downstream corners of both upper and lower divergent flaps to be cut off to eliminate interference when the yaw flaps were deflected. Three different lengths of yaw flaps were tested at several angles of deflection. The nozzle simulated a dry power setting with an expansion ratio typical of subsonic cruise and was tested at nozzle pressure ratios from 2.0 to 7.0. Author

A88-45624#
ELECTRONIC CONTROL SYSTEM FOR A PROPFAN ENGINE
HERBERT C. ZICKWOLF, JR. and E. F. COLE (Pratt and Whitney, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p.
(AIAA PAPER 88-3174)

A full authority digital electronic control system was developed for the PW-Allison 578DX two spool, counter-rotating, open rotor propfan propulsion system. The control was designed to reduce pilot workload by use of a single input command (percent thrust request). All scheduling of engine effectors to control horsepower, prop speed, compressor variable geometry, and protective limits surveillance is accomplished by the control. The electronic control unit is fully redundant and incorporates adaptive logic to accommodate single or multiple failures. A general description of the control system is presented and the benefits are discussed. Author

A88-45681#
REVIEW OF LIQUID-COOLED AIRCRAFT ENGINE INSTALLATION AERODYNAMICS
S. J. MILEY (Texas A & M University, College Station) Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 222-228. refs

The aerodynamic behavior of liquid-cooled aircraft engine cooling installations is reviewed. Design considerations for inlets,

diffusers, and exists are discussed. It is shown that the design of an efficient liquid-cooled installation is a technically sophisticated problem. This problem should not be underestimated in the development program of liquid-cooled aircraft engines. Questions are raised concerning the availability of suitable radiators for aircraft installations. Author

N88-23805*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
AUGMENTOR PERFORMANCE OF AN F100 ENGINE MODEL DERIVATIVE ENGINE IN AN F-15 AIRPLANE
JAMES T. WALTON and FRANK W. BURCHAM, JR. May 1986 21 p
(NASA-TM-86745; H-1309; NAS 1.15:86745) Avail: NTIS HC A03/MF A01 CSCL 21E

The transient performance of the F100 engine model derivative (EMD) augmentor was evaluated in an F-15 airplane. The augmentor was a newly designed 16-segment augmentor. It was tested with a segment-1 sprayring with 90 deg fuel injection, and later with a modified segment-1 sprayring with centerline fuel injection. With the 90 deg injection, no-lights occurred at high altitudes with airspeeds of 175 knots or less; however, the results were better than when using the standard F100-PW-100 engine. With the centerline fuel injection, all transients were successful to an altitude of 15,500 meters and an airspeed of 150 knots: no failures to light, blowouts, or stalls occurred. For a first flight evaluation, the augmentor transient performance was excellent. Author

N88-23806*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE CHALLENGES AND OPPORTUNITIES OF SUPERSONIC TRANSPORT PROPULSION TECHNOLOGY
WILLIAM C. STRACK and SHELBY J. MORRIS, JR. (National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.) Jul. 1988 18 p Prepared for presentation at the 24th Joint Propulsion Conference, Boston, Mass., 11-13, Jul. 1988
(NASA-TM-100921; E-4178; NAS 1.15:100921; AIAA-88-2985) Avail: NTIS HC A03/MF A01 CSCL 21E

The major challenges confronting the propulsion community for civil supersonic transport applications are identified: high propulsion system efficiency at both supersonic and subsonic cruise conditions, low-cost fuel with adequate thermal stability at high temperatures, low noise cycles and exhaust systems, low emission combustion systems, and low drag installations. Both past progress and future opportunities are discussed in relation to perceived technology shortfalls for an economically successful airplane that satisfies environmental constraints. Author

N88-24638# Battelle Columbus Labs., Ohio.
AIRCRAFT EMISSIONS CHARACTERIZATION: TF41-A2, TF30-P103 AND TF30-P109 ENGINES Final Report, Dec. 1985 - Mar. 1987
C. W. SPICER, M. W. HOLDREN, S. E. MILLER, D. L. SMITH, and R. N. SMITH Dec. 1987 76 p
(Contract F08635-85-C-0122)
(AD-A192053; AFESC/ESL-TR-87-27) Avail: NTIS HC A05/MF A01 CSCL 24A

Assessment of the environmental impact of aircraft operations is required by Air Force regulations. This program was undertaken with the aim of quantifying the gaseous and articulate emissions associated with three Air Force turbine engines. These engines were 41-A2, TF30-P103, and TF30-P109. The emissions tests were carried out, using a test cell Tinker AFP, Oklahoma City, OK. All tests employed JP-4 as the fuel, and fuel samples were characterized by standard tests and analyzed for composition. Emissions were measured at power settings of idle, 30 percent, 75 percent, 100 percent, and afterburner (where appropriate). Measurements were made of detailed organic composition, CO, CO2, NO, NOx, smoke number, particle concentration, and particle size distribution. A multiport sampling rake was used to sample the exhaust, and heated Teflon tubing was used to transfer exhaust to the monitoring instrumentation. Measured and calculated fuel/air ratios were compared to assure representative sampling of the exhaust. GRA

N88-24641*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA/INDUSTRY ADVANCED TURBOPROP TECHNOLOGY PROGRAM
JOSEPH A. ZIEMIANSKI and JOHN B. WHITLOW, JR. 1988 26 p Prepared for presentation at the 16th Congress of the International Council of Aeronautical Sciences, Jerusalem, Israel, 28 Aug. - 2 Sep. 1988
(NASA-TM-100929; E-4198; NAS 1.15:100929) Avail: NTIS HC A03/MF A01 CSCL 21E

Experimental and analytical effort shows that use of advanced turboprop (propfan) propulsion instead of conventional turbofans in the older narrow-body airline fleet could reduce fuel consumption for this type of aircraft by up to 50 percent. The NASA Advanced Turboprop (ATP) program was formulated to address the key technologies required for these thin, swept-blade propeller concepts. A NASA, industry, and university team was assembled to develop and validate applicable design codes and prove by ground and flight test the viability of these propeller concepts. Some of the history of the ATP project, an overview of some of the issues, and a summary of the technology developed to make advanced propellers viable in the high-subsonic cruise speed application are presented. The ATP program was awarded the prestigious Robert J. Collier Trophy for the greatest achievement in aeronautics and astronautics in America in 1987. Author

N88-24642*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL VIBRATION DAMPING CHARACTERISTICS OF THE THIRD-STAGE ROTOR OF A THREE-STAGE TRANSONIC AXIAL-FLOW COMPRESSOR
FREDERICK A. NEWMAN 1988 24 p Presented at the 24th Joint Propulsion Conference, Boston, Mass., 11-13 Jul. 1988; sponsored in part by AIAA, ASME, SAE and ASEE
(NASA-TM-100948; E-4240; NAS 1.15:100948; AIAA-88-3229) Avail: NTIS HC A03/MF A01 CSCL 21E

Rotor blade aerodynamic damping is experimentally determined in a three-stage transonic axial flow compressor having design aerodynamic performance goals of 4.5:1 pressure ratio and 65.5 lbm/sec weight flow. The combined damping associated with each mode is determined by a least squares fit of a single degree of freedom system transfer function to the nonsynchronous portion of the rotor blade strain gage output power spectra. The combined damping consists of the aerodynamic damping and the structural and mechanical damping. The aerodynamic damping varies linearly with the inlet total pressure for a given corrected speed, weight flow, and pressure ratio while the structural and mechanical damping is assumed to remain constant. The combined damping is determined at three inlet total pressure levels to obtain the aerodynamic damping. The third-stage rotor blade aerodynamic damping is presented and discussed for the design equivalent speed with the stator blades reset for maximum efficiency. The compressor overall preformance and experimental Campbell diagrams for the third-stage rotor blade row are also presented. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A88-41425
FLUIDIC FLIGHT CONTROL - EARLY TEST RESULTS

Aerospace Engineering (ISSN 0736-2536), vol. 8, June 1988, p. 35-39.

A Navy flight test of a fluidic FCS added to the fly-by wire FCS on a T-2C aircraft is examined. The FCS is a full-authority, two-axis, lateral-directional control system for the aircraft's ailerons and rudder. The FCS effectors are direct-drive, 8000-psi actuators with both fluidic and electric command channels. The pilot-input transducers and the fluidic actuator controller are discussed. Before undergoing flight tests, steady-state tests of pilot input to actuator output and dynamic performance tests of both the fluidic and fly-by-wire modes were conducted. Tests flights have been made at 5,000-ft increments to an altitude of 20,000 ft and at speeds up to 300 knots, the maximum speed for the aircraft. R.B.

A88-41798
DYNAMICS OF THE CONTROLLED MOTION OF A HELICOPTER [DINAMIKA UPRAVLIAEMOGO DVIZHENIIA VERTOLETA]
SERGEI NIKOLAEVICH KOLOKOLOV, ANATOLII PETROVICH KONOVALOV, and VLADIMIR ANTONOVICH KURATOV Moscow, Izdatel'stvo Mashinostroenie, 1987, 144 p. In Russian. refs

Current methods for studying the dynamics of the controlled motion of helicopters are reviewed. In particular, attention is given to mathematical models of helicopter motion, helicopter balancing, qualitative evaluation of the stability and controllability of helicopters, and identification of models of helicopter motion from flight test data. The discussion also covers the dynamics of a closed-loop piloting system, controllability optimization, and parametric studies of the stability and controllability of helicopters. V.L.

A88-41824
DISCRETE-CONTINUOUS CONTROL OF PROGRAMMED AIRCRAFT GUIDANCE [DISKRETNO-NEPRERYVNOE UPRAVLENIE PROGRAMMNYM VYVEDENIEM SAMOLETOV]
IURII PAVLOVICH GUS'KOV Moscow, Izdatel'stvo Mashinostroenie, 1987, 128 p. In Russian. refs

Various aspects of the synthesis of final state control laws are examined, and a discrete-continuous control method is proposed which is based on the discrete correction of the parameters of a continuously stabilized programmed path. A general control algorithm implemented on an on-board computer and the computational routines associated with the synthesis of this algorithm are described. Simplified control algorithms for guiding aircraft to a specified phase point within a specified period of time are also presented. V.L.

A88-43204*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, Calif.
APPLICATION OF PARAMETER ESTIMATION TO HIGHLY UNSTABLE AIRCRAFT
RICHARD E. MAINE and JAMES E. MURRAY (NASA, Flight Research Center, Edwards, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 213-219. Previously cited in issue 23, p. 3412, Accession no. A86-47655. refs

A88-43205*# Minnesota Univ., Minneapolis.
DESIGN OF A MULTIVARIABLE FLUTTER SUPPRESSION/GUST LOAD ALLEVIATION SYSTEM
B. S. LIEBST, W. L. GARRARD, and JEROME A. FARM (Minnesota, University, Minneapolis) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 835-847) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 220-229. Research supported by the University of Minnesota. Previously cited in issue 23, p. 3410, Accession no. A86-47494. refs
(Contract NAG1-217; NSF DMS-84-13129)

A88-43209#
COMPUTER-AIDED CONTROL SYSTEMS DESIGN TECHNIQUE WITH APPLICATIONS TO AIRCRAFT FLYING QUALITIES
L. R. PUJARA (Wright State University, Dayton, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 250-255. refs

The objective of this paper is to propose a frequency-matching technique for the design of single-input, single-output (SISO) control systems. The parameters of a cascade controller are determined by minimizing a weighted mean square error between the frequency responses of the compensated closed-loop system and a desired closed-loop system. The error is so defined that the controller parameters turn out to be solutions of linear algebraic equations. The technique is applied to the control system design of an aircraft incorporating flying qualities criteria for its longitudinal mode.

A88-43617
DETERMINATION OF THE OPTIMAL GEAR RATIOS OF FLIGHT ALTITUDE CONTROL SYSTEMS [OPREDELENIE OPTIMAL'NYKH PEREDATOCHNYKH CHISEL SISTEMY UPRAVLENIIA VYSOTOI POLETA]
L. G. ROMANENKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 67-70. In Russian. refs

Efficient algorithms are proposed for determining the parameters of flight altitude control systems from the condition of minimum integral quadratic estimates, with allowance made for the inertial nature of the drive. Particular cases of practical interest are examined. V.L.

A88-43633
PRINCIPLE OF THE DESIGN OF THE FORCE SCHEME OF MULTIPLE-SUPPORT CONTROL SURFACES [O PRINTSIPE PROEKTIROVANIIA SILOVOI SKHEMY MNOGOOPORNYKH RULEI]
V. A. PAVLOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 110-112. In Russian.

The use of three or more hinges in multiple-support control surfaces introduces statistical indeterminacy into the design of the force scheme of control surfaces. Here, methods of dealing with structural design problems associated with statistical indeterminacy of the force scheme of control surfaces are briefly examined. In particular, it is shown that the problem of the reduction of forces in the middle surface of a rudder and hinges can be solved by designing control surfaces with low flexural stiffness ratios. This condition can be achieved, for example, by using composite materials. A possible version of such a structure is described. V.L.

A88-44901
AIRCRAFT CONTROL MECHANISMS [MEKHANIZMY UPRAVLENIIA SAMOLETOM]
VLADIMIR NIKOLAEVICH KESTEL'MAN and ANDREI VIKTOROVICH FEDOROV Moscow, Izdatel'stvo Mashinostroenie, 1987, 184 p. In Russian. refs

The book is concerned with the general principles of insuring the reliability and endurance of the parts and mechanisms of the aircraft control system. Criteria for estimating the performance of control mechanisms are presented, as are reference data on the structural materials and technological processes employed in the production of control system components. The fundamentals of the design of the individual parts of control mechanisms, such as gears, shafts, and bearing, are briefly discussed. V.L.

A88-45016*# Northrop Corp., Hawthorne, Calif.
TRANSIENT AERODYNAMIC FORCES ON A FIGHTER MODEL DURING SIMULATED APPROACH AND LANDING WITH THRUST REVERSERS
A. P. HUMPHREYS (Northrop Corp., Aircraft Div., Hawthorne, CA), J. W. PAULSON, JR., and G. T. KEMMERLY (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 13 p.
(AIAA PAPER 88-3222)

Previous wind tunnel tests of fighter configurations have shown that thrust reverser jets can induce large, unsteady aerodynamic forces and moments during operation in ground proximity. This is

a concern for STOL configurations using partial reversing to spoil the thrust while keeping the engine output near military (MIL) power during landing approach. A novel test technique to simulate approach and landing was developed under a cooperative Northrop/NASA/USAF program. The NASA LaRC Vortex Research Facility was used for the experiments in which a 7-percent F-18 model was moved horizontally at speeds of up to 100 feet per second over a ramp simulating an aircraft to ground rate of closure similar to a no-flare STOL approach and landing. This paper presents an analysis of data showing the effect of reverser jet orientation and jet dynamic pressure ratio on the transient forces for different angles of attack, and flap and horizontal tail deflection. It was found, for reverser jets acting parallel to the plane of symmetry, that the jets interacted strongly with the ground, starting approximately half a span above the ground board. Unsteady rolling moment transients, large enough to cause the probable upset of an aircraft, and strong normal force and pitching moment transients were measured. For jets directed 40 degrees outboard, the transients were similar to the jet-off case, implying only minor interaction. Author

A88-45276#
STABILITY OF AIRPLANES IN GROUND EFFECT
R. W. STAUFENBIEL and U.-J. SCHLICHTING (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) Journal of Aircraft (ISSN 0021-8669), vol. 25, April 1988, p. 289-294. refs

In ground effect, the aerodynamic coefficients vary considerably with height. Longitudinal motion in ground effect reveals modes and stability conditions remarkably different from out-of-ground characteristics, a fact that has a large impact on a successful concept of 'wing-in-ground' vehicles. Using calculated aerodynamic coefficients and a linearized approach, static and dynamic stabilities were studied for a chosen more conventional configuration. In addition, flare maneuvers were studied for an aircraft equipped with a simple two-term controller. It is shown that the performance of the controller is considerably influenced by the ground effect. The interrelation between height-dependent aerodynamic coefficients and longitudinal stability is explained and shows particular importance in flare maneuvers. Author

A88-45309#
THE RESEARCH OF THE AIRCRAFT NEUTRAL STABILITY
YIDONG YANG, SHUMEI ZHANG, and SUOFENG GUO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, March 1988, p. A156-A163. In Chinese, with abstract in English. refs

This paper presents a new fuselage aiming mode of neutral stable aircraft, which is achieved with the symmetric deflection of flaps and dynamic decoupling for minor disturbance of the angle of attack. This mode transfers an aircraft's model from a short-period oscillation model into a nonoscillation model, which then effectively speeds up the dynamic process of the attitude tracking at the area of attacking, decreases the dynamic error, increases the gust-rejection capability apparently, and achieves the result that the flight path does not change significantly during the process of attitude control, which is the demand of fuselage aiming mode control. This paper takes an aircraft as an example, designs its pitch control system with neutral stability and with subneutral stability. This paper also gives the corresponding results of digital-analog hybrid simulation. Author

A88-45680#
AIRCRAFT DYNAMIC RESPONSE TO VARIABLE WING SWEEP GEOMETRY
JIGUANG AN, MING YAN, WENBO ZHOU, XIANGHAI SUN, ZHEN YAN (Jiaotong University, Shanghai, People's Republic of China) et al. Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 216-221. Previously cited in issue 23, p. 3414, Accession no. A86-47694. refs

A88-45690#
EFFECT OF DENSITY RATIO ON BINARY WING FLUTTER
L. T. NIBLETT (Royal Aircraft Establishment, Farnborough, England) Journal of Aircraft (ISSN 0021-8669), vol. 25, March 1988, p. 284-286.

The effect of density ratio on flutter may be clarified by a particular solution form of the flutter equation that leads to the visualization of the solution as the intersection of a conic and a straight line. Insights into the equations are obtainable even when the coefficients are not exact, as is presently demonstrated by the clarification of the conditions under which 'anomalous' behaviors with increase of damping occur. O.C.

N88-23725*# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
RULE-BASED FAULT-TOLERANT FLIGHT CONTROL
DAVE HANDELMAN *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1986 p 71-79 Apr. 1988
Avail: NTIS HC A06/MF A01 CSCL 01C

Fault tolerance has always been a desirable characteristic of aircraft. The ability to withstand unexpected changes in aircraft configuration has a direct impact on the ability to complete a mission effectively and safely. The possible synergistic effects of combining techniques of modern control theory, statistical hypothesis testing, and artificial intelligence in the attempt to provide failure accommodation for aircraft are investigated. This effort has resulted in the definition of a theory for rule based control and a system for development of such a rule based controller. Although presented here in response to the goal of aircraft fault tolerance, the rule based control technique is applicable to a wide range of complex control problems. Author

N88-23747*# Vigyan Research Associates, Inc., Hampton, Va.
NATURAL LAMINAR FLOW AND AIRPLANE STABILITY AND CONTROL
CORNELIS P. VANDAM *In* NASA, Langley Research Center, Laminar Flow Aircraft Certification p 227-245 May 1986
(Contract NAS1-17797)
Avail: NTIS HC A14/MF A01 CSCL 01C

Location and mode of transition from laminar to turbulent boundary layer flow have a dominant effect on the aerodynamic characteristics of an airfoil section. The influences of these parameters on the sectional lift and drag characteristics of three airfoils are examined. Both analytical and experimental results demonstrate that when the boundary layer transitions near the leading edge as a result of surface roughness, extensive trailing-edge separation of the turbulent boundary layer may occur. If the airfoil has a relatively sharp leading-edge, leading-edge stall due to laminar separation can occur after the leading-edge suction peak is formed. These two-dimensional results are used to examine the effects of boundary layer transition behavior on airplane longitudinal and lateral-directional stability and control. Author

N88-23807*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROL LAW PARAMETERIZATION FOR AN AEROELASTIC WIND-TUNNEL MODEL EQUIPPED WITH AN ACTIVE ROLL CONTROL SYSTEM AND COMPARISON WITH EXPERIMENT
BOYD PERRY, III, H. J. DUNN, and MAYNARD C. SANDFORD May 1988 18 p Presented at the AIAA/ASME/ASCE/AHS/ASC 29th Structures, Structural Dynamics, and Materials Conference in Williamsburg, Va., 18-20 Apr. 1988
(NASA-TM-100593; NAS 1.15:100593; AIAA-PAPER-88-2211)
Avail: NTIS HC A03/MF A01 CSCL 01C

Nominal roll control laws were designed, implemented, and tested on an aeroelastically-scaled free-to-roll wind-tunnel model of an advanced fighter configuration. The tests were performed in the NASA Langley Transonic Dynamics Tunnel. A parametric study of the nominal roll control system was conducted. This parametric study determined possible control system gain variations which yielded identical closed-loop stability (roll mode pole location) and identical roll response but different maximum control-surface deflections. Comparison of analytical predictions with wind-tunnel results was generally very good. Author

N88-23809* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HELICOPTER ANTI-TORQUE SYSTEM USING FUSELAGE STRAKES Patent
HENRY L. KELLEY, inventor (to NASA) and JOHN C. WILSON, inventor (to NASA) 24 Nov. 1987 9 p Filed 30 Jan. 1987 Supersedes N87-23630 (25 - 17, p 2287)
(NASA-CASE-LAR-13630-1; US-PATENT-4,708,305; US-PATENT-APPL-SN-008895; US-PATENT-CLASS-244-17.19; US-PATENT-CLASS-244-91) Avail: US Patent and Trademark Office CSCL 01C

The improvement of the helicopter torque control system is discussed. At low to medium forward speeds helicopter performance is limited by the effectiveness of the means for counteracting main rotor torque and controlling sideslip airloads. These problems may be overcome by mounting strakes on the aft fuselage section. For single rotor helicopters whose main rotor rotates counter-clockwise as viewed from above, one of the strakes would be mounted in the upper lefthand quadrant and the second in the lower left hand quadrant. The strakes alter the air flow around the fuselage by separating the flow so as to produce lateral airloads on the tail boom which oppose main-rotor torque. The upper strake operates in a right crosswind to oppose main rotor torque, and the lower strake has effect in left crosswinds. The novelty of this invention resides in the simple and economical manner in which the helicopter tail boom may be modified by the addition of strakes in order to increase torque control, and reduce the need for supplemental mechanical means of torque control.
Official Gazette of the U.S. Patent and Trademark Office

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A88-41423
GROUND TESTING ENGINES MINIMIZES FIRST FLIGHT RISKS
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 8, June 1988, p. 12-16.

An overview of work done at the USAF's Aeropropulsion Systems Test Facility (ASTF) is presented. ASTF is capable of testing engines rated up to 75,000 pounds of thrust, under simulated flight conditions up to altitudes of 100,000 ft, and at speeds up to Mach 3.8. The capabilities of the facility's two test cells, each 28 ft in diameter and 85 ft in length are discussed. One cell is designed to accomodate the higher pressures associated with high Mach numbers, while the other is designed to deliver mass flow more typical of that required for high bypass ratio turbofan engines. Also, the air supply, exhauster, exhaust gas management, automatic test control, and test instrumentation systems are examined.
R.B.

A88-42944*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
FLIGHT SIMULATOR PLATFORM MOTION AND AIR TRANSPORT PILOT TRAINING
ALFRED T. LEE (NASA, Ames Research Center, Moffett Field, CA) and STEVEN R. BUSSOLARI (MIT, Cambridge, MA) IN: International Symposium on Aviation Psychology, 4th, Columbus, OH, Apr. 27-30, 1987, Proceedings. Columbus, OH, Ohio State University, 1987, p. 135-142. refs

The effect of a flight simulator platform motion on the performance and training of a pilot was evaluated using subjective ratings and objective performance data obtained on experienced B-727 pilots and pilots with no prior heavy aircraft flying experience flying B-727-200 aircraft simulator used by the FAA in the upgrade and transition training for air carrier operations. The results on experienced pilots did not reveal any reliable effects of wide variations in platform motion design. On the other hand, motion variations significantly affected the behavior of pilots without heavy-aircraft experience. The effect was limited to pitch attitude control inputs during the early phase of landing training. I.S.

A88-42946#
USE OF THE ILLIMAC SIMULATOR IN RESEARCH AT THE UNIVERSITY OF ILLINOIS
HENRY L. TAYLOR (Illinois, University, Urbana) IN: International Symposium on Aviation Psychology, 4th, Columbus, OH, Apr. 27-30, 1987, Proceedings. Columbus, OH, Ohio State University, 1987, p. 172-178. refs

The concept and the components of the University of Illinois miniature aviation computer (ILLIMAC) flight simulation system are described together with the course of the ILLIMAC development leading to the ILLIMAC-3 and -4 models developed to meet the Pilot Training requirements. Special consideration is given to the ILLIMAC cockpit instrument panel, the system computer which runs the ILLIMAC flight simulator program, and the Compu-Procomputer, which is a separate computer that makes it possible to transfer data between the two systems. Experimental uses of the ILLIMAC flight simulator are illustrated with seven flight experiments designed to investigate the effect of atropine sulfate, common antiemetic drugs (such as thiethylperazine, promethazine, and cimetidine), and alcohol on pilot's performance, to improve pilot training, and to investigate the relationship between event-related brain potentials and mental workload. I.S.

A88-43521*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SUPER MAGNETS FOR LARGE TUNNELS
RICHMOND P. BOYDEN, ROBERT A. KILGORE, PING TCHENG (NASA, Langley Research Center, Hampton, VA), and COLIN P. BRITCHER (Old Dominion University, Norfolk, VA) Aerospace America (ISSN 0740-722X), vol. 26, June 1988, p. 36, 37, 38, 40.

The development and use of a large Magnetic Suspension and Balance System (MSBS) in wind tunnels is examined, discussing NASA-sponsored research to develop a large MSBS, and the 2 MSBS already in use. The MSBS holds the model in an arbitrary position in the wind tunnel test section and measures the forces and moments acting on the model. Technologies for building a large MSBS have been developed, and research is being done to reduce building costs. Magnetic suspension is advantageous because it completely eliminates interference from mechanical support systems such as stings or struts and it allows for easy rotation and translation of the model. Advances allowing operation at higher temperatures, probably using liquid nitrogen instead of liquid helium may reduce the cost of MSBS operation. A large MSBS would require power controllers with capacity up to 10 MW, efficiency approaching 98 percent and the ability to reverse the sign of both voltage and current. Technologies include the electro-magnetic position sensor, model positioning sensing, digital controller, and a precalibrated resistance strain-gage balance.
R.B.

A88-44599#
DEVELOPMENT OF A NEW HIGH-ENTHALPY SHOCK TUNNEL
M. G. DUNN, J. C. MOLLER, and R. C. STEELE (Calspan Advanced Technology Center, Buffalo, NY) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 14 p. refs
(AIAA PAPER 88-2782)

The design of a new high-enthalpy shock tunnel currently in the planning stage at the Calspan Advanced Technology Center is described. The facility is expected to operate in the reflected-shock mode and to produce a maximum reflected shock enthalpy level on the order of 15,000 Btu/lb at a corresponding pressure of 1800 atm. and a temperature of 21,000 R. The driver tube of this facility is designed for 40,000 psi at 750 F which ensures the capability for very high Reynolds numbers at intermediate enthalpy levels in the expansion flow. K.K.

A88-44707#
DEVELOPMENT OF A HIGH AREA RATIO NOZZLE THRUST STAND
J. J. IDZOREK (FluiDyne Engineering Corp., Minneapolis, MN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 36 p. refs
(AIAA PAPER 88-2964)

A unique static thrust stand is under development at FluiDyne Engineering Corporation in Minneapolis, Minnesota. When fully operational, this facility will have the capability to measure flow and thrust coefficients of high area ratio nozzles typically as proposed for the National Aerospace Plane. The facility is designed to deliver air to the test model at pressures and temperatures up to 1000 psi and 1600 R, sufficient to preclude air condensation at nozzle pressure ratios of 40,000. Author

A88-44708#
A MODERN TEST FACILITY FOR TURBINE ENGINE DEVELOPMENT
P. B. CARTER (Sverdrup Technology, Inc., Tullahoma, TN) and E. S. HSIA (International Turbine Engine Corp., Phoenix, AZ) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p.
(AIAA PAPER 88-2966)

A new turbine engine test facility has been designed and constructed to support product development. The new facility, named the Engine Development Test Facility, consists of four test units including a turbine test cell, a turbofan test cell, a sea-level static engine test cell, and an altitude engine test cell. The facility respresents a unique application of conventional equipment in a tightly integrated and highly versatile facility plant. The overall facility equipment and capabilities are described. Author

A88-44767#
ADVANCED STRUCTURAL INSTRUMENTATION TEST FACILITY
GRAHAM B. FULTON (United Technologies Research Center, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p.
(AIAA PAPER 88-3145)

An attempt has been made to demonstrate the accuracy and durability of advanced, steady-state strain and temperature sensors in environments representative of advanced gas turbine engine hot sections. A first-stage turbine disk operating at up to 13200 rpm and 1250 F was subjected to engine operating conditions on a rig designed for structural dynamic measurements and evaluations of a range of rotating components. Attention is presently given to the spin rig's configuration, drive system, and support equipment, as well as the modifications made to achieve high temperature. O.C.

A88-44862
AIRPORT TECHNOLOGY - INTERNATIONAL
DAVID WOOLLEY, ED. London, Sterling Publications, Ltd., 1987, 236 p. No individual items are abstracted in this volume.

The papers presented in this volume provide an overview of recent developments in airport design, construction, management, and operation. Topics discussed include airport policy and management; planning, design, and construction of airports; airport operation; passenger handling; ramp operations, aircraft maintenance, and hangar operations; airfield operations; air traffic control and navigation; and security. Papers are included on the expanding world market for airport development, new technology in cargo handling, latest technology in ATC equipment, and automation and its expansion. V.L.

A88-45321#
MECHANISM OF SIDE WALL EFFECT FOR TRANSONIC AIRFOIL TESTING
YAOXI SU (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, April 1988, p. B173-B178. In Chinese, with abstract in English. refs

Mechanisms of sidewall effect on airfoil transonic wind tunnel testing are presently investigated through oil flow visualization. It is noted that conventional theoretical concepts are suitable only for subcritical flow conditions; in supercritical cases, the sidewall effects are far more complex and pronounced. Five types of oil flow pattern are discerned. The application of wall suction is suggested as a possible solution of the sidewall problem. Two-dimensional wind tunnel testing of transonic airflows are inadequate. O.C.

N88-23810# Systems Control Technology, Inc., Arlington, Va.
ANALYSES OF HELIPORT SYSTEM PLANS Final Report
DEBORAH PEISEN and JACK THOMPSON Feb. 1988 95 p
(Contract DTFA01-87-C-00014)
(DOT/FAA/PM-87/31; DOT/FAA/PP-88/1; REPT-5542-6A2)
Avail: NTIS HC A05/MF A01

Strengths and weaknesses of various existing heliport system plans are analyzed. Planning concepts are identified and defined to include: (1) baseline parameters for evaluating the plans; (2) identifying data and their sources needed for planning purposes at any jurisdictional level; and (3) developing criteria for assessing the feasibility and economic viability of proposed heliport facilities. The study covers four state heliport system plans (Michigan, New Jersey, Louisiana, and Ohio) and four metropolitan heliport plans (Pittsburgh, Pa.; Phoenix, Ariz.; Houston, Tex.; and Washington, D.C.). Author

N88-24645# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
PARAMETER-ADAPTIVE MODEL-FOLLOWING FOR IN-FLIGHT SIMULATION M.S. Thesis
LUIS A. PINEIRO Dec. 1987 320 p
(AD-A190567; AFIT/GE/ENG/87D-74) Avail: NTIS HC A14/MF A01 CSCL 01C

This thesis implements an adaptive, fast-sampling control law to compensate for changing aircraft parameters. The step-response matrix which is required for this implementation is identified recursively using a recently developed technique which does not require special test signals and which automatically discounts old data depending on the input excitation detected. Tracking fidelity is maintained despite parameter changes which occur either abruptly or slowly. Simulations are conducted, using a model of the AFTI/F-16 aircraft and the control design package MATRIX, to test the resulting adaptive system. Actuator position and rate limits are discussed. The performance of the resulting system is excellent and demonstrates the relative advantages of adaptive controllers for in-flight simulation. Recommendations are made for future analysis including the use of moving-bank estimators. GRA

N88-24647# Carnegie-Mellon Univ., Pittsburgh, Pa. Software Engineering Inst.
AN OOD (OBJECT-ORIENTED DESIGN) PARADIGM FOR FLIGHT SIMULATORS Final Report
KENNETH J. LEE, MICHAEL S. RISSMAN, RICHARD DIPPOLITO, CHARLES PLINTA, and ROGER VANSCOY Dec. 1987 104 p
(Contract F19628-85-C-0003)
(AD-A191097; CMU/SEI-87-TR-43; ESD-TR-87-206) Avail: NTIS HC A06/MF A01 CSCL 01B

This report presents a paradigm for object-oriented implementations of flight simulators. It is a result of work on the Ada Simulator Validation Program (ASVP) carried out by members of the technical staff at the Software Engineering Institute (SEI). Object-oriented design predominates discussions about Ada-based software engineering. The identification of objects and implementation of objects are two separate issues. This paradigm is a model for implementing systems of objects. The objects are described in a form of specification called an object dependency diagram. The paradigm is not about how to create the specification. Although much has been written on object-oriented design, SEI project members could find no examples of object-oriented implementations relevant to flight simulators. Examples were required for two reasons. First, object-orientation was new to both

of the contractors on the ASVP. A methodology which leads to a specification of objects is useful only if developers know how to implement what is specified. Second, managers were skeptical about the benefits of object-oriented design. Examples were needed to determine whether benefits outweight costs. GRA

N88-24648# Essex Corp., Orlando, Fla.
SIMULATOR EVALUATION OF LINEUP VISUAL LANDING AIDS FOR NIGHT CARRIER LANDING Final Report, Aug. 1986 - Mar. 1987
DANIEL J. SHEPPARD, LAWRENCE J. HETTINGER, DANIEL P. WESTRA, and SHERRIE A. JONES 10 Mar. 1987 63 p
(Contract N613339-85-D-0026)
(AD-A191212; EOTR-88-1) Avail: NTIS HC A04/MF A01 CSCL 05I

A simulator performance experiment was conducted to evaluate three lineup visual landing aids for night carrier landing at the Visual Technology Research Simulator (VTRS), Naval Training Systems Center (NAVTRASYSCEN), Orlando, Florida. They were a strobe light (string of sequentially flashed lights) extending down the centerline of the landing deck, a searchlight mounted forward of the landing deck on the centerline, and a crossbar lineup system (a linear array of nine lights mounted on the fantail of the ship perpendicular to the drop lights). The searchlight and crossbar were also combined to form an additional VLA condition. A bare deck condition that represented the standard carrier deck lighting configuration was used as the control comparison. Night carrier landing experience (zero night traps versus approximately 50 night traps), and a difficulty factor (axial winds versus angle wind), were also manipulated in the experiment. Ten naval aviators each performed 60 simulated night carrier landings under all experimental conditions. Lineup performance was significantly more accurate with the crossbar and crossbar/searchlight combination system than with the bare deck for the far and middle segments of the approach. There appeared to be no advantage in performance near the ramp and at touchdown. There was no difference in performance between the crossbar and crossbar/searchlight combination. GRA

N88-24649# Anacapa Sciences, Inc., Fort Rucker, Ala.
AN ENUMERATION OF RESEARCH TO DETERMINE THE OPTIMAL DESIGN AND USE OF ARMY FLIGHT TRAINING SIMULATORS Final Report, Feb. 1984 - Feb. 1985
KENNETH D. CROSS and CHARLES A. GAINER Oct. 1987 22 p
(Contract MDA903-81-C-0504; DA PROJ. 2Q2-63744-A-795)
(AD-A191242; ASI479-066-85; ARI-TR-763) Avail: NTIS HC A03/MF A01 CSCL 05I

This document lists and describes research the authors judged necessary to determine the optimal design and use of Army flight training simulators. Two major lines of research are described; the first addresses the design fidelity issue. Specifically, research is described that is judged necessary to determine the most cost- and training-effective level of fidelity for four simulator components: the visual system, the motion systems, the math models that determine the handling qualities of the flight simulator, and the cockpit displays and controls. The purpose of the second line of research is to determine how best to use production simulators that have been or are soon to be acquired by the Army. This line of research focuses primarily on the use of production simulators for field unit aviators who have completed institutional training and have been assigned to an operational field unit. However, the second line of research addresses some issues associated with the use of flight simulators for institutional training at the U.S. Army Aviation Center received before the aviator's first assignment to an operational unit. GRA

N88-24651# Blocher-Motor G.m.b.H. and Co. K.G., Metzingen (West Germany).
DESIGN STUDY. MANIPULATOR SYSTEMS FOR MODEL HANDLING IN EUROPEAN TRANSONIC WIND TUNNELS [KONZEPTSTUDIE. MANIPULATORSYSTEM FUER MODELHANDHABUNG IM EUROPAEISCHEN TRANSSCHALL-WINDKANAL]
REINER BLOCHER and EBERHARD WEISS 25 May 1987 199 p In GERMAN
(ETN-88-91944) Avail: NTIS HC A09/MF A01

Electrical master slave manipulators in cryogenic temperatures and under pressure are proposed for remote model handling. Economy of time and energy can be achieved without thermal stresses in model and wind tunnel. Manipulator design consists of two arms and seven degrees of freedom. Control is achieved by frequency regulated asynchronous motors. Digital electronics procures total automation for the study of collision protection and special handling cycles. Viewing and associated audio-systems are provided by stereo and monosystems giving optimal global view of the operating field. Mechanical properties of construction parts in cryogenic environment are studied. ESA

N88-24652# Army Engineer Waterways Experiment Station, Vicksburg, Miss. Geotechnical Lab.
DESIGN OF OVERLAYS FOR RIGID AIRPORT PAVEMENTS Final Report, Jan. 1982 - Jun. 1987
RAYMOND S. ROLLINGS Apr. 1988 277 p
(Contract DTFA01-81-Y-10523)
(DOT/FAA/PM-87/19) Avail: NTIS HC A13/MF A01

Existing rigid and flexible overlay pavement design methods are empirical, and they use specific levels of cracking or visual deflection as the defined failure condition. The existing empirical designs are based on tests run 30 years ago, and current analytical models provide greatly improved abilities to examine the overlay pavement structure. Emphasis by many agencies on life-cycle cost analysis and more sophisticated maintenance and rehabilitation strategies require methods of predicting pavement performance rather than simply developing safe designs. A layered-elastic analytical model was selected to evaluate stresses from applied loads in the pavement structure. Pavement performance was measured in terms of a structural condition index (SCI) which related to the type, degree, and severity of pavement cracking and spalling on a scale of 0 to 100. Models were developed to represent the effect of cracking in base slabs under the overlay, to account for fatigue damage of previous traffic on the base pavement, and to account for the effects of substandard load transfer at slab joints. The predicted performance of rigid overlays and pavements using this technique was checked against the results of full-scale accelerated traffic tests conducted by the Corps of Engineers and against current overlay design methods and was found to provide reasonab le agreement. Author

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ASTRONAUTICS

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

A88-43183
RF CHARACTERIZATION OF WIDEBAND OPTICAL LINK FOR INTERCONNECTION OF MICROWAVE RF SUBSYSTEMS FOR AIRBORNE COMMUNICATIONS SATELLITE TERMINALS
P. HEIM, M. HOHMAN, and G. PROVIDAKES (Mitre Corp., Bedford, MA) IN: Fiber optic systems for mobile platforms; Proceedings of the Meeting, San Diego, CA, Aug. 20, 21, 1987. Bellingham,

WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 143-150. refs

The recent availability of ultrafast laser diodes with matching fast photodetectors which can be directly modulated at radio frequencies (RFs) offers an alternative interconnection technology in airborne systems. In this paper, preliminary measurements of the RF/microwave response of laser diodes and matching detector are reported. The measurements include insertion loss, dynamic range, bandwidth, single tone harmonic generation, and two tone intermodulation products. The sensitivity of the laser diode/detector modulation index and frequency is discussed, and the optical subsystem is examined over the frequency range 100 MHz to 10 GHz. A candidate Satcom terminal design is discussed that uses the fiber optics to interconnect subsystems. Recommendations for combining RF and digital signals using RF and color multiplexing are made. C.D.

A88-44740#
COMPUTATION OF PERFORMANCE FOR DIFFERENT SOLID ROCKET MOTORS - CONVENTIONAL MOTORS, NOZZLELESS ROCKET MOTORS, ROCKET RAMJETS
GUY DELANNOY (Societe Nationale des Poudres et Explosifs, Vert-le-Petit, France) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. (AIAA PAPER 88-3046)

The solution of fluid dynamics equations and the computation of performance are discussed for three different rocket motor configurations: a conventional composite propellant solid rocket motor, a nozzleless rocket motor whose nozzle is machined from a portion of the solid rocket propellant grain, and an airbreathing ramrocket. Attention is given to flowcharts for these performance computations. In the case of the ramrocket, thrust and drag curves are obtained as a function of the pressure exponent; also obtained is fuel specific impulse, as a function of velocity at different altitudes. O.C.

N88-23817*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
REVIEW OF CONVECTIVELY COOLED STRUCTURES FOR HYPERSONIC FLIGHT
CHARLES P. SHORE May 1986 70 p Presented at the SAE Aerospace Vehicle Technology Conference, Structural Technology Session, Arlington, Va., 12-14 May 1986
(NASA-TM-87740; NAS 1.15:87740) Avail: NTIS HC A04/MF A01 CSCL 22B

Resurgent interest in development of Aerospace Plane and Orient Express type vehicles promises to stretch structural technology for hypersonic flight vehicles to the uppermost limits. Significant portions of the structure may require active cooling of some type to survive hostile environments. Despite a lack of recent research activity for cooled structures, a significant body of unclassified knowledge exists concerning such structures. Contractual and in-house research conducted mainly by NASA's Langley Research Center during the 60's and 70's on vehicles very similar to the proposed Orient Express has provided a substantial data base for convectively cooled hypersonic flight structures. Specifically, results are presented for regeneratively cooled structural concepts which have a relatively high heat flux capability and use the hydrogen fuel directly as a coolant; and for structural concepts which use a secondary coolant loop to absorb incident heating and then transfer the absorbed heat to the liquid hydrogen fuel as it flows to the engines. Results are presented to indicate application regions in terms of heat flux capability for various concepts and benefits for each concept. Experience gained and costs are discussed in terms of heat flux capability for various concepts and benefits for each concept. Additionally, experience gained and cost involved with design, fabrication, and testing of full-scale convectively cooled structures are discussed. Author

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CHEMISTRY AND MATERIALS

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

A88-41874
DAMAGE TOLERANCE OF ADVANCED COMPOSITE MATERIALS - COMPRESSION
R. JONES (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: Role of fracture mechanics in modern technology; Proceedings of the International Conference, Fukuoka, Japan, June 2-6, 1986. Amsterdam and New York, North-Holland, 1987, p. 653-663. refs

The types of damage produced in CFRP-laminate aircraft structures by compressive loading and the methods used to evaluate such damage are briefly surveyed. The emphasis is on the most common and serious type, impact-induced delamination. Consideration is given to barely visible impact damage, the limited value of test data based on artificially induced flaws, environmental effects, prior service histories, and the growth rates of delamination defects under the cyclic loads typical of aircraft service. Analytical techniques based on energy-release-rate and strain-energy-density determinations are outlined, and some recent results are summarized in tables. T.K.

A88-42345
ENGINEERING SUBSTANTIATION OF FIBRE REINFORCED THERMOPLASTICS FOR AEROSPACE PRIMARY STRUCTURE
A. C. DUTHIE (Westland, PLC, Helicopter Div., Yeovil, England) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 296-307. Research supported by the Ministry of Defence Procurement Executive. refs

An account is given of the design, fabrication, and testing of a thermoplastic composite horizontal stabilizer and fins for a military helicopter; these have been compared with metallic and thermosetting (epoxy) components serving the same function. The primary material for the thermoplastic technology stabilizer is a unidirectional carbon fiber-reinforced PEEK resin, APC2; the stabilizer fins are of a woven carbon fiber-reinforced polyether imide. Improvements in structural efficiency are found to be obtainable at reduced cost by means of the thermoplastic composite systems. O.C.

A88-42353
DAMAGE TOLERANCE OF INTERNALLY PRESSURIZED SANDWICH WALLED GRAPHITE/EPOXY CYLINDERS
DAVID W. TROP (Boeing Commercial Airplane Co., Seattle, WA) and JAMES W. MAR (MIT, Cambridge, MA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 381-387. refs

An analytical and experimental investigation was conducted to determine the damage tolerance of an internally pressurized, sandwich walled cylinder typical of a general aviation aircraft fuselage. A closed form solution for the inner and outer face-sheet stresses and strains was developed. Fracture of the cylinders with manufactured axial slits was predicted by using relative stress intensity factors to extrapolate flat plate data to the cylinder configuration. Good predictions were made for the failure of the large cylinder specimens flawed with long slits using test data from small flat sandwich specimens flawed with small holes. Also, the measured cylinder strains agreed with the predictions of the stress-strain solution. Author

A88-42364
THE TOUGHENING EFFECT OF PBI IN A BMI MATRIX RESIN

MICHELE T. BLAIR, PAUL A. STEINER (Dexter Corp., Hysol Aerospace and Industrial Products Div., Pittsburg, CA), and ELIZABETH N. WILLIS (Hoechst Celanese Corp., Charlotte, NC) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 524-537.

An epoxy thermosetting resin-toughening method involving the introduction of a second-phase material is presently applied to a BMI thermoplastic matrix. The thermoplastic polybenzimidazole (PBI) introduced into the BMI, in the form of second-phase particles, was chosen due to its above-400 C glass transition temperature, inherent toughness, 2-70 micron particle size, and good dispersion properties. Both neat resin and carbon fiber-reinforced composite component tests of the PBI-toughened BMI material were conducted. Mechanical properties are reported. O.C.

A88-42368
FIRE SAFETY TESTING OF PPS THERMOPLASTIC COMPOSITES

ROBERT S. SHUE (Phillips Petroleum Co., Bartlesville, OK) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 626-633. refs

Polyphenylene sulfide (PPS), whose high structural performance capabilities have been the subject of intensive investigation, is also an exceptionally fire-safe resin. Attention is presently given to data for the inherent flammability, smoke-generation tendencies, and toxicity of gases evolved from PPS during combustion, for the cases of two different versions of woven glass fiber-reinforced PPS subjected to such tests as the Oxygen Index, Flash Ignition Temperature, ASTM E-662, and the Flame Spread Index. O.C.

A88-42381
3-D BRAIDED COMMINGLED CARBON FIBER/PEEK COMPOSITES

FRANK KO, PING FANG, and HELEN CHU (Drexel University, Philadelphia, PA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 899-911. refs

This paper describes a novel system concept for the near net shape manufacturing of tough structural composites, in which a highly damage-resistant composite is made by commingling braided carbon fibers with fibrous PEEK filaments. During processing under heat and pressure, the thermoplastic fibers melt and wet out the adjacent reinforcement fibers to form the matrix of the composite. Optical microscopic photographs and SEM photographs of a commingled three-dimensional braided carbon fiber/PEEK composite demonstrated good adhesion between fiber and matrix. In spite of the fact that the percentage crystallinity of the PEEK matrix in the braided composite was found to be high (38 percent), the structure demonstrated higher levels of damage resistance at high impact than did the laminated composites. It is emphasized that the concept of a braided commingled composite can be applied to other material systems. I.S.

A88-42387
SEMI-IPN MATRIX SYSTEMS FOR COMPOSITE AIRCRAFT PRIMARY STRUCTURES

G. R. ALMEN, R. K. MASKELL, V. MALHOTRA (Fiberite Corp., Tempe, AZ), M. S. SEFTON, P. T. MCGRAIL (ICI, PLC, Wilton Materials Research Centre, England) et al. IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 979-989. refs

One approach to improving the toughness of a brittle thermoset is to add a tough, high-performance, polyaromatic thermoplastic. Initial results derived from this approach have been reported by Sefton et al. (1987). Further research has resulted in the development of candidate systems designed for primary structural applications in commercial aircraft. A property summary for these systems is presented. It is shown that significantly improved damage tolerance can be achieved without compromising other laminate mechanical properties. Author

A88-42405
STATISTICAL ASPECTS OF TENSILE STRENGTH OF ARALL LAMINATES

H. FELIX WU (Alcoa Laboratories, Alcoa Center, PA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1249-1259. refs

Variability in the strength of ARALL laminates is studied. Standard statistical procedures are used to determine the distribution function that best fits ARALL laminates strength data. The normal, log-normal, and two-parameter Weibull distributions are compared using the Kolmogorov-Smirnov goodness-of-fit test. At the five percent significant level none of these distributions is rejected. However, the data indicate that the strength of laminates, for a given gauge length and cross-section, can be best fitted to a two-parameter Weibull distribution. In addition, some small panel-to-panel variations in strength are also found. The effect of gauge length on the strength of ARALL laminates is examined. The strength of ARALL laminates seems to exhibit no gauge length effects over the range from 2 to 20 in., holding the strain rate constant. This effect, if true in general, would be a substantial advantage for ARALL laminates, because scaling effects would be minimized. Author

A88-42420
THERMOPLASTIC POWDER TECHNOLOGY FOR ADVANCED COMPOSITE SYSTEMS

TIMOTHY HARTNESS (BASF Structural Materials, Inc., Charlotte, NC) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1458-1472.

The need to define thermoplastic prepregs that are drapeable and tacky, yet incorporating a wide range of thermoplastic matrix materials on any chosen reinforcement without the evolution of reaction byproducts or solvents, has led to the development of novel powder-impregnation technology. These new impregnation techniques have been employed in the cases of PEEK and PPS, Ultem, polyimide 2080, the thermoset resin PMR-15, and polyimide-matramide 9725. The composites thus produced exhibit excellent property translation. O.C.

A88-42426
THERMOSETTING MATRIX COMPOSITIONS WITH IMPROVED TOUGHNESS TO MEET NEW FAA AIRCRAFT INTERIORS FIRE WORTHINESS REQUIREMENTS

B. M. CULBERTSON, M. L. DEVINEY, O. TIBA (Ashland Chemical Co., Research and Development Dept., Columbus, OH), and D. D. CARLOS (Ashland Carbon Fibers Co., KY) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1531-1545. refs

A new class of thermosetting resins has been developed which shows a number of advantages over existing phenolics as a matrix resin for carbon and glass fiber composites. This new class of resins is based on the chain-extending, crosslinking reaction of phenolic resins with bisoxazolines. These thermosetting compositions are readily used to impregnate carbon fiber, such as Carboflex carbon fiber mats, or glass fiber cloth, with said prepregs stacked and cured under modest heat and pressure and showing no volatiles. These cured sandwich (composite) structures have low smoke and low heat release properties, as determined in the Ohio State University heat release apparatus. The low flammability properties profiles of these new composites easily

meet the 65/65 FAA requirements for 1990 aircraft interiors. The physical properties of both the neat resin and the carbon fiber-glass fiber composites produced, as well as the processing of laminates based on this new family of thermosets, are discussed. Author

A88-43099
EFFECT OF VIBRATION ON THE STABILITY OF THE FUEL-WATER SYSTEM IN A FLIGHT VEHICLE [VLIIANIE VIBRATSII NA STABIL'NOST' SISTEMY TOPLIVO - VODA V LETATEL'NOM APPARATE]
B. G. BEDRIK, V. N. GOLUBUSHKIN, and P. P. MERTSALOV Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 5, 1988, p. 20, 21. In Russian. refs

The effect of the full spectrum of vibrational loads on the fuel-water system of a flight vehicle and on the formation of aqueous liquid-phase residues is investigated analytically and experimentally. It is found that vibrational loading has a substantial effect on the stability of the fuel-water system, the main positive effect being the retention of emulsion water during the flight. This phenomenon should be taken into account when investigating the formation of aqueous liquid-phase residues in fuels and developing methods for preventing their negative effects. V.L.

A88-43198
ASSESSMENT OF THE EFFECT OF IMPACT DAMAGE IN COMPOSITES - SOME PROBLEMS AND ANSWERS
R. JONES, J. PAUL (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia), T. E. TAY, and J. F. WILLIAMS (Melbourn, University, Australia) Theoretical and Applied Fracture Mechanics (ISSN 0167-8442), vol. 9, April 1988, p. 83-95. refs

The analysis and testing of impact-damaged graphite-epoxy laminates are discussed. The characterization of delamination resistance is addressed, and fatigue life prediction is considered. Residual strength and bonded repair technology are briefly discussed. The ability of analysis and testing to provide information for establishing a rationale for inspection intervals is examined. C.D.

A88-44745*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH TEMPERATURE METAL MATRIX COMPOSITES FOR FUTURE AEROSPACE SYSTEMS
JOSEPH R. STEPHENS (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. Previously announced in STAR as N88-10938.
(AIAA PAPER 88-3059)

Research was conducted on metal matrix composites and intermetallic matrix composites to understand their behavior under anticipated future operating conditions envisioned for aerospace power and propulsion systems of the 21st century. Extremes in environmental conditions, high temperature, long operating lives, and cyclic conditions dictate that the test evaluations not only include laboratory testing, but simulated flight conditions. The various processing techniques employed to fabricate composites are discussed along with the basic research underway to understand the behavior of high temperature composites, and the relationship of this research to future aerospace systems. Author

A88-45201
ALUMINUM-LITHIUM ALLOYS: DESIGN, DEVELOPMENT AND APPLICATION UPDATE; PROCEEDINGS OF THE SYMPOSIUM, LOS ANGELES, CA, MAR. 25, 26, 1987
RAMESH J. KAR, ED., SUPHAL P. AGRAWAL, ED. (Northrop Corp., Aircraft Div., Hawthorne, CA), and WILLIAM E. QUIST, ED. (Boeing Commercial Airplane Co., Seattle, WA) Symposium organized and sponsored by ASM International. Metals Park, OH, ASM International, 1988, 470 p. For individual items see A88-45202 to A88-45205.

The present conference on the development status of aluminum-lithium alloys for aerospace applications discussed topics in the availability of these alloys, their fatigue, fracture, and corrosion characteristics, their design criteria, and manufacturing techniques developed for them to date. Attention is given to developments in rapidly-solidified Al-Li alloys, the mechanisms of fatigue crack propagation in commercial Al-Li alloys, the effects of processing on Al-Li microstructures and fracture behavior, and Al-Li exfoliation and stress corrosion cracking behavior. Also discussed are design considerations for novel aerospace vehicle materials, critical Al-Li alloy design factors, the application of Al-Li alloys in naval aircraft, and the superplastic forming characteristics of Al-Li sheet alloys. O.C.

A88-45245
MAKING COMPOSITES AIRWORTHY
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 8, July 1988, p. 32-35.

The existing airworthiness regulations governing applications of composite materials in aircraft are reviewed from the standpoint of the introduction of advanced composite materials into the primary structure of civil aircraft. In particular, attention is given to material properties development, static strength testing, and damage tolerance. The need for establishing proper criteria for demonstrating compliance with airworthiness regulations is emphasized. V.L.

A88-45708
THE STATUS AND PROSPECTS OF ALLOY 718
EDWARD A. LORIA Journal of Metals (ISSN 0148-6608), vol. 40, July 1988, p. 36-41. refs

The Inconel 718 alloy has gained wide applicability in aircraft engines and in nuclear and cryogenic structures due to its high LCF strength, fabricability, and cost effectiveness. This paper gives special consideration to the defect types encountered in the Inconel 718 and to the effect of various metal additions and melting processes on the control of these defects. The results obtained with vacuum induction melting/electro-slag refining process indicate that optimum structure is possible with upgraded equipment and process control. Other areas of alloy refinement, including thermomechanical processing, structural casting, powder metallurgy, and alloy optimization, are discussed. I.S.

N88-23839*# Lockheed-California Co., Burbank.
FUEL CONTAINMENT, LIGHTNING PROTECTION AND DAMAGE TOLERANCE IN LARGE COMPOSITE PRIMARY AIRCRAFT STRUCTURES Contractor Report, Feb. 1983 - Feb. 1985
CHARLES F. GRIFFIN and ARTHUR M. JAMES Washington NASA May 1985 38 p
(Contract NAS1-16856)
(NASA-CR-3875; NAS 1.26:3875; REPT-76-20) Avail: NTIS HC A03/MF A01 CSCL 11D

The damage-tolerance characteristics of high strain-to-failure graphite fibers and toughened resins were evaluated. Test results show that conventional fuel tank sealing techniques are applicable to composite structures. Techniques were developed to prevent fuel leaks due to low-energy impact damage. For wing panels subjected to swept stroke lightning strikes, a surface protection of graphite/aluminum wire fabric and a fastener treatment proved effective in eliminating internal sparking and reducing structural damage. The technology features developed were incorporated and demonstrated in a test panel designed to meet the strength, stiffness, and damage tolerance requirements of a large commercial transport aircraft. The panel test results exceeded design requirements for all test conditions. Wing surfaces constructed with composites offer large weight savings if design allowable strains for compression can be increased from current levels. Author

N88-23852# Naval Air Development Center, Warminster, Pa.
INADEQUACIES OF EMI-SEAL MATERIAL: A CORROSION STUDY
VINOD S. AGARWALA, RICHARD C. PACIEJ, and JAMES J.

THOMPSON *In* AFWAL, Proceedings of the 1987 Tri-Service Conference on Corrosion, Volume 2 p 128-141 May 1987
Avail: NTIS HC A20/MF A01 CSCL 11F

Electromagnetic interference (EMI) seals are mandatory for all structural joints in Naval aircraft because of the high electromagnetic environment present on aircraft carriers. Currently, a major component used in these seals is a 20 percent Zn/Sn coating arc sprayed onto an Al alloy substrate. This coating was found to cause major structural damages when exposed to Naval environments. Pits up to 35 mils deep on the Al alloy have been observed under the seal after one year of service on F/A-18 aircraft. A study of this material, 20 percent Zn/Sn arc spray coating, was reported in terms of its compatibility with the substrate metal in Naval environments. Author

N88-23862# Minnesota Mining and Mfg. Co., St. Paul. Adhesives, Coatings and Sealers Div.
WATER BASED PRIMERS FOR STRUCTURAL ADHESIVE BONDING OF AIRCRAFT
A. V. POCIUS and T. H. WILSON, JR. *In* AFWAL, Proceedings of the 1987 Tri-Service Conference on Corrosion, Volume 2 p 343-358 May 1987 Previously announced in IAA as A88-32992
(Contract F33615-86-R-5009)
Avail: NTIS HC A20/MF A01 CSCL 11B

Physical, coating and performance characteristics of three new primers useful for structural adhesive bonding of aircraft are discussed. The most evident characteristic of these new primers is that they are primarily water vehicled primers in contrast to today's primers which are primarily solvent vehicled. Thus, these primers meet the stricter pollution control regulations now found in many states. Two of these primers, XB-3982, and XB-3983, can be spray applied using conventional methods and provide performance characteristics equivalent to today's solvent vehicled primers. Thus, these new primers can directly replace their solvent based analogs. The third primer, XA-3995, is a cathodic electrophoretically applied structural adhesive bonding primer. This primer is primarily water vehicled and provides good high temperature performance. In addition, the cathodic electrophoretic application method allows for uniform, reproducible application of thin coatings of primer with very efficient utilization of material. Author

N88-23863# Lockheed-Georgia Co., Marietta.
PREVENTING AIRCRAFT CORROSION BY PREDICTIVE CORROSION MODELING
ROBERT N. MILLER and FRED H. MEYER, JR. (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.) *In* AFWAL, Proceedings of the 1987 Tri-Service Conference on Corrosion, Volume 2 p 359-385 May 1987
Avail: NTIS HC A20/MF A01 CSCL 11F

Aircraft maintenance scheduling is optimized through the use of a predictive corrosion model which is based on the kinetics of corrosion reactions, the degradation rates of protective systems and the environmental conditions at Air Force bases. A VAX-11 FORTRAN computer program was developed which enables the analysis of specific points on the C-5 aircraft and, utilizing environmental factors and the time periods an aircraft has been at various A.F. bases, gives recommended times for inspection and maintenance. The computer programs include a crack growth module which calculates the remaining flight hours until theoretical cracks grow to half their critical length, a corrosion module which computes the time for exposed aircraft alloys to corrode to a depth of 3 mils, and a coating degradation module which determines the optimum time until the next paint renewal or complete repaint operation. The predictive model, when completed, will be used to optimize field and depot level maintenance for aircraft now in operation, inspection and maintenance schedules for new aircraft, and selection of aircraft for Analytical Condition Inspection. Author

N88-23873*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CERAMICS FOR TURBINE ENGINES
STANLEY R. LEVINE *In its* Structural Ceramics p 1-13 May 1986
Avail: NTIS HC A11/MF A01 CSCL 11C

The Ceramics for Turbine Engines Project is comprised of three main research programs with major elements as indicated: materials and processing (monolithics and fiber reinforcement), design methodology (design code and tribology), and life prediction (environmental effects, nondestructive evaluation, fracture and fatigue, and time dependent behavior). From the NASA perspective an enhanced ceramics technology base directly supports aeronautics initiatives in small engine technology, high-performance turbine engine technology, and hypersonics. An overview of the program, which includes the technical objectives and content of each program, is provided. B.G.

N88-24718# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
SELECTIVE DETECTION IN GAS CHROMATOGRAPHY Final Report, Jan. - Mar. 1985
EDWARD W. PITZER Dec. 1987 25 p
(AD-A191499; AFWAL-TR-86-2039) Avail: NTIS HC A03/MF A01 CSCL 07D

High-resolution gas chromatography (HRGC) is capable of separating a very complex hydrocarbon liquid such as jet propulsion fuel into nearly all of its individual components. However, there is no guarantee that what appears to be a single chromatographic peak is in fact a single fuel component. The method of detecting these HRGC eluents is very often the flame ionization detector (FID), a very sensitive and universally responding hydrocarbon detector. Neither the separating power of HRGC, or the sensitivity of the FID, however, lend information as to the identity of the eluting component. The need to specifically identify HRGC eluents, especially those containing heteroatoms such as nitrogen, sulfur, phosphorus, oxygen, halogens and some materials has been well-documented. The purpose of this report is to review the progress in the area of selective gas chromatographic detectors and to recommend selective detectors for use in the HRGC analysis of jet propulsion fuels. This report will present 24 different selective gas chromatographic detectors. These detectors, while not all directly applicable to the HRGC analysis of jet propulsion fuel, all show the concept of selective detection in gas chromatography. The applicability of these detectors to jet propulsion fuel analyses is determined from a comparison of their complexity and cost versus their effectiveness as high-resolution gas chromatographic detectors. GRA

N88-24739# Lockheed-Georgia Co., Marietta.
PREDICTIVE CORROSION MODELING, VOLUME 1 Final Report, Sep. 1985 - Jul. 1987
ROBERT N. MILLER 23 Nov. 1987 59 p
(Contract F33615-85-C-5058)
(AD-A191229; LG87ER0083-VOL-1; AFWAL-TR-87-4105-VOL-1)
Avail: NTIS HC A04/MF A01 CSCL 01C

This report for a program to develop a predictive corrosion model for aircraft summarizes the work completed in Task 3. The corrosion rate equations and models developed in Task 2 were converted into a VAX-11 FORTRAN program which enables the analysis of specific points on the C-5 aircraft and, utilizing environmental factors and the time periods an aircraft has been at various Air Force bases, gives recommended times for inspection and maintenance. The FORTRAN computer program includes a crack growth module which calculates the remaining flight hours until a theoretical crack grows to half its critical length, a corrosion module which calculates the remaining hours until exposed aircraft alloys corrode to a depth of 3 mils, and a coating degradation module which computes the optimum time remaining until the next paint renewal or complete repaint operation. Volume 1 describes the program effort. Volume 2 contains computer program printouts. GRA

N88-24799# Lockheed-California Co., Burbank.
FUEL CONTAINMENT CONCEPTS: TRANSPORT CATEGORY AIRPLANES Final Report, Jan. 1986 - Mar. 1987
GIL WITTLIN Nov. 1987 214 p
(Contract DTFA03-86-C-00005)
(AD-A189818; LR-31216; DOT/FAA/CT-87/18) Avail: NTIS HC A10/MF A01 CSCL 01C

This report describes a four phase study to identify potential fuel containment concepts for transport category aircraft. A literature survey was performed and the relative contributions from 53 documents are noted. Transport airplane data are summarized including the results from full-scale airplane crash tests and section tests. Analyses results which depict dynamic pulses are presented. Several reports including the U.S. Army Crash Survival Design Guide and the Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee are discussed in detail. Several fuel containment structural design concepts are evaluated with regard to both wing and fuselage usage. The state-of-the-art technology is summarized in this report. Included in this summary is a priority ranking of approaches. A selection of approaches is described. The selected concepts are reviewed with regard to benefit and penalties. The concepts are prioritized in order of effectiveness. GRA

N88-24803# Geo-Centers, Inc., Newton, Mass.
REFERENCE FILTERS FOR ELECTROSTATIC CHARGING TENDENCY MEASUREMENTS OF FUELS Final Report, Jul. 1986 - Jun. 1987
WILBUR A. AFFENS Sep. 1987 36 p
(Contract N00014-86-C-2288; Z08-38)
(AD-A191717; GC-TR-87-1628-F) Avail: NTIS HC A03/MF A01 CSCL 21D

A study has been made to determine whether laboratory filter papers might be suitable as reference filters for the determination of charging tendencies of jet fuels as measured in the EXXON Mini-Static Tester (MST). It was concluded that, compared to commercial fuel filters, these filters do not generate enough charge to afford repeatable and reliable measurements. Some correlation was observed between the polarity of the generated charges and the nature of the filter paper surfaces. However, attempts to repeat these experiments after a time period of about six to eight months were unsuccessful because of variations in the data, particularly that of polarity of the charge. It is suggested that the variations may have been due to relative humidity and temperature changes. Another possible explanation might be changes in fuel composition due to degradation. A few studies of some ion exchange resin coated filter papers suggest some tentative generalizations. It was observed that the flow rate of fuel through each type of filter was not constant for any given run. Since it was necessary to have accurate flow rate data for each filter to be able to calculate charging tendency from the measured streaming current, a method was devised to make this measurement. GRA

N88-24807# Lockheed-California Co., Burbank.
FUEL CONTAINMENT CONCEPTS: TRANSPORT CATEGORY AIRPLANES Final Report, Jan. 1986 - Mar. 1987
G. WITTLIN Nov. 1987 214 p
(Contract DTFA03-86-C-00005)
(DOT/FAA/CT-87/18; LR-31216) Avail: NTIS HC A10/MF A01

A four phase study to identify potential fuel containment concepts for transport category aircraft is described. The study includes a review and evaluation of: accident crash test and analyses data; design guidelines, specifications, and criteria; design procedures; state-of-the-art technology; and design studies and conclusions. A literature survey was performed and the relative contributions from 53 documents are noted. Transport airplane data are summarized including the results from full-scale airplane crash tests and section tests. Analyses results which depict dynamic pulses are presented. Several reports including the U.S. Army Crash Survival Design Guide and the Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee are discussed in detail. Several fuel containment structural design concepts are evaluated with regard to both wing and fuselage usage. The state-of-the-art technology is summarized. Included in this summary is a priority ranking of approaches. A selection of approaches is described. The selected concepts are reviewed with regard to benefit and penalties. The concepts are prioritized in order of effectiveness. 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.

A88-42338
JUST IN TIME MANUFACTURE APPLIED TO COMPOSITE STRUCTURES
C. J. BREAKSPEAR and G. R. GRIFFITHS (Westland, PLC, Helicopter Div., Yeovil, England) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 218-228.

An automated fabrication cell has been designed for the production of a complex helicopter rotor blade spar structure without the use of conventional knitting procedures. The cell cuts plies and lays them up immediately, as required. The spar's design encompasses four different composite materials and 256 distinct details requiring shape-profiling. The production cell uses a tape-placement device, an ultrasonic X-Y cutting table, a transfer device, a consolidation station, and a cell-control computer. The costs and delays associated with conventional knitting procedures are avoided by the production cell. O.C.

A88-42347
FABRICATION OF A BALLISTIC HELICOPTER SEAT WITH A NOVEL SHEET MATERIAL
STEVEN J. MEDWIN (Du Pont de Nemours Engineering Development Laboratory, Wilmington, DE) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 317-323.

Thermoformable sheet materials were used in the fabrication of a half-size ballistic helicopter seat. The composite material consisted of 75 percent by volume Kevlar aramid fiber in a matrix of J2 amorphous nylon thermoplastic resin. A flat preconsolidated panel was heated and then thermoformed in a matched metal mold. The results showed the excellent formability of this new material. A composite seat with a high degree of fiber alignment and no wrinkling was obtained. An economic analysis of this process showed significant savings over the conventional hand lay-up technique. A novel modeling technique was developed that specifies the contours for the flat panel lay-up required to produce parts with uniform thickness and uniform fiber distribution. Author

A88-42373
UTILIZATION OF RHEOLOGICAL AND MICRODIELECTROMETRY TECHNIQUES TO DEVELOP OPTIMUM CURE CYCLE FOR PRIMARY COMPOSITE STRUCTURE
MARTIN P. WAI, DAVID J. PARKER (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT), and FOSTER P. LAMM (United Technologies Research Center, East Hartford, CT) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988.

Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 725-735.

An account is given of the instrumental analyses used to define an optimum cure cycle for the prepreg system of the Blackhawk/Sea Hawk military helicopters' all-graphite/epoxy tail rotor. It is shown that rheometric viscosity data closely represent the actual prepreg's mold-flow behavior. Ply consolidation, uniformity of fiber orientation, and fully cured spar part dimension depend on the material's rheological response. The resin's dielectric response can be related to the viscosity response of the prepreg; microdielectrometry can accordingly be used as a process feedback control loop for the automation of composite fabrication. O.C.

A88-42382
3-D BRAIDING ADAPTED TO AIR FOIL SHAPES NET SHAPE CONTOUR PREFORMS

ROBERT A. FLORENTINE (Braidtech, Inc., Malvern, PA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 922-932. refs

Net shape air foil preforms have been fabricated by the MAGNAWEAVE process for 3-D braided composite preforms. The objective is the increase in damage threshold for composite fan blades in jet engines. The air foil contour, blunt forward edge, thickened middle, tapering to a sharp trailing edge has been achieved with a rectangular 3-D braider, loaded to duplicate the shape of the blade cross section. Five weave geometries were evaluated and loom loadings determined for three fiber combinations (denier, weave geometry). The weave geometries included transverse and through-the-thickness lay-ins separately and jointly, with and without axial stiffening. The composites formed from these preforms provided an evaluation of ease of impregnation, significance of fiber volume, and resin matrix on the fabrication process. The damage thresholds of these geometries are discussed, reviewing the retention of compressive strength and modulus, and fatigue behavior indifferent to damage. Impact damage does not reduce MAGNAWEAVE composite behavior. Author

A88-42455#
INFLUENCE OF FUEL TEMPERATURE ON ATOMIZATION PERFORMANCE OF PRESSURE-SWIRL ATOMIZERS

X. F. WANG and A. H. LEFEBVRE (Purdue University, West Lafayette, IN) (International Symposium on Air Breathing Engines, 8th, Cincinnati, OH, June 14-19, 1987, Proceedings, p. 193-199) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, May-June 1988, p. 222-227. Previously cited in issue 20, p. 3225, Accession no. A87-46198. refs

A88-42458#
COMPLEX MODAL BALANCING OF FLEXIBLE ROTORS INCLUDING RESIDUAL BOW

W. L. MEACHAM, P. B. TALBERT (Allied Signal Aerospace Co., Phoenix, AZ), H. D. NELSON (Arizona State University, Tempe), and N. K. COOPERRIDER (Failure Analysis Associates, Palo Alto, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, May-June 1988, p. 245-251. Previously cited in issue 20, p. 3239, Accession no. A87-45241. refs

A88-42791
AUTOREGRESSIVE MOVING AVERAGE MODELING OF RADAR TARGET SIGNATURES

ROB CARRIERE and RANDOLPH L. MOSES (Ohio State University, Columbus) IN: IEEE National Radar Conference, 3rd, Ann Arbor, MI, Apr. 20, 21, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 225-229. refs
(Contract N00014-85-K-0321)

A method for characterizing radar target signatures with autoregressive moving average (ARMA) models is developed. A parameterization of the model that corresponds directly to the geometric properties of the target is chosen, and an efficient algorithm for estimating these parameters is presented. Procedures for minimizing the effects of unmodeled dynamics are also developed. Experiments on radar measurements obtained from a compact-range are presented to test the effectiveness of the ARMA modeling procedure on scale models of several commercial aircraft. I.E.

A88-42820
POLYSPECTRAL MEASUREMENT AND ANALYSIS OF NONLINEAR WAVE INTERACTIONS

E. J. POWERS and R. W. MIKSAD (Texas, University, Austin) IN: Nonlinear wave interactions in fluids; Proceedings of the Symposium, Boston, MA, Dec. 13-18, 1987. New York, American Society of Mechanical Engineers, 1987, p. 9-16. refs
(Contract NSF MSM-82-11205; F49620-86-C-0045)

The use of digital analysis techniques to extract information on nonlinear wave interactions from experimental data is described and demonstrated, summarizing the results of recent investigations. The concept of polyspectra is introduced; digital techniques for bispectra are outlined; and the detection of three-wave interactions in raw fluctuation data, the estimation of energy transfer, and additional digital wave diagnostics are explained. Numerical results are presented in graphs for the case of the transition to turbulence in the two-dimensional wake of a thin airfoil in a subsonic wind tunnel. T.K.

A88-43085#
FORMATION AND EVOLUTION OF PERTURBATIONS IN SEPARATED FLOWS [VOZNIKNOVENIE I RAZVITIE VOZMUSHCHENII V OTRYVNYKH TECHENIIAKH]

V. V. KOZLOV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Uspekhii Mekhaniki - Advances in Mechanics (ISSN 0137-3722), vol. 10, no. 3, 1987, p. 103-120. In Russian. refs

Recent theoretical and experimental research in the field of laminar separation and turbulence evolution is separated flows is reviewed. In particular, attention is given to flow separation on a smooth surface, effect of acoustic perturbations on flow structure in a boundary layer and in the separation region, stability of separated flow in the case of flow past a surface with a bend, and flow separation at the leading edge of an airfoil with allowance for the effect of acoustic perturbations. The discussion also covers the stability of a separated Poiseuille flow behind a step and the evolution of a wave packet in the separation region. V.L.

A88-43347
COLLECTION OF MAINTENANCE DATA: IMPACT OF PORTER ON R&M

DON HEACOX, GARY MUNOZ, and RUSS WINTERSHEIMER (Support Systems Associates, Inc., Dayton, OH) IN: Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 26-28, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 267-271.

The development, implementation, and impact of a microcomputer-based history tracking system PORTER (for performance-oriented tracking of equipment repair) is reported. The system is for use by radar maintenance technicians in an operational environment at Bitburg Air Base, Federal Republic of Germany. The prototype system collects pertinent radar and other F-15 system information such as date, sortie number, aircraft tail number, and job control number. These data are shared across maintenance levels to aid technicians in identifying and repairing assets that might otherwise circulate repeatedly through the support process. Each section maintains its own unique database which is updated periodically with input from other data collection points. Data can be shared among the organizations. I.E.

A88-43348
FAILURE PREDICTION BY MARGINAL CHECKING

ROBERT A. BOENNING (Westinghouse Electric Corp., Baltimore, MD) and FRANK H. BORN (USAF, Rome Air Development Center, Griffiss AFB, NY) IN: Annual Reliability and Maintainability

Symposium, Los Angeles, CA, Jan. 26-28, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 272-276.

As part of a study to determine the feasibility of operationally detecting incipient avionic system/subsystem failures and predicting actual failures, the concept of marginal checking was developed. Incipient-failure detection and failure prediction is termed marginal checking. Marginal checking is characterized as an evaluation of system/subsystem health by analysis of changes in observable mechanical and electrical parameters that can be correlated with subsequent failures. The degree of parameter change is then used to determine whether or not a system failure is imminent. The rationale for marginal checking and experimental effort underway to demonstrate feasibility is reported. I.E.

A88-43357
ELIMINATING 'CAN NOT DUPLICATE' AND 'EXCESSIVE TROUBLE-SHOOTING' DIAGNOSTIC ACTIONS
TRACY H. JACKSON (McDonnell Aircraft Co., Saint Louis, MO) IN: Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 26-28, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 323-326. refs

The application of a reliability and maintenance (R&M) figure of merit is reported. The figure of merit is known as the expended maintenance importance ratio (EMIR). It relates reliability and maintainability in a single value. It is shown how to use the EMIR in predicting R&M costs and how with data reduction techniques to identify specific improvements. Examples developed from historical data of current aircraft are reported. I.E.

A88-43362
PARTS RENEWAL IN CONTINUOUS-TIME MONTE CARLO RELIABILITY SIMULATION
FRANZ BOEHM, UWE P. HALD, and ELMER E. LEWIS (Northwestern University, Evanston, IL) IN: Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 26-28, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 345-349. refs
(Contract AF-AFOSR-84-0340)

The simulation of complex multicomponent systems by Markov Monte Carlo methods has, to date, been limited to systems where the system performance can be modeled by a time-inhomogeneous Markov process. This model is capable to include component dependencies as well as wear phenomena represented by time-dependent failure rates. A discussion is presented of the formulation and implementation of a generalization of continuous-time Markov Monte Carlo simulation to include the renewal of system components. To demonstrate the use of this generalized Monte Carlo method, it is applied to a variety of problems which include the combined effects of wear and component dependency. Particular emphasis is given to the triple modular redundant system (TMR) with reconfiguration of spares that is widely used in avionic electronics. I.E.

A88-43503#
INTEGRATED COMPUTER AIDED PLANNING AND MANUFACTURE OF ADVANCED TECHNOLOGY JET ENGINES
B. K. SUBHAS, CHACKO GEORGE, and A. ARUL RAJ (Gas Turbine Research Establishment, Bangalore, India) Defence Science Journal (ISSN 0011-748X), vol. 37, Oct. 1987, p. 483-488.

This paper highlights an attempt at evolving a computer aided manufacturing system on a personal computer. A case study of an advanced technology jet engine component is included to illustrate various outputs from the system. The proposed system could be an alternate solution to sophisticated and expensive CAD/CAM workstations. Author

A88-43522#
TRACKING VORTICITY IN FLIGHT
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 26, June 1988, p. 42, 43.

A method for tracking the strengh and position of leading-edge vorticity in flight is discussed. Tests are performed on flight hardware for a NASA delta-wing F-106, using the vapor-screen method. Two series of maneuvers are used to establish Reynolds and Mach number effects on leading-edge vortices, one consisting of 1 g decelerations at Mach 0.4 and angles of attack from 15 to 23 degrees and altitudes from 15,000 to 35,000 ft. and the other consisting of 4.5-5.5 g spiraling turns at Mach 0.8-0.9 and angles of attack between 16 and 19 degrees and altitudes from 30,000 down to 27,000 ft. Test results show that, instead of the expected single vortex core trailing back over a delta wing at transonic combat speeds, multiple vortices often occur at supersonic speeds. Expected single leading-edge vortices were at angles of attack above 24 degrees at all altitudes with the angle at formation proportional to the Reynolds number. Future research will include tailoring the vortex by flying the F-106 with a sharp edged vortex flap along the entire leading edge and obtaining three-dimensional profiles. R.B.

A88-43523
EFFECTIVE IMPLEMENTATION OF NDT INTO AIRCRAFT DESIGN, FABRICATION, AND SERVICE
DONALD J. HAGEMAIER (Douglas Aircraft Co., Long Beach, CA) Materials Evaluation (ISSN 0025-5327), vol. 46, June 1988, p. 851, 852, 854 (8 ff.).

The organization, procedure, and methods used by an aircraft manufacturer to implement nondestructive testing into the total product cycle for commercial aircraft are discussed. In particular, attention is given to the selection of the test method, engineering and quality assurance, design support, preproduction development and testing, damage tolerance, acceptance/rejection criteria, and fabrication inspection implementation. The discussion also covers vendor NDT implementation, in-service NDT implementation, and supplemental inspection of aging aircraft. V.L.

A88-43605
CALCULATION OF AIRCRAFT STRUCTURES USING THE VARIATIONAL-MATRIX METHOD [O RASCHETE AVIATSIONNYKH KONSTRUKTSII VARIATSIONNO-MATRICHNYM METODOM]
V. G. GAINUTDINOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 20-23. In Russian. refs

An applied theory is presented for the variational-matrix calculation of thin-walled and solid wings. An algorithm for solving this problem is proposed which can be used as the basis for developing various computational schemes and selecting the formalism for a numerical implementation of the calculations. The approach described here is illustrated by an example. V.L.

A88-43613
UTILIZATION OF THE EXHAUST JET ENERGY OF GAS-TURBINE ENGINES [UTILIZATSIIA ENERGII VYKHLOPNOI STRUI GAZOTURBINNYKH DVIGATELEI]
V. I. LOKAI, A. F. PAVLOV, A. I. ARKHIPOV, IU. G. KRASIL'NIKOV, A. S. LIMANSKII et al. Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 53-56. In Russian. refs

The possibility of utilizing the energy of the exhaust jet of gas-turbine engines at the test benches of engine-building plants and airfields is discussed. In particular, attention is given to the effect of the distance L from the exit section of the nozzle to the gas intake of the utilization plant on the thrust, fuel consumption, and other parameters of the gas-turbine engine. The optimal value of L is determined. V.L.

A88-43639
NUMERICAL STUDY OF A THREE-DIMENSIONAL LAMINAR BOUNDARY LAYER WITH ALLOWANCE FOR COUPLED HEAT TRANSFER [CHISLENNOE ISSLEDOVANIE PROSTRANSTVENNOGO LAMINARNOGO POGRANICHNOGO SLOIA S UCHETOM SOPRIAZHENNOGO TEPLOOBMENA]
V. I. ZINCHENKO and O. P. FEDOROVA PMFT - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Mar.-Apr. 1988, p. 34-42. In Russian. refs

A solution is presented for the problem of the heating of a

spherically blunted cone in the path of a chemically equilibrium or supersonic air flow. The effect of the nonisothermality of the body surface on the characteristics of flow toward the body are analyzed for different angles of attack. Examples of body heating calculations are presented for a wide range of flight velocities. The applicability limits of some traditional approaches are analyzed. V.L.

A88-43723#
COMPUTATION OF LAMINAR MIXED CONVECTION FLOW IN A RECTANGULAR DUCT WITH WING-TYPE BUILT-IN OBSTACLES
G. BISWAS, N. K. MITRA, and M. FIEBIG (Bochum, Ruhr-Universitaet, Federal Republic of Germany) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 11 p. Research supported by the Alexander von Humboldt-Stiftung. refs
(AIAA PAPER 88-2647)

The object of this investigation is numerical computation of laminar mixed convection flows and heat transfer in a rectangular channel whose bottom plate has been punched out in form of a delta wing. The geometrical configuration represents proposed model of a part of gas-liquid, fin-pipe cross flow heat exchanger (gas side). Enhancement of heat transfer between the gas and the channel wall is evidenced. This augmentation is primarily due to the longitudinal vortices generated by the wing. Mixed convection condition is characterized by buoyancy induced secondary flows which increase the vortex strength and improve the heat transfer still further. Author

A88-43867
HEAT TRANSFER IN GAS TURBINE ENGINES; PROCEEDINGS OF THE SYMPOSIUM, ASME WINTER ANNUAL MEETING, BOSTON, MA, DEC. 13-18, 1987
D. E. METZGER, ED. (Arizona State University, Tempe) Symposium sponsored by ASME. New York, American Society of Mechanical Engineers, 1987, 86 p. For individual items see A88-43868 to A88-43875.

The present conference on gas turbine heat transfer discusses a quasi-steady approach to wake effects on leading-edge heat transfer rates, the numerical modeling of heat transfer in the flow through a rotor cavity, turbulence modeling for convective heat transfer over convex surfaces, and the turbulence modeling of surface heat transfer in a stagnation flow region. Also discussed are turbulent convection heat transfer at the corner intersection of heated and unheated walls in a square flow channel, the influence of a horseshoe vortex on local convection heat transfer rates, the calculation of turbulent flow and heat transfer in channels with streamwise periodic flow, and turbulent transport on the end wall in the region between adjacent turbine blades. O.C.

A88-43869#
NUMERICAL MODELING OF HEAT TRANSFER IN THE FLOW THROUGH A ROTOR CAVITY
B. K. SULTANIAN and D. A. NEALY (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) IN: Heat transfer in gas turbine engines; Proceedings of the Symposium, ASME Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987. New York, American Society of Mechanical Engineers, 1987, p. 11-24. refs

The paper presents the results of characterization of a recently developed calculation method against the heat transfer measurements in a rotating cylindrical cavity formed between two plane disks with axial inflow and radial outflow of coolant air. The available measurements for three flow rate parameters (3,500, 7,000 and 14,000) and the four rotational Reynolds numbers 250,000, 600,000, 1.2 million, and 2.0 million are used for comparison. The predictions are based on a low Reynolds number version of the k-epsilon model. For high rotation, the flow field is dominated by Ekman layers on the cavity disks. The present model is able to resolve these layers and to predict Nusselt numbers that are in nominal agreement with the measured trends. The calculation results provide further insight into the flow and heat transfer characteristics of the rotor cavity being considered. Author

A88-44653#
PERFORMANCE EVALUATION AND DESIGN METHOD FOR STATISTICAL FAILURE DETECTION SYSTEM USING MODIFIED SEQUENTIAL PROBABILITY RATIO TEST
TAKESHI HASHIMOTO and HARUO KIMURA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 412, 1988, p. 249-254. In Japanese, with abstract in English. refs

Equations for evaluating the performances of a failure detection system, whose task is to detect changes of some parameters in an object system, are derived as functions of the design parameters in the detection system, and a design method of the detection system based on the equations is proposed. This detection system consists of the Kalman filters and the Modified Sequential Probability Ratio Test. The usefulness of this design method is examined by means of numerical simulations for the parameter changes in a second-order system and for the failure in an aircraft stability augmentation system. Author

A88-44660#
TOTAL VELOCITY VECTOR MEASUREMENTS IN AN AXIAL-FLOW COMPRESSOR USING A 3-COMPONENT LASER DOPPLER ANEMOMETER
CHRISTOPHER J. CHESNAKAS and CLINTON L. DANCEY (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. refs
(Contract F33615-85-C-2575)
(AIAA PAPER 88-2811)

A three-color, three-component laser Doppler anemometer (LDA) was used to simultaneously measure the three components of velocity in a low speed (2900 rpm) axial-flow compressor rotor blade passage. Although the mean velocities and entire Reynolds stress tensor were obtained with this system, only the mean velocity results are reported here. It is demonstrated that accurate measurements in the mean motion are possible over much of the blade passage and that the secondary motions can be captured. Confirmation of the observed mean flow results is obtained through a comparison of the three dimensional flow with limited stationary pressure probe measurements and simple irrotational flow assumptions. The presentation of the measurements is followed by a discussion of the difficulties encountered in making three-dimensional velocity measurements in blade passages with LDA and suggestions are made for improving the present system for this task. Author

A88-44715#
FINITE-ELEMENT ANALYSIS OF RING GEAR/CASING SPLINE CONTACT
S. SUNDARARAJAN and S. AMIN (Pratt and Whitney Canada, Longueuil) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p. refs
(AIAA PAPER 88-2981)

A two-dimensional FEM computer program has ben extended for the iterative solution of the problem of load-dependent spline contact, in the case of a turboprop engine gearbox in whose epicyclic gear train the ring gear is locked to the casing through external splines. The program has permitted the calculation of the reactive load and the relative sliding on the loaded splines for any planet gear load position. By changing the spline pressure angle from 20 to 30 deg on the basis of analysis results, spline wear was practically eliminated in field engine gearboxes. O.C.

A88-44716#
APPLICATION OF QUANTITATIVE DEBRIS MONITORING TO GEAR SYSTEMS
FRANK DIPASQUALE (Aeroquip Corp., Tedeco Div., Glenolden, PA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 6 p. refs
(AIAA PAPER 88-2982)

The Quantitative Debris Monitor (QDM) system for on-line oil debris diagnostics, used in conjunction with a uniquely designed housing to ensure high wear particle capture, has been applied to

various aircraft gearboxes to maximize early failure detection probabilities and reduce false alarm rates. An account is given of QDM's sensor locations, supporting electronics, and novel oil debris separator. Attention is given to experience with cases of QDM monitoring of labyrinth seal wear, gearbox bearing races, and gearbox bearing retainer fretting. O.C.

A88-44717#
ADVANCES IN AIRCRAFT TRANSMISSION LUBRICANT FILTRATION TECHNOLOGY
PULIYUR MADHAVAN (Pall Corp., Glen Cove, NY) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 6 p. refs
(AIAA PAPER 88-2984)

Contaminant particles entering lubricated gear tooth contact zones can cause severe abrasive wear, surface fatigue, and adhesive wear; fine filtration is accordingly required to remove abrasive particles smaller than 5 microns. Also important are recently developed dual filter systems in which a secondary filter furnishes backup against the event of large debris particle bypassing of the primary filter. Examination of the wear debris collected by the filter can furnish insight into system condition, as in the 'Dirt Alert' filter element currently being incorporated into aircraft engine ground test equipment. O.C.

A88-44726#
EXPERIMENTAL HEAT TRANSFER AND FRICTION FACTORS IN TURBULATED COOLING PASSAGES OF DIFFERENT ASPECT RATIOS, WHERE TURBULATORS ARE STAGGERED
M. E. TASLIM (Northeastern University, Boston, MA) and S. D. SPRING (General Electric Co., Lynn, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p. refs
(AIAA PAPER 88-3014)

Turbulator ribs of different height/passage hydraulic diameter, positioned in different configurations relative to one another, are used in advanced aircraft engines to enhance heat transfer from the blade surface to the internal cooling air. An experimental investigation has been conducted to ascertain the effect that turbulators positioned perpendicular to the direction of flow and in a staggered configuration have on heat transfer coefficients and friction factors in cooling passages of different aspect ratios. Comparisons are made between staggered and in-line turbulator configuration results; higher heat transfer coefficients are obtained for the staggered configuration. O.C.

A88-44735#
SELECTION OF A LASER ANEMOMETER TECHNIQUE FOR PROPELLER TESTS IN WIND TUNNELS
J. W. KOOI and J. H. M. GOODEN (Nationaal Lucht- en Ruimtevaartlaboratorium, Emmeloord, Netherlands) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. Research sponsored by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. refs
(AIAA PAPER 88-3035)

A commercially available laser Doppler and a laser transit anemometer were used in a comparative way to measure the flow field of a 732 m diameter 6-bladed propeller. The tests were performed in the NLR low speed wind tunnel which has a 3.0 x 2.25 sq m test section. Free stream velocity was 40 m/s and the propeller rotational speed was selected to be either 3500 or 6000 r.p.m.. Both laser anemometers were two-component systems and during the flow field surveys in front of, in between and behind the propeller blades the axial and tangential velocity components were measured. The results of the two systems were found to be within 1.4 m/s of each other. The LDA angular resolution proved to be better and showed significant flow details which were missed by the LTA. The LTA underlined its well known advantage of high light concentration in the spots. Both systems performed flawlessly and proved their capability to work in an industrial environment. The LDA had about a 3 times larger productivity than the LTA system. Author

A88-44736#
PYROMETRY FOR TURBINE BLADE DEVELOPMENT
E. SUAREZ and H. R. PRZIREMBEL (Pratt and Whitney, West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p. Research supported by United Technologies Corp.
(Contract F33657-84-C-2137)
(AIAA PAPER 88-3036)

This paper discusses the use of pyrometry for turbine health monitoring and experimental substantiation of turbine heat transfer models and designs. It also addresses techniques to correct for high levels of reflection and random flame spikes. An overview of the technical issues involved in the use of pyrometry on ceramic coatings is also presented. Author

A88-44737#
EVALUATING LENS PURGE SYSTEMS FOR OPTICAL SENSORS ON TURBINE ENGINES
T. HAYDEN, D. MYHRE (Rosemount, Inc., Aerospace Div., Eagan, MN), DAVID Y. H. PUI, THOMAS H. KUEHN, and C. J. TSAI (Minnesota, University, Minneapolis) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 11 p. refs
(AIAA PAPER 88-3037)

The present numerical analysis and experiments attempt to characterize purge air systems applicable to gas turbine engine optical sensors, with emphasis on 'scrubbing' type purge systems employing contaminated compressor bleed air. The primary particle-deposition mechanism is found to be the eddy diffusion of submicron-sized particles, followed by the turbulent deposition and inertial impact of particles larger than 1 micron in aerodynamic diameter. Large, nonsticky particles are easily removed by a purge air system due to the exertion of the fluid drag force's exertion on a larger projection area; nevertheless, a virtual impactor has had to be incorporated in order to remove large, sticky particles. O.C.

A88-44742*# General Motors Corp., Indianapolis, Ind.
DESIGN AND DEVELOPMENT OF CERAMIC COMPONENTS
R. L. HOLTMAN (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p. DOE-supported research.
(Contract DEN3-168; DEN3-336)
(AIAA PAPER 88-3054)

The development of the AGT 100 turbine components in structural ceramic materials is described. Development is defined as the complete and iterative cycle from design, analysis, test, and design refinement culminating in successful demonstration of the design requirements. The components are analyzed by a linear elastic probabilistic approach, which involves finite element (three- and/or two-dimensional) simulation of the component combined with a Weibull characterization of the brittle ceramic material strength distribution to calculate a probability of survival for the component in the operating environment. Component test failure investigation has resulted in design modifications, and an improvement in component reliability has been demonstrated. Engine testing (over 570 h to date) continues to assess design/development of structural ceramic components. Author

A88-44748#
A MODIFIED-BRAYTON CYCLE PULSE TURBINE ENGINE
KENNETH W. PORTER (Pulse Turbines, Ltd., Mercer Island, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p. refs
(AIAA PAPER 88-3067)

Conventional engines of comparable output are presently compared with a pulse-turbine engine employing a Brayton cycle in which pistons achieve a high compression ratio in a single stage, followed by a pulsed combustion process in a middle chamber and full-expansion energy recovery from the combustion products in a larger cylinder. Better fuel efficiency is thereby obtainable than with conventional reciprocating or gas-turbine

engines. A ceramic combustion chamber and expansion cylinder can be incorporated. The radially-balanced piston arrangement is essentially vibration-free. An installation of less than half the size and weight of an equivalent diesel is anticipated. O.C.

A88-44774#
NONLINEAR FINITE ELEMENT ANALYSIS TO PREDICT FAN BLADE IMPACT DAMAGE
N. F. MARTIN, JR. (Pratt and Whitney, West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p. refs
(AIAA PAPER 88-3163)

PW/WHAM is a nonlinear FEM impact analysis code that couples a transient geometric and material nonlinear plate FEM analysis, a fluid FEM projectile, and contact algorithms, in order to form an advanced numerical tool for the prediction of structural impact damage in gas turbine engine components. The direct-integration time-marching solution employed uses the explicit form of the Newmark B-Method difference equations; the fluid FEM makes use of a compressible nonlinear fluid constitutive law. The general contact algorithms continually track the bird/structure interaction, eliminating the need for empirical tracking corrections. Excellent correlations are obtained with test results. O.C.

A88-44775#
CRACK GROWTH ANALYSIS OF GAS TURBINE ENGINE COMPONENTS
R. N. TADROS and K. REZAI (Pratt and Whitney Canada, Longueuil) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 5 p.
(AIAA PAPER 88-3164)

Application of fracture mechanics to gas turbine engine components requires a knowledge of the initial flaw in the location of analysis. In general, initial flaws may be obtained by Non-Destructive Inspection (NDI) methods. Another known method is based on statistical analysis of flaw sizes. Flaw sizes can be obtained in two ways: either direct assessment of flaw distribution from specimen/component cut-ups, or back calculation of Pseudo-Initial Flaws (PIF) that correlate with the available fatigue data. In the latter method, first flaw sizes are obtained through iterative fracture mechanics analyses until good correlations between the predicted crack growth lives and actual component fatigue lives are obtained. These flaws are then statistically analyzed to obtain a PIF, reflecting the production batch of a given engine component. In this paper, the PIF approach is discussed and typical results are presented. Author

A88-44783*# Oklahoma State Univ., Stillwater.
LATERAL JET INJECTION INTO SWIRLING COMBUSTOR FLOWFIELDS
DAVID G. LILLEY (Oklahoma State University, Stillwater, OK) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 15 p. refs
(Contract NAG3-549)
(AIAA PAPER 88-3183)

An experimental program has been conducted to ascertain the effects of the number of lateral jets, the jet velocity ratio, and the crossflow swirl strength, on the isothermal flowfield patterns in jets injected normally to a round-section crossflow. Attention has been given to the trajectory, penetration, and mixing efficiency of the lateral injection, using flow visualization, pitot-probe and hot-wire methods. In addition, such predictive techniques as a simple, explicit, fully three-dimensional turbulent computer code have been employed. O.C.

A88-44787#
CONSIDERATIONS FOR THE DESIGN OF HIGH-EFFECTIVENESS CERAMIC ROTARY REGENERATORS FOR REGENERATED, LOW-PRESSURE-RATIO GAS-TURBINE ENGINES
CARLA D. HAGLER and DAVID GORDON WILSON (MIT, Cambridge, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p. refs
(AIAA PAPER 88-3191)

To realize the high efficiencies of regenerated low-pressure-ratio gas-turbine engines, a regenerator having a high effectiveness is necessary, resulting in a large, thin rotary disk. In this paper, we examine the effects that some design parameters have on the size, seal leakage and drive-power requirements of a rotary regenerator constrained by effectiveness and by either hot-stream pressure drop or by disk thickness. These parameters include the matrix heat-capacity ratio, the fluid heat-capacity ratio, the conductance ratio and properties of the matrix core itself. Author

A88-44791#
APPLICATION OF CFD TO GAS TURBINE ENGINE SECONDARY FLOW SYSTEMS - THE LABYRINTH SEAL
GEOFFREY J. STURGESS and PRASANTA DATTA (United Technologies Corp., Pratt and Whitney Engineering, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 13 p. refs
(AIAA PAPER 88-3203)

In order to evaluate the suitability of CFD techniques for improving the accuracy of secondary flow calculations, test computations were performed on the flow through the hard-edged orifice plate of a gas-turbine engine labyrinth seal. Results are presented for a four-knife, straight-through labyrinth seal operating through a range of overall pressure ratios, seal clearances, and rotational speeds. When careful modeling is used for the knives, the application of CFD can reduce the uncertainty associated with leakage flow calculations to the level of the uncertainty associated with accurate knowledge of seal running clearances. O.C.

A88-45473
INVESTIGATION OF THE DYNAMIC CHARACTERISTICS OF A SENSOR WHICH MEASURES THE VERTICAL COMPONENT OF WIND VELOCITY - THE VEGA BALLOON EXPERIMENT [ISSLEDOVANIE DINAMICHESKIKH KHARAKTERISTIK DATCHIKA VERTIKAL'NOGO KOMPONENTA SKOROSTI VETRA - AEROSTATNYI EKSPERIMENT PROEKTA 'VEGA']
S. N. ALEKSASHKIN, R. I. ZUKAKISHVILI, K. M. PICHKHADZE, R. CH. TARGAMADZE, and A. V. TERTERASHVILI Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 26, May-June 1988, p. 441-447. In Russian. refs

Experimental results are presented on the dynamic characteristics of the Vega balloon sensor which is designed to measure the vertical component of the wind velocity in the Venusian atmosphere. It is shown that a minimum error is achieved in a narrow frequency range of the input signal down to 0.1 Hz, permitting the reliable determination of the slowly varying drift of the mean velocity of vertical turbulence in the Venusian atmosphere. B.J.

A88-45620#
DEVELOPMENT OF POROUS PLUG RADIOMETERS FOR USE IN ADVANCED GAS TURBINE ENGINE PROGRAMS
W. H. ATKINSON, R. R. STRANGE (Pratt and Whitney, East Hartford, CT), and R. J. MOFFAT (Stanford University, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 5 p.
(AIAA PAPER 88-3040)

Development of Advanced Gas Turbine Engines with improved performance and durability requires a detailed knowledge of the heat load on engine components. Due to increased pressure ratios, higher temperatures and alternative fuels, design systems require determination of radiative as well as total heat loads on hot section components. Porous plug radiometers are instruments designed to measure the radiative load on hot engine components, exclusive of convective effects. These instruments depend on blowing through a porous surface to uncouple the convective heat load. An energy balance approach is then used to determine the radiation load on the surface. Author

A88-45622#
ROTATING TESTS OF ADVANCED HIGH TEMPERATURE WIRE AND THIN-FILM STRAIN GAGES
H. P. GRANT, W. L. ANDERSON, and J. S. PRZYBYSZEWSKI (Pratt and Whitney, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 14 p. refs
(Contract F33615-83-C-2330)
(AIAA PAPER 88-3146)

Two different 1/8-inch static strain gages capable of elevated temperature operation on aircraft gas turbine disks were hot spin-pit tested to 1250 F and 2000 microstrain at 30,000 G acceleration. While one gage was of FeCrAl alloy, in wire form, the other was a PdCr alloy in sputtered-film form. Both types were found to be mechanically durable; the long-term goal of achieving an uncertainty of less than 200 microstrains, however, has not been approached at temperatures above 725 F. The performance-limiting factor for the FeCrAl gages may be metallurgical phase-stability, while that of the PdCr is insufficient oxidation protection. O.C.

A88-45623#
ROTATIONAL TESTING OF HEAT FLUX SENSORS IN TURBINE BLADES
W. H. ATKINSON and R. R. STRANGE (Pratt and Whitney, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 6 p. refs
(Contract F33615-83-C-2330)
(AIAA PAPER 88-3148)

Heat flux sensors have been fabricated into turbine blades and tested under rotation in a spin pit rig. After brazed assembly, the blades with their integral sensors were machined to demonstrate the feasibility of such an operation without sensor wiring deterioration. One sensor failed early in the test program, and its thermocouple functioned intermittently. Posttest analyses showed that all sensor failures were in the external lead wires, indicating that the heat flux sensor fabrication technique yields sensors capable of withstanding the centrifugal forces generated. O.C.

N88-23718*# Massachusetts Inst. of Tech., Cambridge.
EXPERIMENTAL MEASUREMENTS OF HEAT TRANSFER FROM AN ICED SURFACE DURING ARTIFICIAL AND NATURAL CLOUD ICING CONDITIONS
MARK S. KIRBY and R. JOHN HANSMAN, JR. *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1986 p 17-26 Apr. 1988 Previously announced in IAA as A86-39948 Sponsored in cooperation with FAA
(Contract NGL-22-009-640; NAG3-666)
(AIAA-PAPER-86-1352) Avail: NTIS HC A06/MF A01 CSCL 20D

The heat transfer behavior of accreting ice surfaces in natural (flight test) and simulated (wind tunnel) cloud icing conditions were studied. Observations of wet and dry ice growth regimes as measured by ultrasonic pulse echo techniques were made. Observed wet and dry ice growth regimes at the stagnation point of a cylinder were compared with those predicted using a quasi steady state heat balance model. A series of heat transfer coefficients were employed by the model to infer the local heat transfer behavior of the actual ice surfaces. The heat transfer in the stagnation region was generally inferred to be higher in wind tunnel icing tests than in natural flight icing conditions. Author

N88-23742*# PRC Kentron, Inc., Hampton, Va. Aerospace Technologies Div.
BOUNDARY LAYER FLOW VISUALIZATION FOR FLIGHT TESTING
CLIFFORD J. OBARA *In* NASA, Langley Research Center, *Laminar Flow Aircraft Certification* p 129-140 May 1986
Avail: NTIS HC A14/MF A01 CSCL 20D

Flow visualization is used extensively in flight testing to determine aerodynamic characteristics such as surface flow direction and boundary layer state. Several visualization techniques are available to the aerodynamicist. Two of the most popular are oil flows and sublimating chemicals. Oil is used to visualize boundary layer transition, shock wave location, regions of separated flow, and surface flow direction. Boundary layer transition can also be visualized with sublimating chemicals. A summary of these two techniques is discussed, and the use of sublimating chemicals is examined in some detail. The different modes of boundary layer transition are characterized by different patterns in the sublimating chemical coating. The discussion includes interpretation of these chemical patterns and the temperature and velocity operating limitations of the chemical substances. Information for selection of appropriate chemicals for a desired set of flight conditions is provided. Author

N88-23743*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
BOUNDARY LAYER MEASUREMENTS USING HOT-FILM SENSORS
HARLAN K. HOLMES and DEBRA L. CARRAWAY (Old Dominion Univ., Norfolk, Va.) *In its* Laminar Flow Aircraft Certification p 141-153 May 1986
Avail: NTIS HC A14/MF A01 CSCL 20D

Measurements in the aerodynamic boundary layer using heat transfer, hot-film sensors are receiving a significant amount of effort at the Langley Research Center. A description of the basic sensor, the signal conditioning employed, and several manifestations of the sensor are given. Results of a flow reversal sensor development are presented, and future work areas are outlined. Author

N88-23956*# United Technologies Research Center, East Hartford, Conn.
THE EFFECTS OF INLET TURBULENCE AND ROTOR/STATOR INTERACTIONS ON THE AERODYNAMICS AND HEAT TRANSFER OF A LARGE-SCALE ROTATING TURBINE MODEL. PART 4: AERODYNAMIC DATA TABULATION
R. P. DRING, H. D. JOSLYN, and M. F. BLAIR Nov. 1987
135 p
(Contract NAS3-23717)
(NASA-CR-179469; NAS 1.26:179469; UTRC-R86-956480-4)
Avail: NTIS HC A07/MF A01 CSCL 20D

A combined experimental and analytical program was conducted to examine the effects of inlet turbulence and airfoil heat transfer. The experimental portion of the study was conducted in a large-scale (approx. 5X engine), ambient temperature, rotating turbine model configured in both single-stage and stage-and-a-half arrangements. Heat transfer measurements were obtained using low-conductivity air foils 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, first stator-rotor axial spacing, Reynolds number and relative circumferential position of the first and second stators. Aerodynamic measurements obtained 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. Results include airfoil heat transfer predictions produced using existing 2-D boundary layer computation schemes and an examination of solutions of the unsteady boundary layer equations. Author

N88-23957*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HEAT TRANSFER IN AEROSPACE PROPULSION
ROBERT J. SIMONEAU, ROBERT C. HENDRICKS, and HERBERT J. GLADDEN 1988 48 p Presented at the National Heat Transfer Conference, Houston, Tex., 24-27 Jul. 1988; sponsored by ASME, AICE and ANS
(NASA-TM-100874; E-4105; NAS 1.15:100874) Avail: NTIS HC A03/MF A01 CSCL 20D

Presented is an overview of heat transfer related research in support of aerospace propulsion, particularly as seen from the perspective of the NASA Lewis Research Center. Aerospace

propulsion is defined to cover the full spectrum from conventional aircraft power plants through the Aerospace Plane to space propulsion. The conventional subsonic/supersonic aircraft arena, whether commercial or military, relies on the turbine engine. A key characteristic of turbine engines is that they involve fundamentally unsteady flows which must be properly treated. Space propulsion is characterized by very demanding performance requirements which frequently push systems to their limits and demand tailored designs. The hypersonic flight propulsion systems are subject to severe heat loads and the engine and airframe are truly one entity. The impact of the special demands of each of these aerospace propulsion systems on heat transfer is explored. Author

N88-23977*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VIBRATION AND CONTROL OF FLEXIBLE ROTOR SUPPORTED BY MAGNETIC BEARINGS
KENZOU NONAMI 1988 23 p Presented at the 1st International Conference on Magnetic Bearings, Zurich, Switzerland, 6-8 Jun. 1988; sponsored in part by the Swiss Federal Inst. of Technology, and the Swiss Society of Microtechnics
(NASA-TM-100888; E-4123; NAS 1.15:100888) Avail: NTIS HC A03/MF A01 CSCL 13E

Active vibration control of flexible rotors supported by magnetic bearings is discussed. Using a finite-element method for a mathematical model of the flexible rotor, the eigenvalue problem is formulated taking into account the interaction between a mechanical system of the flexible rotor and an electrical system of the magnetic bearings and the controller. However, for the sake of simplicity, gyroscopic effects are disregarded. It is possible to adapt this formulation to a general flexible rotor-magnetic bearing system. Controllability with and without collocation sensors and actuators located at the same distance along the rotor axis is discussed for the higher order flexible modes of the test rig. In conclusion, it is proposed that it is necessary to add new active control loops for the higher flexible modes even in the case of collocation. Then it is possible to stabilize for the case of uncollocation by means of this method. Author

N88-23978* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THERMAL STRESS MINIMIZED, TWO COMPONENT, TURBINE SHROUD SEAL Patent
ROBERT F. HANDSCHUH, inventor (to NASA) 1 Mar. 1988 12 p Filed 18 Jun. 1986 Supersedes N86-32740 (24 - 24, P 3735)
(NASA-CASE-LEW-14212-1; US-PATENT-4,728,257; US-PATENT-APPL-SN-875798; US-PATENT-CLASS-415-136; US-PATENT-CLASS-415-170-R) Avail: US Patent and Trademark Office CSCL 13I

In a turbine machine, a two-component shroud seal which maximizes insulation and sealing around the rotating turbine blades, and is made by independently fabricating each of the two components then joining them together, is disclosed. The two components may be joined together at room temperature. The resulting shroud seal provides greater engine efficiency and thrust. Official Gazette of the U.S. Patent and Trademark Office

N88-23982* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VARIABLE RESPONSE LOAD LIMITING DEVICE Patent
DWIGHT D. MCSMITH, inventor (to NASA) 19 Jan. 1988 9 p Filed 6 Oct. 1981 Supersedes N82-20544 (20 - 11, p 1515)
(NASA-CASE-LAR-12801-1; US-PATENT-4,720,139; US-PATENT-APPL-SN-309291; US-PATENT-CLASS-297-216; US-PATENT-CLASS-188-373; US-PATENT-CLASS-248-548; US-PATENT-CLASS-248-608) Avail: US Patent and Trademark Office CSCL 13I

An energy absorbing device used as a load limiting member in a structure to control its response to applied loads is described. It functions by utilizing a spool assembly having flanged ends and an interior cavity of sufficiently large diameter to cause it to deform plastically at a prescribed load. In application, the spool is utilized as a pivot point for the legs of an airplane seat. When properly designed and integrated into the seat arrangement the spool will twist about its axis, deforming plastically when the impact load exceeds the spool yield value. Through this deformation, the spool absorbs the kinetic energy of the movement of the seat at a substantially constant rate, thereby controlling the level of loads transmitted to the seat occupant. By proper sizing and collection of materials, it is possible to control load response in a predictable manner.
Official Gazette of the U.S. Patent and Trademark Office

N88-24001*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATION OF INTEGRATED FLUID-THERMAL-STRUCTURAL ANALYSIS METHODS
ALLAN R. WIETING, PRAMOTE DECHAUMPHAI, KIM S. BEY, EARL A. THORNTON, and KEN MORGAN (Wales Univ., Swansea.) May 1988 13 p Prepared for presentation at the 16th Congress of the International Council of the Aeronautical Sciences, Jerusalem, Israel, 28 Aug. - 2 Sep. 1988
(NASA-TM-100625; NAS 1.15:100625) Avail: NTIS HC A03/MF A01 CSCL 20K

Hypersonic vehicles operate in a hostile aerothermal environment which has a significant impact on their aerothermostructural performance. Significant coupling occurs between the aerodynamic flow field, structural heat transfer, and structural response creating a multidisciplinary interaction. Interfacing state-of-the-art disciplinary analysis methods is not efficient, hence interdisciplinary analysis methods integrated into a single aerothermostructural analyzer are needed. The NASA Langley Research Center is developing such methods in an analyzer called LIFTS (Langley Integrated Fluid-Thermal-Structural) analyzer. The evolution and status of LIFTS is reviewed and illustrated through applications. Author

N88-24002*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ENGINE STRUCTURES: A BIBLIOGRAPHY OF LEWIS RESEARCH CENTER'S RESEARCH FOR 1980-1987
Apr. 1988 212 p Compiled by the Committee for LST 88, the Lewis Structures Technology Symposium and Exposition, Cleveland, Ohio, 24-25 May 1988
(NASA-TM-100842; E-4033; NAS 1.15:100842) Avail: NTIS HC A01/MF A01 CSCL 20K

This compilation of abstracts describes and indexes the technical reporting that resulted from the scientific and engineering work performed and managed by the Structures Division of the NASA Lewis Research Center from 1980 through 1987. All the publications were announced in the I980 to 1987 issues of STAR (Scientific and Technical Aerospace Reports) and or IAA (International Aerospace Abstracts). Included are research reports, journal articles, conference presentations, patents and patent applications, and theses. Author

N88-24875# Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Engineering Mechanics.
COMPOSITE REDUCED NAVIER-STOKES PROCEDURES FOR FLOW PROBLEMS WITH STRONG PRESSURE INTERACTIONS Annual Report, 1 Feb. 1987 - 31 Jan. 1988
S. G. RUBIN and P. K. KHOSLA 2 Feb. 1988 60 p
(Contract F49620-85-C-0027)
(AD-A191127; AFOSR-88-0296TR) Avail: NTIS HC A04/MF A01 CSCL 20D

A Reduced Navier Stokes (RNS) system is more computationally efficient than full Navier Stokes solvers and more accurate and less cumbersome than matched viscous and inviscid methods has been shown to apply to a significant class of aerodynamic problems. The RNS system is a composite of the full Euler and boundary layer equations and is discritized to optimize the numerical representation of viscous and inviscid regions, respectively. GRA

N88-24876# Douglas Aircraft Co., Inc., Long Beach, Calif.
INSTABILITY OF LAMINAR SEPARATION BUBBLES: CAUSES AND EFFECTS Technical Report, Mar. - Sep. 1987
TUNCER CEBECI Sep. 1987 16 p
(Contract F49620-84-C-0007)
(AD-A191168; MDC-K0534; AFOSR-88-0249TR) Avail: NTIS HC A03/MF A01 CSCL 01A

A combination of interactive boundary layer and stability theories has been used to investigate the reasons for the instability of laminar separation bubbles on the leading edge of thin airfoils. It is shown that transition plays an important role and is likely to preclude the existence of long separation bubbles and their supposed instability. GRA

N88-24882# Rutgers - The State Univ., New Brunswick, N. J. Dept. of Mechanical and Aerospace Engineering.
THEORETICAL INVESTIGATION OF 3-D SHOCK WAVE-TURBULENT BOUNDARY LAYER INTERACTIONS, PART 6 Annual Report, 1 Oct. 1986 - 30 Sep. 1987
DOYLE D. KNIGHT Jan. 1988 48 p
(Contract AF-AFOSR-0266-86)
(AD-A191546; RU-TR-171-MAE-F; AFOSR-88-0127TR) Avail: NTIS HC A03/MF A01 CSCL 20D

The research concerns the understanding of 3-D shock wave-turbulent boundary layer interactions. The research activity has focused on several areas. First, the 3-D swept compression corner has been computed at Mach 3 for a sweep angle of 40 deg and compression angle of 24 deg. The calculated flows are in good agreement with experiment. Second, the flowfield structure of the 3-D swept compression corner is dominated by a large vortical structure. Third, the interaction has been found quantitatively to be dominated by inviscid effects except within a small fraction of the boundary layer. Fourth, the effect of boundary layer bleed has been examined for the 3-D shock wave-turbulent boundary layer interaction generated by a sharp fin. The effects of bleed are principally limited to the near surface region. The overall vortical structure is insensitive to surface bleed. GRA

N88-24897# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
TWO DIMENSIONAL HYPERBOLIC GRID GENERATION
ZUHEYR ALSALIHI Oct. 1987 60 p
(VKI-TN-162; ETN-88-92482) Avail: NTIS HC A04/MF A01

A two dimensional body-fitted coordinate system was generated for use in solving the turbulent or laminar, (thin-layer) Navier-Stokes equations for transonic flow fields about airfoils. The technique employed is hyperbolic grid generation with the condition of orthogonality and cell area (inverse of the metric Jacobian) specification. Addition of fourth-order numerical dissipation terms in the streamwise direction has no detrimental effect on the orthogonality. Results indicate that the method is applicable to any kind of grid topology without modification if the outer boundary is not prescribed. However, incorporation of a shooting method or combination of the technique with another method (such as transfinite interpolation technique) can be utilized in cases where specification of points on the outer boundary is required. Extension of the technique to three space dimensions and incorporation of physical grid adaptivity (dynamic remeshing) making use of the gradients of physical quantities in the specification of the cell area is also possible. The listing and user instructions of a FORTRAN program written for the implementation of the technique are included. ESA

N88-24900*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CHARACTERISTICS OF MERGING SHEAR LAYERS AND TURBULENT WAKES OF A MULTI-ELEMENT AIRFOIL
DESMOND ADAIR and W. CLIFTON HORNE Feb. 1988 79 p
(NASA-TM-100053; A-88048; NAS 1.15:100053) Avail: NTIS HC A05/MF A01 CSCL 20D

Flow characteristics in the vicinity of the trailing edge of a single-slotted airfoil flap are presented and analyzed. The experimental arrangement consisted of a NACA 4412 airfoil equipped with a NACA 4415 flap whose angle of deflection was 21.8 deg. The flow remained attached over the model surfaces except in the vicinity of the flap trailing edge where a small region of boundary-layer separation extended over the aft 7 percent of flap chord. The flow was complicated by the presence of a strong, initially inviscid jet emanating from the slot between airfoil and flap, and a gradual merging of the main airfoil wake and flap suction-side boundary layer. Downstream of the flap, the airfoil and flap wakes fully merged to form an asymmetrical curved wake. The airfoil configuration was tested at an angle of attack of 8.2 deg, at a Mach number of 0.09, and a chord based Reynolds number of 1.8 x 10 to the 6th power in the Ames Research Center 7- by 10-Foot Wind Tunnel. Surface pressure measurements were made on the airfoil and flap and on the wind tunnel roof and floor. It was estimated that the wall interference increased the C sub L by 7 percent and decreased the C sub M by 4.5 percent. Velocity characteristics were quantified using hot-wire anemometry in regions of flow with preferred direction and low turbulence intensity. A 3-D laser velocimeter was used in regions of flow recirculation and relatively high turbulence intensity.
Author

N88-24901 Yale Univ., New Haven, Conn.
MANIPULATION OF THE STRUCTURE OF A TURBULENT BOUNDARY LAYER Ph.D. Thesis
THEODORE BROOKS LYNN 1987 168 p
Avail: Univ. Microfilms Order No. DA8729107

The manipulation of a turbulent boundary layer for the purpose of net drag reduction is an attractive topic for research, because even modest success will result in large energy savings. The focus is on passive manipulation, one of the simplest manipulation techniques. The most promising manipulator is the so-called BLADE device, consisting of two thin ribbons or foils suspended in the outer portion of the boundary layer. When the research was begun, there was significant controversy over the magnitude of the net drag reduction possible (20 percent) and the maximum skin friction reduction obtainable (50 percent). Accurate local skin-friction measurements were made using sublayer fences in a perturbed boundary layer. By comparing the direct measurements with those obtained by indirect methods, it was determined that the degree of drag reduction obtained depends on the method used to calculate the combined device drag and skin friction drag. Using auto and two-point correlation measurements as well as space-time correlations, the effects of BLADE were investigated on the turbulent structures in the boundary layer, comparing them with wire devices, which are not known to produce a net reduction in drag. The space-time correlation revealed that the most significant effect of the BLADE device was on the large structures (the dominant structures in the outer region of the boundary layer). The inner layer devices consisting of sublayer wires were also investigated. The results from both the inner and outer layer manipulations suggest that the effective alteration of a turbulent boundary layer depends on the scaling of the device.
Dissert. Abstr.

N88-24903 Purdue Univ., West Lafayette, Ind.
FORCED RESPONSE UNSTEADY AERODYNAMICS IN A MULTISTAGE COMPRESSOR Ph.D. Thesis
VINCENT RALPH CAPECE 1987 208 p
Avail: Univ. Microfilms Order No. DA8729723

The fundamental flow physics of the unsteady aerodynamics associated with forced vibrations in turbomachinery are investigated. Unique data are obtained through a series of experiments in a three stage axial flow research compressor which quantify the unsteady harmonic gust interaction phenomena over a range of operating and geometric conditions at high values of reduced frequency. In these experiments the effects of the following on the stator vane unsteady aerodynamics were quantified: (1) the steady aerodynamic loading, (2) the detailed waveform of the aerodynamic forcing function, including the chordwise and transverse gust components, (3) multistage blade row interactions, and (4) the solidity, ranging from a design value of 1.09 to an

isolated airfoil. In addition, the effect of flow separation on the unsteady aerodynamics of an isolated airfoil was also investigated. Dissert. Abstr.

N88-24910*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
METHOD AND APPARATUS FOR DETECTING LAMINAR FLOW SEPARATION AND REATTACHMENT Patent Application
JOHN P. STACK, inventor (to NASA) and SIVARAMAKRISHNAN M. MANGALAM, inventor (to NASA) (Analytical Services and Materials, Inc., Hampton, Va.) 7 Jun. 1988 22 p
(NASA-CASE-LAR-13952-1-SB; NAS 1.71:LAR-13952-1-SB; US-PATENT-APPL-SN-203178) Avail: NTIS HC A03/MF A01 CSCL 20D

The invention is a method and apparatus for detecting laminar flow separation and flow reattachment of a fluid stream by simultaneously sensing and comparing a plurality of output signals, each representing the dynamic shear stress at one of an equal number of sensors spaced along a straight line on the surface of an airfoil or the like that extends parallel to the fluid stream. The output signals are concurrently compared to detect the sensors across which a reversal in phase of said output signal occurs, said detected sensors being in the region of laminar separation or reattachment. The novelty in this invention is the discovery and use of the phase reversal phenomena to detect laminar separation and attachment of a fluid stream from any surface such as an airfoil supported therein. NASA

N88-24922*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
APPLICATION OF ADVANCED GRID GENERATION TECHNIQUES FOR FLOW FIELD COMPUTATIONS ABOUT COMPLEX CONFIGURATIONS Progress Report, period ended 31 Jul. 1988
MONCHAI KATHONG and SURENDRA N. TIWARI Jul. 1988 202 p
(Contract NCC1-68)
(NASA-CR-183049; NAS 1.26:183049) Avail: NTIS HC A10/MF A01 CSCL 20D

In the computation of flowfields about complex configurations, it is very difficult to construct a boundary-fitted coordinate system. An alternative approach is to use several grids at once, each of which is generated independently. This procedure is called the multiple grids or zonal grids approach; its applications are investigated. The method conservative providing conservation of fluxes at grid interfaces. The Euler equations are solved numerically on such grids for various configurations. The numerical scheme used is the finite-volume technique with a three-stage Runge-Kutta time integration. The code is vectorized and programmed to run on the CDC VPS-32 computer. Steady state solutions of the Euler equations are presented and discussed. The solutions include: low speed flow over a sphere, high speed flow over a slender body, supersonic flow through a duct, and supersonic internal/external flow interaction for an aircraft configuration at various angles of attack. The results demonstrate that the multiple grids approach along with the conservative interfacing is capable of computing the flows about the complex configurations where the use of a single grid system is not possible. Author

N88-24928# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugfuehrung.
OPTICS: PERSPECTIVES FOR MEASUREMENT TECHNIQUES AND SIGNAL PROCESSING FOR FLIGHT GUIDANCE
Aug. 1987 295 p Partly in ENGLISH and GERMAN Colloquium held in Brunswick, Fed. Republic of Germany, 21-22 May 1987 Report will also be announced as translation (ESA-TT-1112)
(DFVLR-MITT-87-21; ISSN-0176-7739; ETN-88-92313) Avail: NTIS HC A13/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 88 Deutsche marks

Concepts for the improvement and stabilization of laser gyroscopes, and the use of rate-bias techniques for laser gyroscopes are presented. The development of mirrors for high-precision laser gyroscopes, and the use of laser gyroscopes in multifunction navigation and flight guidance systems are outlined. Navigation using fiber optic gyroscopes, and the limits of accuracy and range of laser radars are discussed. The optical accelerometer as a sensor for inertial flight guidance is presented. The status of development and the development potential of fiber optic gyroscopes and Global Positioning System receivers is described. Digital fiber-optic displacement sensors, and electro-optical multistability for signal processing were investigated. The status of optical computers and optical methods for data processing is described. ESA

N88-24932# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
LABORATORY TESTS OF LASER GYROSCOPES FOR FUTURE UTILIZATION IN MULTIFUNCTION SYSTEMS FOR PRECISION NAVIGATION AND FLIGHT GUIDANCE [LABORTESTS VON LASERKREISELN FUER DEN ZUKUENFTIGEN EINSATZ IN MULTIFUNKTIONSSYSTEMEN ZUR PRAEZISIONSNAVIGATION UND ZUR FLUGREGELUNG]
H. NIEDERSTRASSER, V. WETZIG, and E. LUEBECK *In its* Optics: Perspectives for Measurement Techniques and Signal Processing for Flight Guidance p 107-126 Aug. 1987 In GERMAN
Avail: NTIS HC A13/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 88 Deutsche marks

The use of laser gyroscopes in multifunction Inertial Reference Units was investigated in the laboratory using a single-axis revolving platform. The use of the laser gyroscope as sensor for inertial navigation shows a good reproducibility of the average slope of the characteristic (0.5 ppm). For the measurement of single angular shifts, the laser gyroscope shows a constant error of 2.9 sec and an error between 0.004 and 0.0016 deg/hr depending on the interval length. The dynamic investigation of the laser gyroscope as sensor for flight guidance shows an amplitude distortion below 1 percent and a phase shift below 0.4 mrad in the whole frequency range up to 100 Hz. ESA

N88-24934# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
LIMITS OF ACCURACY AND RANGE OF LASER RADARS [GRENZEN VON GENAUIGKEIT UND REICHWEITE BEIM LASERRADAR]
KURT FRICKE *In its* Optics: Perspectives for Measurement Techniques and Signal Processing for Flight Guidance p 143-158 Aug. 1987 In GERMAN
Avail: NTIS HC A13/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 88 Deutsche marks

The limitations and errors involved in laser range finding for flight guidance are treated. The measurement principle of the developed laser radar is explained. Limitation in laser power to protect humans is discussed. The laser power and the radiation noise level at the multiplier cathode, and the possible range were calculated. Errors of the range and angle measurements are discussed. The comparison between measured and calculated laser radar data shows that the range is 12 percent too small. The required measurement accuracy is outlined. Instrument errors are significantly smaller than those due to atmospheric effects. An optimized laser design, as well as a controlled beam shape and a postamplification of the laser pulse in the receiver can increase the range. ESA

N88-24935# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
THE OPTICAL ACCELEROMETER: A NOVEL SENSOR FOR VERTICAL FLIGHT GUIDANCE [DER OPTISCHE BESCHLEUNIGUNGSMESSER - EIN NEUER SENSOR FUER DIE INERTIALE FLUGFUEHRUNG]
WOLFGANG HOLZAPFEL *In its* Optics: Perspectives for Measurement Techniques and Signal Processing for Flight

Guidance p 159-192 Aug. 1987 In GERMAN
Avail: NTIS HC A13/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 88 Deutsche marks

Concepts for optical accelerometers, functioning according to the laser principle and using oscillator-internal conversion effects, are presented. The physical and measuring principles of these optical accelerometers are explained. The theoretical expected measurement range is between 100 g and 10 to the 8th power g. Seismic and photoelastic laser accelerometers are presented. Experimental results with both accelerometers show proportionality over almost 5 decades of the input signal. The resolution and estimated accuracies are of the order of 0.00001 g. ESA

N88-24970*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURALLY TAILORABLE NON-LINEAR SNAP-THROUGH SPRING SYSTEM Patent Application
GARY L. FARLEY, inventor (to NASA), JAMES H. STARNES, JR., inventor (to NASA), and WAYNE R. MANTAY, inventor (to NASA) (Army Aviation Systems Command, Hampton, Va.) 1 Apr. 1988 11 p
(NASA-CASE-LAR-13729-1; NAS 1.71:LAR-13729-1; US-PATENT-APPL-SN-176544) Avail: NTIS HC A03/MF A01 CSCL 13K

The invention relates to a structural, tailorable, nonlinear spring system which has a controllable, predictable and abrupt change in load-deflection response and which is readily adaptable to structural applications. In particular, the system can be employed to change the geometry of helicopter rotor blades as the aerodynamic and centrifugal forces acting upon the rotor blades change. The spring system comprises an external case containing a pin-connected two-bar linkage and a tension or compression spring. As a load is applied to the snap-through spring the linkage bars laterally deform until the bars collapse and snap-through. The stiffness as the load is applied is a function of the axial stiffness of the internal spring and bending stiffness of the pin-connected two-bar linkage. When the snap-through occurs, a large deformation occurs as a result of the small increase of applied load. The load-deflection response at this point is a function of the internal spring and the membrane stiffness of the bars. Additional stiffness can be provided to the post-snap-through response by including restraints that contact the external spring case. The load-deflection response of the system is tailorable by changing the size, stiffness and orientation of its various components. In addition, multiple devices can be put in parallel or series to produce an infinite number of different load-deflection responses. NASA

N88-24975*# Transmission Technology Co., Inc., Fairfield, N. J.
DESIGN, MANUFACTURE AND SPIN TEST OF HIGH CONTACT RATIO HELICOPTER TRANSMISSION UTILIZING SELF-ALIGNING BEARINGLESS PLANETARY (SABP) Final Contractor Report
DEZI FOLENTA and WILLIAM LEBO Washington NASA Jun. 1988 112 p
(Contract NAS3-24539; DA PROJ. 1L1-62209-AH-76)
(NASA-CR-4155; E-4049; NAS 1.26:4155; TTC-87-07R; AVSCOM-TR-88-C-009) Avail: NTIS HC A06/MF A01 CSCL 13I

A 450 hp high ratio Self-Aligning Bearingless Planetary (SABP) for a helicopter application was designed, manufactured, and spin tested under NASA contract NAS3-24539. The objective of the program was to conduct research and development work on a high contact ratio helical gear SABP to reduce weight and noise and to improve efficiency. The results accomplished include the design, manufacturing, and no-load spin testing of two prototype helicopter transmissions, rated at 450 hp with an input speed of 35,000 rpm and an output speed of 350 rpm. The weight power density ratio of these gear units is 0.33 lb hp. The measured airborne noise at 35,000 rpm input speed and light load is 94 dB at 5 ft. The high speed, high contact ratio SABP transmission appears to be significantly lighter and quieter than comtemporary helicopter transmissions. The concept of the SABP is applicable not only to high ratio helicopter type transmissions but also to other rotorcraft and aircraft propulsion systems. Author

N88-24994# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction Scientifique de la Resistance des Structures.
INVESTIGATION OF THE EFFECT OF MINIMUM LOADS AND COMPRESSION OF LOAD SPECTRA ON THE PREDICTION CAPACITIES OF THE ONERA CRACK MODEL Final Report [ETUDE DE L'EFFET DES CHARGES MINIMALES ET DE COMPRESSION DES SPECTRES DE CHARGEMENT SUR LES CAPACITES DE PREVISION DU MODELE DE FISSURATION ONERA]
G. BAUDIN and M. ROBERT Oct. 1987 46 p In FRENCH
(Contract STPA-85-95-004)
(ONERA-RTS-33/7169-RY-064-R; ETN-88-92546) Avail: NTIS HC A03/MF A01

The ONERA fatigue crack prediction model was tested for the case of a wing with high compression loads. Results for various thicknesses are satisfactory (conservative in a ratio of 0.53 to 0.68). This type of load spectrum needs a simple adaptation of the model: cycles which are entirely compressive should be ignored when calculating the loading parameter. Another possible amelioration would be to widen the measuring domain of threshold functions towards negative R ratios and big thicknesses during model identification. ESA

N88-25118*# Massachusetts Inst. of Tech., Lexington.
THE FEDERAL AVIATION ADMINISTRATION/MASSACHUSETTS INSTITUTE OF TECHNOLOGY (FAA/MIT) LINCOLN LABORATORY DOPPLER WEATHER RADAR PROGRAM
JAMES E. EVANS *In* Tennessee Univ. Space Inst., Tullahoma. Meteorological and Environmental Inputs to Aviation Systems p 155-166 Jun. 1988 Sponsored by FAA
Avail: NTIS HC A11/MF A01 CSCL 20N

The program focuses on providing real-time information on hazardous aviation weather to end users such as air traffic control and pilots. Existing systems will soon be replaced by a Next Generation Weather Radar (NEXRAD), which will be concerned with detecting such hazards as heavy rain and hail, turbulence, low-altitude wind shear, and mesocyclones and tornadoes. Other systems in process are the Central Weather Processor (CWP), and the terminal Doppler weather radar (TDWR). Weather measurements near Memphis are central to ongoing work, especially in the area of microbursts and wind shear. J.P.B.

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GEOSCIENCES

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

N88-25104# Clermont-Ferrand Univ. (France). Lab. Associe de Meteorologique Physique.
ICE FORMATION ON AIRCRAFT Final Report [GIVRAGE DES AERONEFS]
J. F. GAYET Dec. 1986 15 p In FRENCH
(Contract DRET-85-34-016)
(ETN-88-92154) Avail: NTIS HC A03/MF A01

he in-flight icing measurements carried out onboard a Transall aircraft are discussed. A total of 50 flight hr for different meteorological conditions were included. The data acquisition system allowed the recording of one and two dimensional parameters, including microphysics, thermodynamic, dynamic, and electrical data with 10 min resolution. The interpretation of the

results clarifies problems about the localization of icing zones and electric fields in highly convective clouds. ESA

N88-25105*# Tennessee Univ. Space Inst., Tullahoma.
METEOROLOGICAL AND ENVIRONMENTAL INPUTS TO AVIATION SYSTEMS
DENNIS W. CAMP, ed. and WALTER FROST, ed. Jun. 1988 226 p Workshop held in Tullahoma, Tenn., 12-14 Mar. 1985; sponsored by NASA, Washington, NOAA, FAA, DOD, and Office of the Federal Coordinator for Meteorology
(NASA-CP-2498; L-16338; NAS 1.55:2498) Avail: NTIS HC A11/MF A01 CSCL 04B

Reports on aviation meteorology, most of them informal, are presented by representatives of the National Weather Service, the Bracknell (England) Meteorological Office, the NOAA Wave Propagation Lab., the Fleet Numerical Oceanography Center, and the Aircraft Owners and Pilots Association. Additional presentations are included on aircraft/lidar turbulence comparison, lightning detection and locating systems, objective detection and forecasting of clear air turbulence, comparative verification between the Generalized Exponential Markov (GEM) Model and official aviation terminal forecasts, the evaluation of the Prototype Regional Observation and Forecast System (PROFS) mesoscale weather products, and the FAA/MIT Lincoln Lab. Doppler Weather Radar Program.

N88-25110*# Aircraft Owners and Pilots Association, Frederick, Md.
GENERAL-AVIATION'S VIEW OF PROGRESS IN THE AVIATION WEATHER SYSTEM
DOUGLAS J. LUNDGREN *In* Tennessee Univ. Space Inst., Tullahoma. Meteorological and Environmental Inputs to Aviation Systems p 79-85 Jun. 1988
Avail: NTIS HC A11/MF A01 CSCL 04B

For all its activity statistics, general-aviation is the most vulnerable to hazardous weather. Of concern to the general aviation industry are: (1) the slow pace of getting units of the Automated Weather Observation System (AWOS) to the field; (2) the efforts of the National Weather Service to withdraw from both the observation and dissemination roles of the aviation weather system; (3) the need for more observation points to improve the accuracy of terminal and area forecasts; (4) the need for improvements in all area forecasts, terminal forecasts, and winds aloft forecasts; (5) slow progress in cockpit weather displays; (6) the erosion of transcribed weather broadcasts (TWEB) and other deficiencies in weather information dissemination; (7) the need to push to make the Direct User Access Terminal (DUAT) a reality; and (7) the need to improve severe weather (thunderstorm) warning systems. J.P.B.

N88-25113*# Analytic Sciences Corp., Reading, Mass.
NATIONAL PLANS FOR AIRCRAFT ICING AND IMPROVED AIRCRAFT ICING FORECASTS AND ASSOCIATED WARNING SERVICES
RALPH P. PASS *In* Tennessee Univ. Space Inst., Tullahoma. Meteorological and Environmental Inputs to Aviation Systems p 121-123 Jun. 1988
Avail: NTIS HC A11/MF A01 CSCL 04B

Recently, the United States has increased its activities related to aircraft icing in numerous fields: ice phobics, revised characterization of icing conditions, instrument development/evaluation, de-ice/anti-ice devices, simulated supercooled clouds, computer simulation and flight tests. The Federal Coordinator for Meteorology is involved in two efforts, one a National Plan on Aircraft Icing and the other a plan for Improved Aircraft Icing Forecasts and Associated Warning Services. These two plans will provide an approved structure for future U.S. activities related to aircraft icing. The recommended activities will significantly improve the position of government agencies to perform mandated activities and to enable U.S. manufacturers to be competitive in the world market. J.P.B.

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A88-42724
CONC: A PROGRAM FOR ANALYZING CONCURRENT ROBOT PROGRAMS WITHOUT LOOPS
BARRY IRVIN SOROKA (Southern California, University, Los Angeles, CA) IN: 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, Mar. 31-Apr. 3, 1987, Proceedings. Volume 3. Washington, DC, IEEE Computer Society Press, 1987, p. 1450-1455. refs

CONC is a language and simulator for multiarm Cartesian robot systems performing assembly of flat aircraft parts. CONC provides constructs for concurrency which permit the user to command simultaneous motion of multiple arms. Robot programs are represented internally as trees, and functions are provided to traverse these trees, computing new properties such as the origins and timings of motion statements. Users learn properties of programs and statements by means of a question/answer interface. LISP appears to be an appropriate language in which to embed the language and simulator. I.E.

A88-43161
A MULTIGRID FINITE ELEMENT METHOD FOR SOLVING THE TWO-DIMENSIONAL EULER EQUATIONS
MARIE-HELENE LALLEMAND and ALAIN DERVIEUX (Institut National de Recherche en Informatique et en Automatique, Valbonne, France) IN: Multigrid methods: Theory, applications, and supercomputing; Proceedings of the Third Copper Mountain Conference, Copper Mountain, CO, Apr. 5-10, 1987. New York, Marcel Dekker, Inc., 1988, p. 337-363. refs

An explicit multigrid FEM employing nested levels of unstructured meshes is developed to calculate two-dimensional Euler flows around complete geometries. A novel topological approach is taken in which the coarse meshes are generalized finite-volume partitions rather than FEM triangulations, the spatial approximation is derived on each level, and a full approximation-storage scheme is used. Particular attention is given to the generation of the different levels, the first-order-accurate upwind scheme, and the multigrid implementation. Numerical results for flow at freestream Mach number 0.85 in a channel with a 4.2-percent circular bump and for Mach 0.72 flow around a NACA 0012 airfoil at zero angle of attack are presented in extensive graphs and compared with those obtained using a multitriangulation FEM. T.K.

A88-43336
SUPPORTABILITY EVALUATION PREDICTION PROCESS
MICHAEL K. LAPPIN (McDonnell Aircraft Co., Saint Louis, MO) IN: Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 26-28, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 102-107. refs

Methodology has been developed that allows identification of supportability design criteria (SDC) and quantification of total field logistics support requirements. Interface with design engineers via computer-aided design (CAD) workstations is described. Specific development efforts include: a maintenance discrepancy database (MDDB) that is used to provide cause and effect relationships; impact of associated maintenance tasks; automated like and similar analysis capabilities; and use of the expended maintenance importance ratio (EMIR). I.E.

A88-43501#
REAL-TIME SIMULATION APPLICATIONS
V. SRINIVAS (Aeronautical Development Establishment, Bangalore,

India) Defence Science Journal (ISSN 0011-748X), vol. 37, Oct. 1987, p. 433-442. refs

This paper deals with development of the real-time simulation systems. Two systems, one for supporting the research and development programs of the aircraft industry and the other to provide pilot training of modern aircraft are described. The presentation brings out the effectiveness of such systems in their respective roles and the techniques developed in the design and realization of hardware and software. This also gives an overview of various activities which have culminated in the establishment of research simulation facility and training simulators. Also plans of actions and techniques proposed to be employed in terms of future programs are discussed. Author

A88-43601
SELECTION OF THE SAMPLING PERIOD IN A HYBRID CONTROL SYSTEM WITH ALLOWANCE FOR PARAMETER SCATTER [O VYBORE TAKTA KVANTOVANIIA V GIBRIDNOI SISTEME UPRAVLENIIA S UCHETOM RAZBROSA PARAMETROV]
IU. V. ALEKSANDROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 3-8. In Russian. refs

The problem of selecting the sampling period is stated as the inverse problem of the analysis of the guaranteed sensitivity of a hybrid system. Methods for solving the problem are presented. The value of the sampling period in a hybrid system for stabilizing the angular position of a flight vehicle platform is determined over a specified range of imbalance variation. V.L.

A88-43602
A SET OF APPLIED PROGRAMS FOR SOLVING NOMOGRAPHIC APPROXIMATION PROBLEMS IN DESIGN STUDIES OF WORKING PROCESSES IN FLIGHT VEHICLE ENGINES [PAKET PRIKLADNYKH PROGRAMM SANA DLIA RESHENIIA ZADACH NOMOGRAFICHESKOI APPROKSIMATSII PRI PROEKTNYKH ISSLEDOVANIIAKH RABOCHIKH PROTSESOV V DLA]
V. E. ALEMASOV, E. A. DAUTOV, A. F. DREGALIN, and M. L. SERGIEVSKAIA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1988, p. 8-12. In Russian. refs

A set of application software has been developed for solving problems associated with the multidimensional approximation of tabulated data in the development of computer-aided design systems. Examples of nomograms and analytical expressions based on them which can be useful in the computer-aided design of flight vehicle engines are presented. A diagram of a system for the computer-aided design of nomograms is included. V.L.

A88-44652#
DESIGN OF ADAPTIVE CONTROL SYSTEM WITH STOCHASTIC DISTURBANCES AND ITS APPLICATION TO C FLIGHT CONTROL SYSTEM
KIMIO KANAI, SHIGERU UCHIKADO, and MITUHIRO SAKAYANAGI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 412, 1988, p. 242-248. In Japanese, with abstract in English. refs

Two design methods of adaptive flight control system with stochastic disturbances are considered. The first method ensures that the expected output error zero approaches asymptotically, and the other is based upon the minimum variance control. Both methods are designed via the polynomial algebraic method, which is a good tool to construct the control system easily. These methods are applied to the flight control system of a small-size high-performance aircraft, and numerical simulations under the stochastic environment can be shown to justify the proposed schemes. Author

A88-44654#
EXPANSION SERIES IN THE LAPLACE DOMAIN OF INTEGRAL FUNCTIONS OCCURRING IN THE LIFTING SURFACE THEORY FOR NONPLANAR WINGS
TETSUHIKO UEDA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 412, 1988, p. 255-257. In Japanese, with abstract in English. refs

An exact expansion series of the integral function occurring in the lifting surface theory is presented. The series is applicable to nonplanar wings treated in the Laplace domain with the nondimensional Laplace variable p as well as the reduced frequency k which corresponds to the imaginary axis of the p-plane. Author

A88-45320#
AI METHOD OF MACROSCOPIC MANAGEMENT ON AIRCRAFT MAINTENANCE
HUILI CHENG, BENGANG KUANG, and JIANSHENG SHANG (Air Force College of Engineering, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, April 1988, p. B165-B171. In Chinese, with abstract in English.

This paper introduces the AI technique into the field of aircraft maintenance management engineering, so as to establish a macroscopic management expert system which pools the wisdom of experts. It presents a reasoning model developed on the basis of the theory of fuzzy sets, and a new method of knowledge acquisition and revision according to the theory of random sets and set-valued statistics (the characteristic value method). The paper also explores the way to implement the system in PROLOG language. This method may be applied to making an overall and partial quantitative estimation of the capability of an aircraft maintenance system and diagnosing the abnormality of the system. The rate of conformity approaches 92.6 percent. Author

A88-45731
GATES: AN AIRLINE GATE ASSIGNMENT AND TRACKING EXPERT SYSTEM
ROBERT P. BRAZILE and KATHLEEN M. SWIGGER (North Texas State University, Denton, TX) IEEE Expert (ISSN 0885-9000), vol. 3, Summer 1988, p. 33-39. Research supported by Trans World Airlines, Inc. and USAF. refs

A description is given of GATES, an expert system that assigns gates to arriving and departing flights at New York's John F. Kennedy International Airport (JFK). GATES uses flight information and knowledge about current constraints to produce possible gate assignment schedules. GATES is a constraint-satisfaction expert system. To make its decisions, it uses two types of production rule: permissive rules and conflict rules. Permissive rules determine when it is appropriate to consider a particular gate for a particular flight, and permit the system to search the next level of rules to obtain an assignment. Conflict rules determine when particular flights cannot be assigned to particular gates. System operators can modify schedules by retracting rules, adjusting tolerances, and deleting information. The system was developed for a PC, thereby providing an efficient and flexible user environment. The approach is extensible to various engineering and industrial problems where limited resources and weakly defined constraints exist and in which scheduling must occur. I.E.

N88-23798# British Aerospace Public Ltd. Co., Preston (England). Military Aircraft Div.
SOFTWARE ENGINEERING FOR THE BRITISH AEROSPACE EXPERIMENTAL AIRCRAFT PROGRAMME (EAP)
W. E. R. KELLAWAY *In* AGARD, The Design, Development and Testing of Complex Avionics Systems 14 p Dec. 1987 Sponsored in part by the Ministry of Defence, United Kingdom
Avail: NTIS HC A18/MF A01

The software engineering approach adopted by British Aerospace in the specification, design and implementation of the Avionics and Utility Systems Management software for the Experimental Aircraft Program (EAP) is described. The software life cycle and supporting methods and tools are described, in particular the Controlled Requirements Expression (CORE) method, supported by the CORE Work Station, and the PERSPECTIVE programming support environment. The considerable benefits obtained in both productivity and quality are highlighted and developments leading to a full Integrated Project Support Environment (IPSE) are indicated. 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.

A88-41567#
FUSELAGE STRUCTURAL-ACOUSTIC MODELING FOR STRUCTURE-BORNE INTERIOR NOISE TRANSMISSION
J. F. UNRUH and S. A. DOBOSZ (Southwest Research Institute, San Antonio, TX) ASME, Transactions, Journal of Vibration, Acoustics, Stress, and Reliability in Design (ISSN 0739-3717), vol. 110, April 1988, p. 226-233. refs
(ASME PAPER 87-WA/NCA-15)

Detailed finite element models of a fuselage structure and acoustic cabin volume of a laboratory based prototypical aircraft fuselage were generated for the purpose of studying the predictive capabilities of deterministic modeling procedures for structure-borne noise transmission. Comparative predictions are made to measured wing-to-fuselage attach point inertances and interior noise to force responses. Several structural models with increased structural definition were evaluated. It was found that to accurately predict wing-to-fuselage attach point inertances required increased local area structural definition, while interior noise can be reasonably well predicted without paying additional attention to local area structural details. Author

A88-43184
CABLE AND CONNECTOR DESIGN ISSUES FOR MOBILE PLATFORM APPLICATIONS
W. R. LITTLE, T. A. LINDSAY, and Q. G. MENDOZA (Eldec Corp., Sensing Systems Div., Bothell, WA) IN: Fiber optic systems for mobile platforms; Proceedings of the Meeting, San Diego, CA, Aug. 20, 21, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 151-156. refs

This paper presents the most important system parameters associated with typical mobile platforms. Emphasis is placed on aircraft system needs. Based on these system parameters, an integrated set of termination characteristics is proposed, including requirements for cable losses, connector usage, buffer coatings, cable bundles, fiber diameter, cable strength, use of LEDs, tooling, and plastic fiber. C.D.

A88-43301
COLLOQUE D'ACOUSTIQUE AERONAUTIQUE ET NAVALE, 10TH, MARSEILLE, FRANCE, NOV. 19-21, 1986, PROCEEDINGS
Colloquium organized by the Societe Francaise d'Acoustique and Association Aeronautique et Astronautique de France; Sponsored by CNRS. Revue d'Acoustique (ISSN 0557-7713), vol. 20, no. 82, 1987, In French. For individual items see A88-43302 to A88-43313.

Papers are presented on an analysis of the unsteady-loading noise generated by helicopter in-fin tail rotors, an experimental study of the wall pressure field downstream of a wing/body junction, a 'flight effect' analysis of turbojet and turbofan nozzle models, and boundary layer control. Also considered are source coherence in jet noise prediction, a turbulent boundary layer submitted to an intense acoustic field, a numerical simulation of acoustic wave propagation in a local immersion NDT system, and acoustic propagation in the low atmosphere. Other topics include cavity thermoacoustics, the prediction of the vibratory response of stiffened structures by the super-matrix method, the application of a modal routing method to the calculation of sound transmission through finite thin shells, and the sound propagation of vibrating structures. R.R.

A88-43302
ANALYSIS OF THE UNSTEADY-LOADING NOISE GENERATED BY HELICOPTER IN-FIN TAIL ROTORS [ANALYSE DU BRUIT DE CHARGES INSTATIONNAIRES EMIS PAR UN FENESTRON D'HELICOPTERE]
F. FOURNIER and M. ROGER (Lyon, Ecole Centrale, Ecully, France) (Societe Francaise d'Acoustique, Association Aeronautique et Astronautique de France, and CNRS, Colloque d'Acoustique Aeronautique et Navale, 10th, Marseille, France, Nov. 19-21, 1986) Revue d'Acoustique (ISSN 0557-7713), vol. 20, no. 82, 1987, p. 11-19. In French. refs
(Contract DRET-83-025; DRET-84-368)

An experimental apparatus for evaluating the noise generated in helicopter in-fin tail rotors is described, and a model of unsteady loading noise has been developed in order to account for the observations. When the in-fin tail rotor is functioning at zero incidence, the two principal noise sources, the preturbulence of the rotor itself and the rotor-stator interaction noise, are found to be distinct, with the rotor-stator interaction manifesting itself by residual lines of the first two harmonics of the blade passage frequency. At large incidence, the rotor-stator interaction appears to dominate the spectral structure. R.R.

A88-43304
'FLIGHT EFFECT' ANALYSIS OF TURBOJET AND TURBOFAN NOZZLE MODELS IN THE CEPRA 19 ANECHOIC WIND TUNNEL AT THE CEP [MISE EN EVIDENCE DE 'L'EFFET DE VOL' SUR DES MAQUETTES DE TUYERES MONOFLUX ET DOUBLE-FLUX DANS LA SOUFFLERIE ANECHOIQUE CEPRA 19 DU C.E.PR.]
C. FAYOT and D. GELY (Centre d'Essais de Propulseurs de Saclay, Orsay, France) (Societe Francaise d'Acoustique, Association Aeronautique et Astronautique de France, and CNRS, Colloque d'Acoustique Aeronautique et Navale, 10th, Marseille, France, Nov. 19-21, 1986) Revue d'Acoustique (ISSN 0557-7713), vol. 20, no. 82, 1987, p. 27-31. In French. refs

Measurements have been obtained at the Centre d'Essais des Propulseurs CEPRA 19 anechoic wind tunnel using turbojet and turbofan nozzle models in order to study the effect of flight velocity on jet noise. The present results are found to be in good general agreement with both theoretical results and flight test data. It is suggested that noise spectra anomalies noted at frequencies higher than 40 kHz may reflect the passage of sound waves across the mixing zone and/or the turbulent boundary layer which develops along the nozzle fuel line. R.R.

A88-43306
IS SOURCE COHERENCE AN IMPORTANT FACTOR IN JET NOISE PREDICTION? [LA COHERENCE DES SOURCES EST-ELLE UN FACTEUR IMPORTANT POUR LA PREVISION DU BRUIT DE JET?]
R. E. MUSAFIR and M. ZINDELUK (Rio de Janeiro, Universidade Federal, Brazil) (Societe Francaise d'Acoustique, Association Aeronautique et Astronautique de France, and CNRS, Colloque d'Acoustique Aeronautique et Navale, 10th, Marseille, France, Nov. 19-21, 1986) Revue d'Acoustique (ISSN 0557-7713), vol. 20, no. 82, 1987, p. 42-45. In French. refs

Evidence for the existence of coherence among jet noise sources is examined, and it is pointed out that significant coherence in the hydrodynamic pressure field does not imply the coherence of noise sources. It is shown that the use of jet-flow pressure spectra to obtain source properties is based upon an incorrect identification of shear and self-noise, and that this identification includes a source term which is improperly identified as a major contribution to the noise field. Experimental results obtained using either one or two microphones are found to be consistent with a model of moving-point quadrupoles. Situations where coherence may play an important role are identified. R.R.

N88-24233*# Cambridge Acoustical Associates, Inc., Mass.
ANALYTICAL MODELING OF THE STRUCTUREBORNE NOISE PATH ON A SMALL TWIN-ENGINE AIRCRAFT
J. E. COLE, III, A. WESTAGARD STOKES, J. M. GARRELICK,

and K. F. MARTINI Washington NASA Jun. 1988 127 p (Contract NAS1-18020)
(NASA-CR-4136; NAS 1.26:4136; U-1541-349-PT-1) Avail: NTIS HC A07/MF A01 CSCL 20A

The structureborne noise path of a six passenger twin-engine aircraft is analyzed. Models of the wing and fuselage structures as well as the interior acoustic space of the cabin are developed and used to evaluate sensitivity to structural and acoustic parameters. Different modeling approaches are used to examine aspects of the structureborne path. These approaches are guided by a number of considerations including the geometry of the structures, the frequency range of interest, and the tractability of the computations. Results of these approaches are compared with experimental data. Author

N88-24234# Federal Aviation Administration, Washington, D.C.
ADVISORY CIRCULAR: NOISE CERTIFICATION HANDBOOK
23 Mar. 1988 66 p
(FAA-AC-36-4B) Avail: NTIS HC A04/MF A01

The aim of this technical manual is to promote uniformity of implementation of the noise certification requirement of Part 36 of the Federal Aviation Regulations (FAR) by presenting test, analysis, and documentration procedures for subsonic turbojet airplanes that were determined by the FAA to be technically acceptable for demonstrating compliance with that regulation. Where appropriate, FAA policy governing such certifications is reviewed. Author

N88-24239*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SOURCES AND LEVELS OF BACKGROUND NOISE IN THE NASA AMES 40- BY 80-FOOT WIND TUNNEL Status Report
PAUL T. SODERMAN May 1988 44 p
(NASA-TM-100077; A-88112; NAS 1.15:100077) Avail: NTIS HC A03/MF A01 CSCL 20A

Background noise levels are measured in the NASA Ames Research Center 40- by 80-Foot Wind Tunnel following installation of a sound-absorbent lining on the test-section walls. Results show that the fan-drive noise dominated the empty test-section background noise at airspeeds below 120 knots. Above 120 knots, the test-section broadband background noise was dominated by wind-induced dipole noise (except at lower harmonics of fan blade-passage tones) most likely generated at the microphone or microphone support strut. Third-octave band and narrow-band spectra are presented for several fan operating conditions and test-section airspeeds. The background noise levels can be reduced by making improvements to the microphone wind screen or support strut. Empirical equations are presented relating variations of fan noise with fan speed or blade-pitch angle. An empirical expression for typical fan noise spectra is also presented. Fan motor electric power consumption is related to the noise generation. Preliminary measurements of sound absorption by the test-section lining indicate that the 152 mm thick lining will adequately absorb test-section model noise at frequencies above 300 Hz. Author

N88-25263# Army Construction Engineering Research Lab., Champaign, Ill.
OPERATIONAL NOISE DATA FOR CH-47D AND AH-64 ARMY HELICOPTERS Final Report
PAUL D. SCHOMER, AARON J. AVERBUCH, RICHARD RASPET, and RICHARD K. WOLF Mar. 1988 44 p
(AD-A191059; CERL-TR-N-88/04) Avail: NTIS HC A03/MF A01 CSCL 01C

The objectives of this study were to develop sound exposure level (SEL) versus distance curves for flight operations and time-average sound level (LEQ) contours versus distance for static operations for two new Army aircraft. Sound levels produced by the helicopters were measured for the aircraft both hovering and traveling at various speeds. The CH-47D was operated in both a heavily and a lightly loaded configuration; the heavy load was achieved by sling-loading a 10-ton Army truck. The data show that the aircraft are quieter than the types they are replacing; the CH-47C and the AH-1G. Except at the highest speeds, sound variation with speed is not a large factor. In terms of sound variation with load, the CH-47D actually made less sound during level flight at full load than it did lightly loaded, although the sound did increase with load during takeoff and landing. As with other aircraft, the CH-47D makes more sound during landing than it does during level flight or takeoff, but the sound levels for the AH-64 are virtually independent of operation. Only two of each aircraft were supplied. Both types of aircraft exhibited sound levels which were a little higher than expected, and more aircraft would have enhanced the statistical reliability of the data. In the future, a minimum of four aircraft of any type should be supplied. They should be measured in two groups of two, separated by at least 1 month in time to better insure the statistical reliability of the data. GRA

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A88-42924#
ANTIDOTES FOR RUNAWAY HELICOPTER INSURANCE RATES
GEORGE M. POWELL (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: Vertical flight training needs and solutions; Proceedings of the AHS National Specialists' Meeting, Arlington, TX, Sept. 17, 18, 1987. Alexandria, VA, American Helicopter Society, Inc., 1987, p. 97-111. refs

A study concerning the problem of high helicopter insurance rates, based on interviews with aircraft manufacturers, insurers, legislators, risk managers, operators, lawyers, trade associations, the FAA, and the public is presented. Various influences on insurance costs are discussed, finding that those involved in every aspect of the helicopter industry are responsible for high rates. It is suggested that more training to reduce the human factor in accidents would help reduce rates. The Helicopter Association International hull/liability insurance program and the possibility for tort liability reform legislation are also examined. R.B.

A88-43369
LIFE CYCLE COST PROCEDURE FOR COMMERCIAL AIRCRAFT SUBSYSTEM
LESZEK M. DACKO and RALPH F. DARLINGTON (Dowty Canada, Ltd., Ajax) IN: Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 26-28, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 389-394.

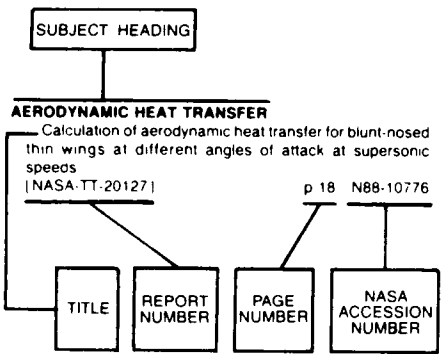
The authors identify the need to analyze the commercial aircraft subsystem cost effectiveness to optimize the design and production decisions of the subsystem manufacturer. The life cycle cost (LCC) methodology developed by Dowty Canada Limited, together with the computer program that supports it, and an optimizing procedure, is presented. I.E.

A88-44713#
LESSONS LEARNED - AN INTEGRATED APPROACH TO AIRBREATHING PROPULSION DESIGN AT THE UNITED STATES AIR FORCE ACADEMY
D. NEAL BARLOW, CHARLES W. WOOD, and JOHN K. HARVELL (U.S. Air Force Academy, Colorado Springs, CO) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p.
(AIAA PAPER 88-2975)

This past academic year, the Department of Aeronautics at the Air Force Academy expanded its propulsion design sequence to two semesters and expanded its content to include

engine/airframe integration. All Aeronautical Engineering students at the Academy develop a preliminary airframe and determine a potential engine cycle during the fall of their senior year. In the spring semester each student takes either the follow-on propulsion design course or the airframe design course. While the propulsion students work primarily on component design during the Spring semester, crossflow between the airframe and propulsion teams in the areas of drag, thrust, and fuel consumption information is critical if a final airframe/propulsion system which will meet the requirements of a Request for Proposal is to be achieved. This paper summarizes the philosophy and content of the propulsion curriculum at the United States Air Force Academy, with detailed discussion of the capstone design sequence and the lessons learned during the first year of this integrated approach. Author

Typical Subject Index Listing



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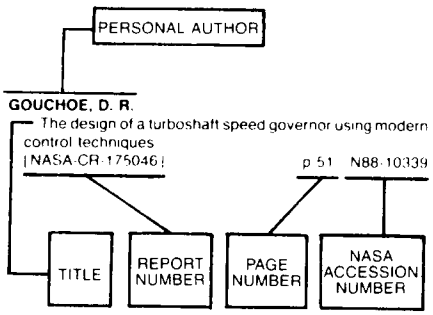

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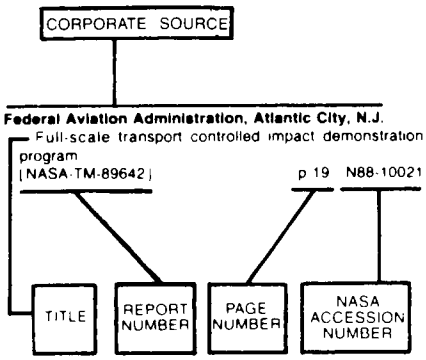

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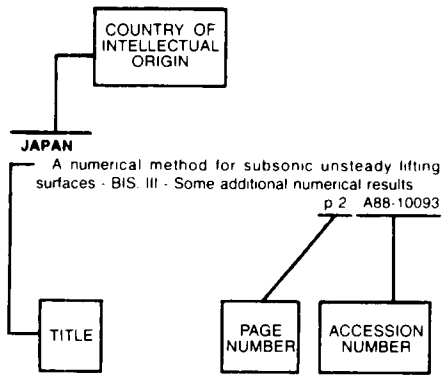

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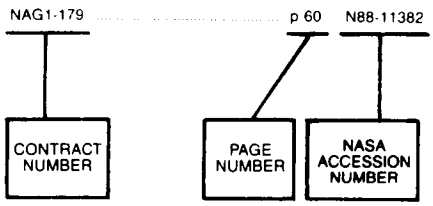

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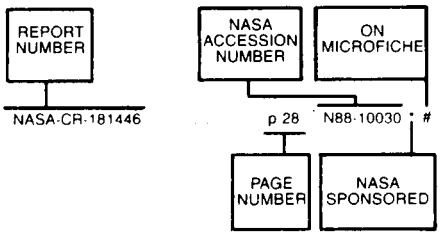

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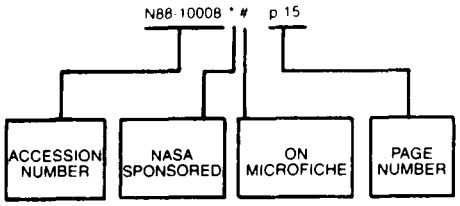

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